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Obsidian Economy in the Armenian Highlands During the Late Neolithic. A View from Masis Blur

A dissertation submitted in partial satisfaction of the

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by

Kristine Olshansky

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ABSTRACT OF THE DISSERTATION

Obsidian Economy in the Armenian Highlands During the Late Neolithic. A View from Masis Blur

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Professor Charles S. Stanish, Chair

The research reported here focuses on the social mechanisms underlying the widespread distribution of obsidian in prehistoric sites of the Southern Caucasus in general, and Armenia in particular, during the Neolithic period ca. 6000 – 5300 cal. BCE. This work challenges the assumption that the acquisition and exchange of obsidian, a raw material ubiquitous in the Southern Caucasus, requires little explanation. It is widely held that obsidian is easily available throughout the Armenian Highlands, as well as in Anatolia, thus obsidian sourcing can offer very little information on contact and exchange during the Neolithic. Prior research on obsidian sourcing has focused on the identification of the sources used at a given site. These earlier studies generally concluded that while many Neolithic settlements of the Southern Caucasus, and those located in the Ararat plain of Armenia specifically, relied on multiple sources for raw material procurement, most had a greater preference (over 60%) for the obsidian source located at the least travel distance from the settlement. These data support a least-cost model of procurement. The present work employed portable X-ray fluorescence spectroscopy (pXRF) to analyze a statistically significant sample (854 out of ca. 11000 or about 8 %) of obsidian artifacts excavated from the site of Masis Blur in the Ararat Plain. In contrast to earlier works, these data indicate a pattern of source utilization substantially more complex than presently theorized. We find that the residents of Masis Blur utilized at least nine sources. These sources remained surprisingly constant throughout the occupational history of the site. We discovered that acquisition was not driven by a single factor and that a simple least-cost model does not sufficiently explain the obsidian acquisition pattern observed at Masis Blur. The Neolithic inhabitants of Masis Blur obtained obsidian through both direct and indirect means. In short, this work provides insight into the strategies of obsidian procurement which in turn allows us to draw larger conclusions of socio-economic networking in the Neolithic of Armenia and beyond.

The dissertation of Kristine Olshansky is approved.

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“Wherever I wander, wherever I rove,
The hills of the Highlands forever I love.”

Robert Burns, 1789

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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CHAPTER 1: INTRODUCTION

The Southern Caucasus occupies an intermediate position between Europe and Asia and has acted as an important corridor for the movement of peoples and goods between these two continents since the early Paleolithic period. In spite of the critical geographical position of the South Caucasus and the relatively early presence of sedentary farming communities, which appear ca. 8000 BP, our knowledge of the Neolithization process in the region remains incomplete. The mountainous topography of the Southern Caucasus has served as a geographic and environmental filter, both constraining and directing the types and frequency of cultural and technological interaction of prehistoric populations. This topography has also influenced the location of settlements of early agriculturalists, making vast fertile plains, such as the Ararat plain in Armenia, a focal point in the region.

Contradicting hypotheses have suggested either a local independent development of agriculture or an introduction via population replacement by neighboring Near Eastern groups. Discussions on the development of food-producing economies in the region have concentrated on the spread of domesticated crops and animals, while resource acquisition, technological transfer, and knowledge sharing, which would have been integral aspects of this transition have been left out. Our understanding of the mechanisms which lay behind the widespread distribution of obsidian in prehistoric sites of the Southern Caucasus in general and Armenia in particular is under-researched and under-theorized. The phenomenon is not considered to be an important factor in the cultural developments of the region; the acquisition, use, and exchange of obsidian, a raw material ubiquitous in the Southern Caucasus, is largely taken for granted, requiring little explanation. It is widely held that obsidian is easily available in the Southern Caucasus and in Turkey, thus obsidian sourcing can offer very little information on contact and exchange during the Neolithic. The obsidian economy has either been entirely omitted from most synopses of prehistoric periods in the Southern Caucasus or is merely mentioned in passing. Recent research on obsidian sourcing simply identifies the sources used at a given site without attempting to problematize the choice of a source(s) within a larger socio-economic or socio-political context and its implications for our understanding of prehistoric social organization in the Southern Caucasus. These studies have argued that while many Neolithic settlements of the Southern Caucasus, and those located in the Ararat plain specifically, relied on multiple sources for raw material procurement, most had a greater preference for the obsidian source nearest to the settlement. The implication is that economic factors, i.e. energy expenditure on the task, were the leading factors behind utilization of the nearest obsidian sources. In other words, the default assumption is a model based upon least-cost assumptions.

However, it is now well established that social cultural and social factors can be as significant as economic or functional ones in decision making such as in resource selection. The use of obsidian from distant sources, when qualitatively comparable ones are available closer to the site can lead to insightful interpretations, such as the presence of inter-regional social or economic networks. Since the interaction and movement of people between the Near East and the Southern Caucasus has long been a favored explanation for the appearance of sedentary farming communities in the Southern Caucasus, illustrating these movements (or the lack thereof) will improve our understanding of how Neolithic lifeways developed in the region.

It has been argued that identifying materials that moved "between different areas and different societies are the most tangible evidence that an archaeologist can hope for when looking to establish contact between prehistoric peoples" (Glascock 2002a:1). The use of chemical characterization to match obsidian artifacts to their raw material origin is one of the most successful ways movement of materials between regions can be established. While the nature and mode of long-distance interactions is more difficult to ascertain, it can be suggested that such interactions would not necessarily occur as part of daily routines and patterns of mobility. Nevertheless, such contacts are observable through the movement of materials can better our understanding of resource acquisition, social networks, and exchange patterns of prehistoric societies.

Through this study, I aim to address the socio-economic strategies and developments during the Neolithic period from the perspective of procurement, production, and exchange of obsidian in the Ararat plain of Armenia. The theoretical lines of inquiry utilized in this dissertation makes use of ideas which link tangible material remains, such as obsidian tools, to human economic behavior, evaluate diachronic patterns of obsidian procurement and utilization, and investigate structures and forms of exchange networks. The goal of this project is to investigate the relationship between the obsidian economy (raw material acquisition, use, and distribution) and the broader regional and inter-regional social and economic interaction in the Neolithic context of the Southern Caucasus and neighboring regions.

I employed portable X-ray fluorescence spectroscopy (pXRF) to analyze 854 artifacts excavated from the Masis Blur Neolithic settlement located in the Ararat plain of Armenia. By using a statistically-significant sample size from an assemblage of over 11,000 artifacts recovered between 2012 and 2014 it becomes clear that the pattern of source utilization is more complex than previous studies suggested. The obsidian acquisition pattern at Masis Blur is diverse, with the inhabitants obtaining obsidian through direct and indirect procurement strategies. It also became clear that acquisition was not driven by a single factor, such as distance to source or travel time to source. The results do not lend support to the existence of long-distance exchange networks in which obsidian was the predominant commodity exchanged, but clearly illustrate that the Neolithic communities of the Ararat plain, and likely the Southern Caucasus as a whole, maintained long-distance links to social networks located in Eastern Turkey and the rare obsidian artifacts, along with the rare Halaf pottery fragments are merely the only archaeologically visible remnants of these interactions.

The dissertation is organized as such: In Chapter 2, I discuss the theoretical background I employed in this research, focusing on theoretical approaches to economy, exchange, and raw material procurement. In Chapter 3, I present a brief overview of obsidian sourcing research in the Southern Caucasus and discuss our current state of knowledge. In Chapter 4, I present archaeological data on Masis Blur, including important regarding excavations, context, and dating of Masis Blur. I review the regional archaeological context against which data from Masis Blur is considered and interpreted. Chapters 5, presents the methods of analysis employed in obsidian sourcing research and statistical methods employed to attribute an artifact to a geological source. In Chapter 6, I present the results of chemical characterization of 167 geological specimens collected from Armenian and eastern Turkish sources, as well as analysis and attribution results of 854 artifacts from Masis Blur. Finally, in Chapter 7, I discuss the implications of this research and consider them within an inter-regional context. Various tables, images, and elemental concentrations results for both geological specimens and artifacts are presented in Appendices 1-8.

CHAPTER 2: THEORETICAL APPROACHES TO ECONOMY, EXCHANGE, AND RAW MATERIAL PROCUREMENT

> "Far from being a scattering of discrete units, the neolithic world should be viewed as a continuous chain of communities. Each would be linked to its neighbours on either side by recurrent.... contacts" Childe (Childe 1965 [1936]:84).

2.1 Introduction

Discussion of the mechanisms which lay behind the widespread distribution of obsidian on prehistoric sites in Armenia (and the Southern Caucasus in general) have been largely absent from scholarly discourse. The phenomenon is not considered to be an important factor in the cultural developments of the region and the acquisition and exchange of obsidian, a raw material ubiquitous in Armenia, is largely taken for granted, requiring little explanation. In large, the obsidian economy has either been entirely omitted from most synopses of prehistoric periods in the Southern Caucasus (particularly for the Bronze Age) or is merely mentioned in passing. Recent research on obsidian sourcing simply identifies the sources used at a given site without attempting to problematize the choice of source(s) within a larger socio-economic or socio-political context and its implications for our understanding of prehistoric social organization in the Southern Caucasus.

From its early stages, archaeological research in the Southern Caucasus was constrained by Marxist theory, a historical materialism that better accorded with the demands of the new regime in the USSR. Soviet archaeologists were forced to denounce pre-revolutionary archaeological literature for its *"goloye veshevedeniye"* or "bare artifactology" (Bulkin, et al. 1982). Ideas of migration and diffusion were rejected as they stood against the regime's ideological underpinnings that society could be changed and improved through collective efforts of its people. The legacy of Soviet archaeological school of thought, rooted in the historical sciences, coupled with the regime's control, strongly affected theorizing efforts prior to the break of the Soviet Union. However, it must be noted that great achievements were still made by Soviet archaeologist and the work of Boris Piotrovsky are of particular importance for the study of the Southern Caucasus. The collapse of the Soviet Union, ushered in a new age of archaeological research in the region. International collaborations became possible and open interactions among Armenian, European, and American archaeologists in the last two decades have provided a context for the exchange of ideas, new means of comparative and scientific analysis.

Theoretical work on the Neolithic period in the region rests largely on three main issues: 1) the transition from foraging to food production, 2) the degrees of mobility and sedentism, and 3) the social and economic organization of Neolithic communities. Our ability to address these issues is further restrained by the limited number of systematically excavated and well published Neolithic sites in the Southern Caucasus. Unfortunately, research on the Neolithic and Chalcolithic periods in Armenia has not kept pace with studies of these periods in the Near East in general. Aside from Rafik Torosyan's (1976) excavations of the Chalcolithic settlement of Teghut, Badalyan and his colleagues' excavations at the Neolithic-Chalcolithic settlement of Aratashen (2002; 2004b; 2007) and Aknashen-Khatunarkh (2010), and our own excavations at the Neolithic settlement of Masis Blur, little is known about the early settled agricultural communities of Armenia. The results of archaeological investigations at Aratashen and Aknashen-Khatunarkh, under excavations for 10 and 9 years respectively, have been published only in way of preliminary reports detailing the occupational chronology and material culture present at the sites. A more comprehensive interpretive analysis of the findings is awaiting publication.

This study seeks to address social and economic development and change from the perspective of procurement, production, and exchange of obsidian during the Neolithic period in the Ararat plain of Armenia. The theoretical issues presented here are linked to 1) evaluating the diachronic patterns of obsidian procurement and utilization strategies, and 2) evaluating the structure and form exchange networks.

2.2 Anthropological Approaches to Economy and Exchange

2.2.1 Substantivist/Formalist Economies

The study of ancient economies has been a dominant theme in archaeological research, as economic approaches to prehistory have the potential to link the material remains we find within archaeological contexts with their prehistoric communities in a quantifiable way in order to examine changes in subsistence, production, and exchange. The universal applicability of economic models developed primarily for explaining behaviors in marked-oriented societies has been a central question in economic anthropology. Debates between advocates of formalist and substantivist approaches to economy have been ongoing for over 70 years (Plattner 1989:10-15) and substantivist/formalist theoretical approaches to ancient economy encompass the majority of investigations of prehistoric exchange. Proponents of the substantivist approach recognize fundamental differences between ancient and non-capitalist societies and modern economies. In contrast, formalists argue that ancient and non-western societies differ from those of modern capitalist societies in degree but not in kind (Wilk 1996). The assumptions associated with substantive and formal economics play a critical role in formulating research questions about ancient economy and exchange.

Formalist approaches perceive economic behavior in terms of universally self-interested social actors in pursuit of scare resources. Anthropologists use these approaches by applying energy or time invested as value units to studies of raw material procurement, food production, knapping strategies, and settlement choices (e.g., Earle and Christenson 1980; Jochim 1976; Kennett and Winterhalder 2006). In studies of prehistoric exchange, archaeologists have used formalist approaches to study the evolution in exchange systems both on the individual and institutional level (Earle 1982:2). Using assumptions of cost minimization, Renfrew (1977) and his colleagues (1968) and Hodder (1974; 1978) have used regression analysis and gravity models to differentiate between exchange systems in prehistory. Earle contends that "the sociopolitical institutions establish constraints in terms of the distribution and value of items. Then, individuals, acting within these institutional constraints, procure and distribute materials in a cost-conscious manner" (Earle 1982:2). Under the formalist approach, economic life is examined as the fulfillment of culturally defined wants based on limited resources (natural or labor), relying on concepts such as scarcity, production and labor efficiency, and economizing drives to analyze economy regardless of social and cultural contexts or scale.

There have been various critiques of formal approaches, but Ian Hodder, an ex-formalist himself, has strongly criticized the methodological problems associated with this approach. He (1982:202) has pointed out that formalist approaches to prehistoric exchange are weakened by the equifinality in the empirical evidence. He further argues that formal approaches, such as regression analysis, do not sufficiently account for middle range links between social context, political strategies, and the empirical evidence provided by distributions of archaeological data.

Dissatisfaction with formal approaches and its inapplicability to ethnographic case studies and the assumptions of neoclassical economics (Wilk 1996:1-26) gave rise to s*ubstantive* *approaches* in anthropology. This school of thought emphasizes that economy and exchange are fundamentally linked to other aspects of human behavior and undertaken within specific cultural contexts. Therefore, techniques designed around "modern" or "western" conceptions of rational self-interested social agents are inadequate for application in non-western cultural contexts (Bohannan and Dalton 1962; Dalton 1969). First articulated by Karl Polanyi (1957), the substantivist position argues that economy is "embedded" in socio-political institutions. This view of economy traces its beginnings to the studies by Malinowski (1922) and Mauss (1925), and while the focus in their studies was on social relationships, social change dominated the discourse in economic anthropology during the 1960s (Dalton 1969). In its early stages substantivism had a largely functionalist view of society as static, aiming to maintain the equilibrium within the social environment (Schneider 1974) and interactions took place through reciprocity, redistribution, and exchange. Sahlins (1965) further elaborated on reciprocity-based exchange places generalized, balanced, and negative reciprocities along a continuum that describes the dynamics of interaction within specific social contexts. Gregory outlines a further distinction between alienable commodities as transfer between reciprocally independent people "that establish a qualitative relationship between the objects exchanged" (Gregory 1982:100) and the transfer of inalienable gifts between reciprocally dependent individuals "that establishes a qualitative relationship between the transactors" (1982:100-101).

Critiques of the substantivist approach to the study of economy and exchange emerged from early versions of agency theory. The substantivist view sees society as constructed of consistent rules within which agents must act (Dalton 1969:77). Hodder has argued that in this perspective, there is "little room for individual construction of social strategies and manipulation of rules, and there is little intimation of conflicts and contradictions between interests" (Hodder

1982:200). The second critique focuses on the distinction the substantivist approach draws between complex societies, among which formal approaches are deemed to be more appropriate, and small-scale societies for which substantivist approaches are more relevant. This dichotomy is problematic as it necessitates a clear distinction between the various levels of socio-political complexity, creating a dilemma of where to draw the line. Monica L. Smith (1999:111) has argued that premodern polities had higher population densities and involved multi-layered and overlapping interaction spheres then can be found in the ethnographic cases on which many substantivist models rely. Therefore, formal approaches might have more relevance in premodern complex societies. Another major critique is that there is no empirical support for direct correlation between forms of exchange and level of socio-political complexity (Hodder 1982:201). Pryor (1977:4) has argued that anthropological studies suggest that extensive reciprocal exchange is more directly correlated with unpredictability in food supply and that reciprocity is encountered more frequently among hunters, fishers, and farmers than among gatherers and pastoralists who exploit relatively predictable resources.

Polanyi's framework of economic anthropology focusing on the distinction between reciprocity, redistribution, and market exchange continues to be widely used in anthropological archaeology. As Michael E. Smith (2004) argues, a more refined differentiation of transaction mechanisms can be used to distinguish the degree of internal and external commercialization in state-level societies. However, in places such Egypt, the Andes, and to a certain extent the Armenian Highland, where historical and archeological evidence attest to strong state control of uncommercialized economies without market-based economics, the subtleties of ancient economic activities are less relevant. Despite the criticism, Polanyi's coarser distinction of reciprocity, redistribution, and non-market trade has been shown to be sufficient in regions such as the Andes where many scholars believe that trade played a minor role in prehistoric development (LaLone 1982; Stanish 2003).

Hodder (1982:200) contends that formal and substantive approaches are targeting different behaviors; while formal economics focuses on output and performance, substantive analyses account for social contexts of exchange. It may be a productive endeavor to drawing on the advantages of both approaches, but some scholars warn against the tendency to apply formal analyses to state-level societies and substantive analysis to small-scale societies (Granovetter 1985; Gregory 1982; Smith 1999). Granovetter (1985:482) asserts that there is a greater degree of variance of embeddedness of economic behavior than is allowed by either model.

The protracted debates on substantivist/formalist approaches of the past 70 years have passed without resolution, though these discussions have outlined and problematized the strengths and weaknesses of both approaches. In my dissertation research, I generally follow a substantivist tradition, being aware of the weaker elements of this approach. I will avoid these by not assuming a direct correlation between socio-political complexity and type or volume of exchange. Exchange activates are universal characteristics of human behavior and this emphasis on consumption allows for broad cross-cultural comparisons. In small, egalitarian Neolithic communities of the Southern Caucasus economic enterprise most likely took place within a framework of reciprocity and non-market exchange. Resources were likely controlled by large kin-based units rather than individuals, hence production and exchange decisions hat to be made at the homestead level. I argue that economic activities of these communities were embedded in their cultural contexts and served to establish or reinforce existing ties with other communities in the region.

2.2.2 Modes of Exchange

While some scholars have built upon Polanyi's original modes of exchange, others have developed entirely new schemes. Earle (1977:213-216) argues that Polanyi's definition of *redistribution* as "appropriational movements towards a center and out of it again…" is vague and so broad that it could apply to economic systems ranging from central storage of goods in Babylonia to meet distribution in band-level hunters. Instead, Earle advocates separating leveling mechanisms from institutional mechanisms, where institutionalized redistribution involves wealth accumulation and political transmission between elites across broad regions in the mode of peer-polity interactions (1997).

Expanding on Polanyi's system, Stanish (2003:21) describes political economy in the prehispanic Andes through competitive feasting and political support as a form of deferred reciprocity (Hayden 1995; Stanish 2003). He further asserts that while there was an implicit evolutionary sequence going from reciprocity to redistribution to markets, recent data suggest that these modes are not mutually exclusive, thus, can co-occur and that the relationships are too complex to fit into a single sequence.

Renfrew and his colleagues (1969; 1966; 1968) inaugurated a systematic approach to the study of raw material movement. In their seminal paper "Obsidian and the Origins of Trade" Dixon, Cann, and Renfrew proposed that:

> The raw materials of which objects are made, on the other hand, may offer an opportunity for a more decisive inquiry. If a material used by a community does not occur locally in the raw state, one must conclude it was imported, and the possibility exists that it was obtained in trade with another population. One can then start on the task of tracing the material to its source. It occurred to us obsidian might be an ideal material for a tracer investigation of this kind (Dixon, et al. 1968:108 – 110).

Their influential work demonstrated that geochemical characterization and attribution of artifacts or raw materials, such as obsidian, to a source could be used to infer not only extent of interactions, but also modes of exchange. The publication of this work spurred numerous sourcing studies both in the Old World and in the New World (Hughes 1978; Hughes 1986; Hughes 1992). Specifically, they introduced the concepts of *down-the-line* exchange, *fall-off patterns*, and *Law of Monotonic Decrement* exchange whereby the quantity of obsidian (or any other traded material) decreases at a specific rate as it moves farther from its geographical sources, or its the *supply zone*. Renfrew defines the *supply zone* as an area between 250-350 km from the raw material source, while the *contact zone* is everything beyond 350 km. Renfrew and colleagues proposed that within the supply zone obsidian was acquired through direct access, without intermediaries or trade, whereas within the contact zone, obsidian was obtained through contact with other groups. According to this model, obsidian can serve as an indicator of contact between different groups, in the case of their study, between Neolithic groups.

Renfrew's *reciprocity* and *down-the-line* exchange models (1975:520) involve the direct acquisition of obsidian by people living within the supply zone for the purpose of transferring the obsidian to neighboring communities in exchange for other items. Renfrew and colleagues argue that this type of exchange activities result in a distinct *fall-off* pattern where the volume of material is inversely correlated with distance from the source. According to this model, the inhabitants of Masis Blur, residing no more than a day's travel from the nearest high-quality sources, procured the raw material and exchanged it with neighboring communities.

Additional components of the model were added by the researchers to describe spatial distribution of obsidian. The *obsidian interaction zone* is an area within which all the sites have at least 30% of obsidian from a particular source, and a given site can belong to multiple interaction zones. The *gravity model* added an "attractiveness" component to a certain obsidian source, explaining that if multiple sources are available at a site, their relative abundance is reflective of the inhabitant's preference for that source.

Renfrew (1975:8) considers trade as interaction between communities in terms of both energy and information exchange, tabulating Polanyi's scheme as follows:

	Configuration	**Geographical**	**Affiliation**	**Solidarity**
Reciprocity:	Symmetry	No Central Place	Independence	Mechanical
***Redistribution*:**	Centricity	Central Place	Central Organization	Organic

Table 2.1 – Characteristics of reciprocity and redistribution. After Renfrew 1975:8.

He has further developed a graphical representation of the spatial relationship implied by each mode of exchange. The exchange modes depicted by Renfrew (1975:520), shown in Table 2.1, efficiently convey the variety in organization represented by exchange relationships. In some regions of the world, such as the Southern Caucasus, market-based economies are not believed to have operated during the prehistoric or even early historic period, which modifies one's expectations for the activities of traders. We do not expect to see all of these modes in any one particular archaeological context, but the figure serves to highlight the inherent difficulty of isolating specific types of exchange based on archaeological evidence. Moreover, these modes are not mutually exclusive; without imposed restrictions on production, consumption, or circulation of goods these modes very well may have been operating concurrently.

Various criticisms of Renfrew and colleagues' models have emerged over the years (e.g.,Hodder and Orton 1979; Wright 1969; Wright and Grodus 1969). Wright's (1969) early criticisms centered on the argument that artifact counts are not an accurate representation of the amount of obsidian present at a given site and instead obsidian weights should be used. He also argued that site types – permanent villages versus seasonal settlements – must be factored into the discussion of obsidian distribution and spatial patterning. Hodder and Orton (1979) showed that simple random-walk patterns could produce similar curves as the ones reported by Renfrew et al.. Despite the shortcomings of their models, Renfrew and colleagues were the first to explore obsidian movement patterns in the Near East and to offer explanations and possible models for movement of objects and interactions of people. Their paper brought obsidian sourcing and exchange dynamics onto a much delayed staged of research in comparison to similar projects undertaken in New World archaeology.

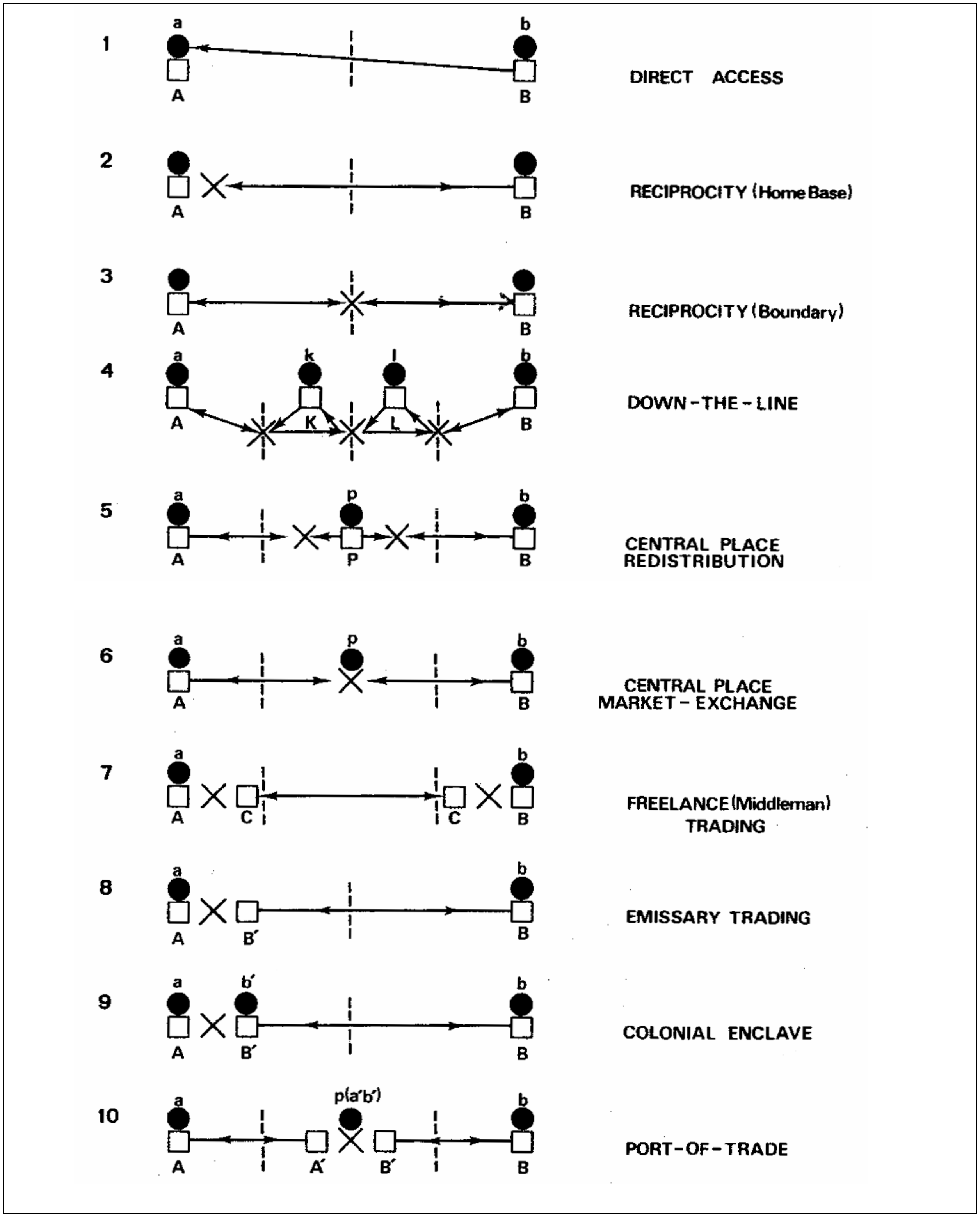


Figure 2.1 – Modes of exchange from Renfrew (1975:520) showing human agents as squares, commodities as circles, exchange as an X, and boundaries as a dashed line.

Nielsen uses network configurations to describe three main characteristics of interactions that resulted in the distribution of goods in the ancient Andes (2000:73-74): 1) *distance* over which the goods are transported; 2) *segmentary* networks, where each node is connected to a limited number of other nodes, versus *continuous* networks, where all nodes are connected to one another; 3) *convergent* versus *divergent* networks; in convergent networks the participants (and the goods being exchanged) tend to concentrate in a small number of central places. In this model, *continuous* networks may represent reciprocal exchange relationships that take the form of *down-the-line* trade, whereas exchange controlled by centralized institutions and market mechanisms will more likely result in *converging* networks at central places. However, as Robin Torrence (1986:5) argues, exchange is not directly observable in the archaeological record but rather requires interpretation of the evidence found in procurement, production, and consumption sites; the activity of exchange must be inferred from circumstances surrounding these actives. When non-local materials are encountered in archaeological research three main interpretations are offered as evidence of contact: 1) migration, 2) exchange/trade, 3) conquest by a non-local group. While differentiating these forms of contact, possibly with the exception of conquest, from archaeological data can be difficult, and a larger view of exchange in conjunction with a more holistic approach to material studies is required.

In a region, such as the Southern Caucasus, where exchange dynamics have not featured extensively in scholarly debate on prehistory movement of goods, particularly for the Neolithic period, some of these models can be used as heuristic devices in order to test the patterns of obsidian acquisition and distribution at a local level before the region can be incorporated into the larger theoretical discussions of inter-regional ancient economics and exchange.

2.2.3 Transfer of Goods and Exchange Value

In the 1980s the conversation emphasis shifted to consumption. In his influential paper titled "Commodities and the Politics of Value" (1986) Appadurai argued that anthropologists can more effectively examine cross-cultural patterns in economy and exchange by focusing on exchange from the perspective of consumption. He contended that the source of an object's value is based in its exchangeability and the desire of the consumer rather than the labor that went into the production of the object. Appadurai's focus on value that goods accrue through transfer constrains the analytical potential for looking at social and symbolic significance of human relationships structured around exchange. The shift in emphasis from individuals or communities exchanging goods to the relationship of value between objects (Appadurai 1986:12-17) deemphasizes the role of social relationships and thus obscures aspects of human behavior normally of interest to archaeologists.

A significant challenge to Appadurai's contention that "circulation creates value" is the observation that among the societies discussed by Mauss (1925) the value of the objects is associated with their original owners and not as the product of consumption. In other words, the value is not determined by demand, but rather it reflects the immutable properties of specific artifacts, such as family heirlooms, which are out of commercialized circulation.

2.2.4 Exchange and Social Distance

Malinowski (1922) describes a variety of exchange forms ranging from *pure gifts* to *trade* with an increasing focus on personal gain as one moves towards trade relations. In contrast, Mauss (1990 [1925]) rejects the notion of a *pure gift* and instead emphasizes gift-giving, what is effectively an ancient form of credit. He focuses on the social aspect of gift exchange with the idea that gifting may inflict obligations that the recipient may fear. Sahlins (1972:191) collapses the sociality of exchange relations into a single concept of "social distance." This distance is a way of thinking of the degree of familiarity between the producer and consumer of goods. Thus, social distance effects the form of reciprocity and, in turn, the type of reciprocity can reflect the nature of the social relationship. In his typology of reciprocity, Sahlins identifies *generalized*, *balanced*, and *negative reciprocity*, which form a continuum ranging from gift to exchange bartering, and theft. Each type of reciprocity entails different moral standards that are applied to transfers occurring at each level. The various modes of reciprocity are directly correlated to increasing social distance originating at the household level and spreading outward to kin groups, village, tribe, and so forth. Much like Polanyi, Sahlins envisaged more than one definition for exchange relationships, concluding that the kind of exchange relationship which could be found between two individuals or groups was determined by the nature of the relationship between them. Since exchange and reciprocity are *distinct* expressions of existing relationships between people, there are many possible definitions of exchange. But while Polanyi's redistribution and exchange model focuses on vertical exchange, Sahlins' model focuses on the horizontal axis, therefore, on the ways in which exchange differs with the degree to which people "related" themselves to one another.

Jonathon Ericson applies Sahlins' concept of a continuum of "social distance" to the reductive nature of lithic production systems. Ericson proposes that the degree of lithic reduction that occurs could be reduced as social distance increases because producers have less information about the consumer wants or needs for the final form of the material (Ericson 1984:6). For example, if the producer does not know if the desired final form of the product is a long sickle insert (which requires a large core) or a bifacial arrowhead, it would be best to leave the raw material in the form of a large nodule.

Many scholars have pointed out, that producers can be slow to respond to changing needs or desires of consumers in a given exchange network (Ericson 1984:6; Harding 1967; Rappaport 1967; Spence 1982), and the effects of social distance can influence patterns of production, consumption, and exchange. Since lithic reduction is a subtractive process, the final form an artifact can take is limited by the initial size and shape of the raw material. To countering this tendency, people can reduce risk in tool production by producing blanks closer to raw material source, where the value of the material and the cost of knapping errors or breakage, and inconsistent or poor-quality material is reduced. If the raw material, rather than the final product, is the commodity desired by the consumers, the material will be minimally altered and reduced to maximize distributive potential.

2.2.5 Everyday Goods and Luxury Goods

The distinction between the circulation of common and luxury goods observed by anthropologists can be considered in terms of the larger economy and the organization of technology. Hayden (1998) describes two types of technologies: *practical technologies* – those that are primarily organized around principles of sufficiency and effectiveness, and *prestige technologies* – those that are oriented towards social strategies where greater labor investment in products serves to communicate the wealth, success, and power of the parties involved. Appadurai's "common" and "luxury" goods can be placed within Hayden's framework of practical and prestige technologies. The concepts of practical, cultural, and prestige goods will be used to link long term changes in the organization of technology and production with consumption patterns and sociopolitical evolution.

The concepts of *practical* and *prestige technologies* parallel in some ways the economic distinction made by Earle (1987; 1994) between subsistence and political economies. According to Hayden's (1998) general description, *practical technologies* are largely organized on notions of effectiveness and sufficiency, whereas *prestige technology* uses social strategies to communicate wealth, therefore the success and power of the parties involved. Subsistence economy is primarily found at the household level and is based on sufficiency, while the political economy focuses on surpluses and competition between elites and is based on maximizing strategies between the actors. In the organization of technology Binford (1962) distinguishes three categories: "technomic," "sociotechnic," and "ideotechnic." For Binford, technomic objects correspond to "practical technology," and the sociotechnic and ideotechnic groups largely overlap with "prestige technologies." In his discussion of Australian Aboriginal string headbands, Hayden (1998:15) notes that labor inputs are low but sociotechnic significance is high in the headbands which signal adult status, whereas in a crucifix made out of a pair of twigs tied together labor is low but ideotechnic significance is high. Hayden points out that, in general, items imbued with ritual and social significance are often made with relatively costly materials, such as gold for crucifixes, at the same time he acknowledges that many items can fall between his categories, such as decorated antler digging-stick handles, and "the analysis of such objects becomes especially complex where the prestige materials such as metals or jade are actually more effective, but more costly, than more commonly used materials" (Hayden 1998:44-45).

Obsidian presents a similar challenge where, on the one hand, it is rare in many regions and yet it is also a more effective material for many activities requiring cutting or piercing; thus, determining the incentive for the use of the material is not straight-forward. Since an object can move between categories, its ultimately significance is not an inherent property, but rather it is ascribed by contexts of consumption and use and should best be considered in terms of labor, exchangeability or life-history (Appadurai 1986; Graeber 2001).

Hayden (1998: 44) argues that any material transported more than two-days' journey should be considered a *prestige technology* due to labor investment. However, he also notes that perhaps it might be useful to define an intermediate category of "cultural goods" consisting of non-prestige ritual or social artifacts. The inherent difficulty in developing a generalized framework for investigating exchange during prehistory is evident in the fact that many artifacts cannot easily be classified into one of the above categories in a particular time or cultural context. Obsidian is a prime example of a material that has practical value as it is generally the dominant raw material type used for making everyday tools, yet it is visually distinct, it does not occur in every region, and in certain contexts it is also a material imbued with cultural significance and prestige associations. Thus, while exchange studies have largely focused on prestige goods as markers of status, objects typically classified as subsistence goods or cultural goods may also contain social information. The association of an object to luxury or ordinary category is a function of geography, technology, and socially assigned values.

Monica L. Smith (1999) argues that nonlocal "ordinary goods" such as micaceous pottery and sandstone used by the Kaundinyapura in everyday household activities were transported through kin-based exchange networks and formed an important, material component of group identity. Smith argues that the movement and consumption of such ordinary but visibly distinct household goods are visual displays of identity and status and serve to maintain cultural ties with distant groups. She notes that in archaeological discussions of exchange it is often incorrectly imply that exchange networks were established by the elite largely for the trade of luxury goods and only eventually expanded to ordinary goods. M. L. Smith argues that the use of particular materials can have social significance and can convey information at different levels. Indeed, she argues that the cultural need for household items promoted the establishment and maintenance of trade networks long before the rise of state-level structures. Thus, the ability of kin-based exchange networks to distribute ordinary household items over long distances should not be underestimated.

Consumption patterns and imbued meanings of subsistence goods, cultural goods, and prestige goods can change with availability, demand, or changing cultural values, thus they are not nonexclusive categories. Many archaeologists note that close to the source of the raw material there is no distinction associated with the commodity as the item is abundant, whereas farther from the source, the possession of such commodities may acquire grater symbolic importance (Knapp 1990:161). According to this argument, as one moves closer to the source of a given material such that it becomes less scarce, one should observe a reduction in ritual or exclusive association for that material. In contexts of intensified craft production, availability may be determined by labor specialization, production units and intensity, context of production, and locus of control, (Costin 2000). The main determinant of availability of commodities based on raw materials is geographical distance from the source, although economic patterns, socio-political control, as well as technologies of procurement and transport all affect availability. One may expect to find behaviors associated with scarcity of raw materials, such as obsidian, which is often irregularly distributed across the landscape, with diminished availability as one moves farther away from the source of these materials. Thus, the availability of goods such as obsidian over an extensive consumption zone will vary depending on geographical relationships and socio-economic links between the source and the consumption zone with the goods being more abundant closer to the source and scare farther out.

As a material class, lithics are among the more ubiquitous and durable archaeological materials present in prehistoric sites; thus, they are often used as a proxy for mobility and exchange. A singular characteristic that sets obsidian apart from many other stone types is its unique ability to be traced back to a raw material source of origin. Unlike clays or metals, the chemical composition of obsidian cannot be altered through natural or anthropogenic forces, making it an ideal material for sourcing studies and investigations of exchange and movement of obsidian artifacts. At the same time, lithics are comparable to other artifacts of consumption such as ceramics in that lithics are used to produce a wide range of goods beginning with everyday utilitarian tools used and discarded at the household level to specialized forms, such as ceremonial knives, vessels, mirrors, or seals which imply that these objects were inscribed with social or ritual importance.

Archaeologists have used the spatial distances between lithic raw material sites where artifacts the lithics are discovered to study how the availability of a particular material type affect prehistoric behavior in terms of production, curation/reuse, and mobility (Bamforth 1986; Luedtke 1984; Shott 1996). The distance from source, procurement modes, and the embeddedness of lithics in a subsistence economy all have specific consequences with regard to raw material use in the vicinity of a source area (Binford 1979; Gould and Saggers 1985), an issue discussed in more detail below. The use of lithic raw materials, as with other artifact categories, regardless of the mode of transfer, is dependent on a number of variables, including is abundance or rarity, intensity of production, imbedded cultural or prestigious associations, as well as demand and circulation, although many of these variables can be difficult to isolate in archaeological contexts.

2.2.6 Territoriality and Access to Raw Material Sources

Access to particular sources dictates procurement, consumption, and distribution of a particular material, thus social distance may correspond directly with procurement and use patterns. Access to raw material sources and notions of territoriality vary widely across cultures, time, and space. Efforts and benefits associated with resource control are frequently considered in the context of specialized production. Investigating raw material access and territoriality in California, Ericson (1984) reviews evidence of multi-ethnic access to the Saint Helena obsidian source, which fell within the territory of the Wappo ethnic group, yet a number of groups living nearby were also able to acquire obsidian from Saint Helena. Bryan states that at some California obsidian quarries management was “tribal but related and nearby groups had the right to quarry either freely or on the payment of small gifts. Wars resulted from attempts by some distant tribes to use a quarry without payment. On the other hand, the Clear Lake obsidian quarries were neutral ground” (1950:34).

In Australia, Gould and colleagues (1971) observed that chert and chalcedony sources themselves were not controlled by any group. Material of good knapping quality is equally valued, and knapping is now assigned a great deal of importance. However, an important affiliation exists between a person and stone from the region in which they were born. Cherts from a person’s ancestral region are sometimes visually distinct and therefore materials of a particular region will be transported over long distances as a physical and symbolic link to the region of origin. Correlating archaeological evidence with social, political, or symbolic limitations on source use, in the absence of detectable boundaries or access restrictions, has proven to be one of the primary challenges for examining access to sources by a particular group. Unfortunately, in the absence of ethno-historic records to guide archaeological research, many social and symbolic limitations on quarry access leave no direct material correlates and thus are extremely difficult to detect archaeologically.

2.3 Discussion

Lying at the juncture of material goods and human behavior the study of ancient economies has long been a focal theme in archaeological research. Combining archaeological and economic anthropological approaches to prehistory allows us to examine processes such as change in social and political complexity, subsistence, as well as the exchange of objects. The theoretical goal of this project is to define the relationship between the obsidian economy (raw material acquisition, use, and distribution), and the broader regional and inter-regional exchange and social interaction in the Neolithic context of the Southern Caucasus and neighboring regions. Exchange in this context is more than merely the trade of goods. I feel that it is best conceptualized as:

> *…. primarily an economic behaviour that is intended to assure the supply of needed or valued commodities not accessible or produced by the groups being supplied. However, exchange is also a way of establishing and maintaining social relationships, whereby exchange networks can also be avenues for social exchange (experiences, values, beliefs. etc.) or tools of political relations. Therefore, the study of exchange dynamics is also an analysis of social interaction between communities (Ortega et. al. 2013:2).*

This definition goes beyond the mere exchange of commodities to the social interaction between communities. Such networks can act as conduits for exchange of technology, values, belief systems, for gaining access to exogenous marriage partners, as well as for acquiring resources not available locally. Thus, the study of exchange dynamics can help us understand social interactions and their consequences between communities engaged in such activities. While obsidian was "not necessarily the prime object of such contact," (Renfrew, et al. 1966:50) the presence of obsidian artifacts in regions lying outside of its natural occurrence zones is a proxy of a much larger set of social interactions. In some regions, such as the prehistoric Southern Caucasus, Polanyi's interaction types continue to be viable because there is little to no evidence of commercialization and open markets, particularly for the Neolithic and Chalcolithic periods.

The exchange issues reviewed above can be summarized in three main topics: 1) exchange value, 2) social distance, and 3) social and political consequences of exchange. Exchange from the perspective of commodity "exchangeability" and demand by consumers is a cross-culturally comparable and often detectable means of assessing value, but this approach depends on the goods being circulated. Some scholars have noted that some objects are valued precisely because they do not circulate and that the ability of an object to "accumulate history" is another means of establishing value. However, archaeologically, it is difficult to establish a measure for value. The continuum of social distance is a useful tool in that it captures the role of different behavior and institutions in exchange. Numerous archaeological and anthropological studies have shown that a dichotomy between "primitive" household exchange against a "modern" and commercialized realm is false. Virtually all exchange contexts contain elements of both social contracts and economic behavior. Exchange is a medium that brings people and goods together across different social boundaries. One of the frequently noted social consequences of regular exchange is its function to reinforce long-distance social ties over time, to buffer risk, and to express cohesiveness through common access to distant resources.

In summary, in recent decades, exchange studies have acquired a new technical rigor with advances in chemical characterization studies. While cultural, institutional, and theoretical ramifications of exchange remain complex, the demonstrable fact of sourcing studies offers invigorating certainty to the otherwise restrictive study of exchange.

CHAPTER 3: OBSIDIAN SOURCING STUDIES IN THE SOUTHERN CAUCASUS

"Dans l'étude des origines des métaux, le Caucase présente un intérêt tout spécial ; il est, vers l'Orient, le dernier point connu dans les sciences préhistoriques ; plus ancien que l'Europe et la Grèce, il renferme les vestiges de ces civilisations que les nôtres ont e ues pour berceau."
Jacques de Morgan, Tiflis, le 31 décembre 1888 (de Morgan 1917:iii)

3.1 Uses of Obsidian in the Southern Caucasus

In the Southern Caucasus, where obsidian sources are abundant, obsidian was used for making tools as early as the Paleolithic period. While during the early stages of the Lower Paleolithic inhabitants of the region preferred dacite or basalt, obsidian becomes widespread in all sites with the development of the Late Acheulian industry sometime around 140,000-100,000 BP, a transitional period between the Lower and Middle Paleolithic, (Gasparyan 2010). Located on or near obsidian outcrops, most of the identified sites represented specialized open-air workshops for blank production (Lubin 1965; 1978; Matyukhin 2001). Thus, in the Southern Caucasus obsidian has been utilized since at least 400,000 - 300,000 BP (Adler, et al. 2014). In this chapter I review previous obsidian artifact sourcing studies and discuss the state of obsidian sourcing research in the Southern Caucasus, covering the Paleolithic through the Iron Age period. I outline the scale of obsidian sourcing research in the region by presenting a detailed overview of existing research from the Paleolithic through the Iron Age. While most of the earlier studies (and even some later ones) lacked sufficient geological reference collection, thus impacting their findings and interpretations, this chapter presents the prior research in order to put the current dissertation within a larger obsidian sourcing framework and is not a critique of previous undertakings.

Though geological obsidian samples from the Southern Caucasus, particularly from Armenia, where included in the initial Near Eastern obsidian sourcing studies by Renfrew, Cann, and Dixon in the 1960s, the first obsidian artifacts from the region were analyzed only in the 1990s. Keller and colleagues sourced five artifacts from Neolithic-Chalcolithic levels at Aratashen, which they obtained from M.-C. Cauvin. The types of artifacts and their contexts (surface collection, excavated finds, museum collection, etc.) are not specified in the publication. Based on the trace elements Rb, Sr, Ba, Zr, and Nb obtained with XRF and INAA Keller and colleagues attributed four of the five artifacts to Gutanasar and Arteni (Keller, et al. 1996). The authors did not identify how many of the four artifacts were assigned to each source. The fifth artifact was not assigned to any source analyzed in the study. As the main purpose of the study was the chemical characterization of Armenian and Caucasian obsidian sources, the analyzed artifacts were not given much attention and did not feature prominently in the discussions of their results.

One of the first and few systematic geological obsidian studies in the region was carried out by Blackman and colleagues. Using INAA, they analyzed nearly 700 obsidian artifacts at the Smithsonian Institution, 576 of which were from 53 different archaeological sites from the Caucasus region. One hundred and eighteen (118) geological samples coming from the Caucasus and a single Eastern Turkish[1] source (Doğubayazıt) were used for reference. They report that 510 (ca. 89%) of the obsidian artifacts analyzed can be attributed to one of the Caucasian obsidian sources identified in the study and only seven were assigned to a single Eastern Turkish source, and finally three artifacts were assigned to Renfrew's Group 3a (Blackman, et al. 1998). Out of the 59 unassigned artifacts they assign 54 to six distinct groups called TCUNK 1-6

[1] While the modern political boarders are commonly used in reference to obsidian source locations, the modern-day Eastern Turkey is geophysically part of the Armenian Highland, a geographical region defined by a range of discontinuous mountains including the Lesser Caucasus in the east and bordering the Anatolian plateau in the west. Thus, the obsidian sources and the Neolithic groups which utilized them belong to the same oikoumené.

(Transcaucasian[2] Unknown) based on their compositional groupings. The remaining four unassigned artifacts go unmentioned. Much like in Keller et al.'s publication above, Blackman et al. discuss their findings only as general trends of obsidian source utilization in the region without specific temporal or archaeological site references. Thus, it is impossible to ascertain from Keller et al.'s publication how many of the analyzed artifacts come from Neolithic sites. The obsidian artifacts analyzed by James Blackman are used again by Badalyan, Chataigner, and Kohl (2004a) in a synthesizing article on Southern Caucasus obsidian source utilization and distribution. In the latter article, Badalyan et al. present the results by enumerating how many artifacts from the total 576 were attributed to each source and how many to each archaeological site in particular. I compiled a list of sites, number of artifacts per site, and a list of artifact attribution by source, which is presented in Table 3.1. Thus, out of the 53 sites represented in Badalyan et al.'s study, 28 sites are in Armenia, 16 sites in Georgia, 7 sites in Azerbaijan, and 2 sites in Dagestan. The temporal period covered by these sites is from the Neolithic through the Iron Age.

Nearly half a century has passed since obsidian samples originating from the Southern Caucasus were incorporated into Near Eastern obsidian studies by the seminal work of Renfrew, Cann, and Dixon, yet still obsidian sourcing research in the Southern Caucasus lags behind that in Anatolia and the Mediterranean. For example, in a paper titled "Obsidian in the Southern Caucasus: The use of raw materials in the Neolithic to Early Iron Ages" (Badalyan 2010), the entire Neolithic period is represented by only 151 artifacts from five Neolithic-Chalcolithic sites in Armenia when tens of thousands of obsidian artifacts have been recovered from each of these

[2] "Transcaucasus" or "Transcaucasia" is the Latinized rendering of the Russian word "Zakavkaz'ye" (Закавказье), which translates to "the area beyond the Caucasus [Mountains]". I prefer the term Southern Caucasus, which is a geographically defined region and does not present the region from a Russo-centric point of view.

sites (Aratashen ~20,000, Aknashen-Khatunarkh ~60,000, and Masis Blur ~ 12,000 to date). This number is even smaller when we consider that the Neolithic date for three (Mashtoc Blur, Adablur, and Artashat) out of the five sites is highly suspect. Therefore, out of 151 artifacts only 96 artifacts, those from Aratashen (n=67) and Masis Blur (n=29), can be securely attributed to the Neolithic period. The present research increases this count by nearly 600 percent, and the sum of analyzed artifacts from post-Paleolithic Southern Caucasus sites by 300 percent. Most importantly, my analyses were non-destructive, which is essential if we hope to continue sourcing work on any significant scale.

Obsidian artifacts from various Paleolithic sites in the Southern Caucasus were incorporated into obsidian sourcing studies only in the past decade, but while they are more recent they surpass obsidian research for other periods both in the quantity of artifacts analyzed and in the quality of research (for examples see all publications by Frahm and colleagues referenced throughout the present text). Nearly 3400 obsidian artifacts have been analyzed from just six Paleolithic sites in the Southern Caucasus, of these 4 sites are in Armenia and 2 in Georgia. At the time of this research, no Paleolithic obsidian artifacts have been analyzed from sites in Azerbaijan. In contrast, while artifacts from Neolithic through Iron Age sites became a focus of sourcing research in the early 1990s, as it was believed that these could answer questions about the spread of agriculture and the origin of Neolithic communities in the Southern Caucasus, the number of artifacts analyzed is negligible.

The number of sourced obsidian artifacts from the Neolithic and Chalcolithic period is difficult to determine. As I discuss in Chapter 4, several factors, including issues of nomenclature and lack of systematically excavated and well dated sites, complicate a straight-forward synthesis of obsidian sourcing studies for these periods. Most site attributions to the

Neolithic and Chalcolithic have been based on surface finds lacking secure contexts and radiocarbon dates. Due to the sparsity of systematically excavations and material studies, many sites in the Southern Caucasus were attributed to a generic Neolithic-Chalcolithic period and their precise dates remain debatable. Moreover, while the number of obsidian sourcing studies for post-Paleolithic sites is greater, the publications are less complete and the datasets not well defined. To complicate the matters further, analyzed datasets, either whole or in part, have been used by various scholars in review articles (e.g. Badalyan 2010) or to conduct related research (e.g. Chataigner and Gratuze 2014a and 2014b) without explicit identification. The specifics of the dataset are often left out, so that it is unclear how many artifacts from a given site were used or if analyzed artifacts from a given site mentioned in multiple articles are indeed the same or different. To cite just two examples, I briefly summarize the work of Badalyan et al. published in two separate articles synthesizing their obsidian sourcing research from the Neolithic settlements Aratashen and Aknashen-Khatunarkh. In a 2004 article (Badalyan, et al. 2004b:408) the authors note that 24 obsidian artifacts have been analyzed from Aratashen, in their 2007 article the number of analyzed obsidian artifacts is 69 (Badalyan, et al. 2007:43), and in Badalyan's 2010 article this number is at 67 (Badalyan 2010:28). What is not clarified in the latter publication is if the 69 artifacts discussed are in addition to or include the 24 artifacts published previously. Are the 67 artifacts presented in Badalyan's 2010 article different from the 69 articles discussed in Badalyan et al. 2007? Even if we assume that in the 2010 publication Badalyan is using 67 out of the 69 artifacts discussed in the 2007 publication, the total number of obsidian artifacts analyzed from Aratashen is still either 69 or 93. Likewise, various numbers are presented for artifacts analyzed from Aknashen-Khatunarkh without a clear delineation of the datasets: 5 artifacts in Keller, et al. (1996, 23 artifacts in Badalyan, et al. (2004a, 69 artifacts in Badalyan, et al. (2007, and 30 artifacts in Chataigner and Gratuze (2014b. In other cases, artifacts were assigned to a very vague “source”, such as “Armenia” or “Erevan,” based on composition similarities more to one source than another. These uncertainties are largely a result of a very small and incomplete geological reference collections, which were used in initial sourcing research. In the present work, every effort was made to avoid “double counting” artifacts when compiling the list of obsidian artifacts sourced for post-Paleolithic sites and wherever it was not possible to ascertain this it is clearly stated.

3.1.1 Sourced Artifacts from the Paleolithic

In the recent years, obsidian sourcing research in the Southern Caucasus has seen a significant increase in number of artifacts analyzed as a result of a collaborative Armenian-American Paleolithic research project headed by Daniel S. Adler. However, this research is highly skewed towards data from Armenia and even within Armenia, the majority of obsidian artifacts analyzed come from a single Paleolithic site. Out of the hundreds of Paleolithic sites recorded in the Southern Caucasus, only five have been included in obsidian sourcing research. The following list highlights the uneven representation of sourced obsidian from various Paleolithic sites. The Lower Paleolithic is represented by a single site, Nor Geghi 1 (Armenia) n=316; the Middle Paleolithic by two sites: Lusakert 1 (Armenia), n=1401; and Ortvale Klade (Georgia), n=5; and the Upper Paleolithic by four sites: Kalavan 1 (Armenia), n=18; Aghitu-3 (Armenia), n=1121; Bondi Cave (Georgia), n=5; Ortvale Klade (Georgia), n=2. Most recently, Biagi, et al. (2017 analyzed surface finds collected from Paleolithic open-air workshops near the Chikiani obsidian source, however the number of artifacts, as well as to which phase of the Paleolithic they date to, was left out of the publication. No published data is available for Paleolithic sites in Azerbaijan.

The Lower Paleolithic period is represented by 316 analyzed artifacts from Nor Geghi 1 open-air site (ca. 325 ka) in Armenia. The lithic assemblage based on Levallois technology is produced entirely on obsidian. The results show that over 94 percent of the artifacts come from the Gutanasar volcanic complex located around 5 km from the site, while a small number of artifacts can be assigned to a source located 120 km southeast of the site (Adler, et al. 2014).

The most number of analyzed obsidian artifacts date to the Middle Paleolithic, with the Lusakert 1 cave site contributing 99.6 percent of this dataset. In 2011, Frahm analyzed 1401 obsidian artifacts from Lusakert 1 cave site in Armenia. Much like at Nor Geghi 1, the lithic assemblage of Lusakert 1 is also comprised solely of obsidian. Using a portable XRF he was able to attribute over 90 percent of the analyzed artifacts to the Gutanasar flows (Frahm, et al. 2014). In contrast, only five artifacts have been analyzed from the Ortvale Klade site in Georgia and assigned to the Chikiani/Paravani flows of southern Georgia (Le Bourdonnec, et al. 2012).

Until very recently, the Upper Paleolithic period was represented by mere 24 analyzed artifacts of which 18 artifacts come from the Kalavan 1 site in Armenia, 4 artifacts from Bondi Cave and 2 artifacts from the Ortvale Klade cave located in northern Georgia. Kandel, et al. (2017 published the results of pXRF analyzes of 1124 obsidian artifacts from the Upper Paleolithic site of Aghitu-3 in Armenia. Their research significantly increased the number of sourced obsidian artifacts from the Upper Paleolithic of the Southern Caucasus, though as noted above the data are heavily reliant on Armenian sites. Aghitu-3 is a cave site located in the Syunik province of Armenia with occupation phases dating between 39,000 and 24,000 cal. BP. Similar to Armenian Lower and Middle Paleolithic sites mentioned above, at 84 percent, the lithic industry is predominantly obsidian with chert representing the second largest raw material type (Kandel, et al. 2017:43). The results of pXRF analysis show that the Syunik sources were the dominant raw material sources for the inhabitants of Aghitu-3, representing 92 percent of the analyzed assemblage, although artifacts from six other Armenian sources were also present in the assemblage (Kandel, et al. 2017:48). Kalavan 1 is located on the northern edge of Lake Sevan and has been dated to the 15th millennium BC. The lithic industry of Kalavan 1 is dominated by obsidian. In contrast, the two Georgian sites yielded an insignificant number of obsidian artifacts, each having a few dozen examples out of the thousands of lithic materials excavated. The results of the LA-ICP-MS analysis of 18 artifacts from Kalavan 1 show that the inhabitants of the site utilized 3 to 4 distinct sources located west and south-east of Lake Sevan, each source 3-4 days walk from the site (Chataigner and Gratuze 2014b). The artifacts from Bondi Cave and Ortvale Klade were analyzed using PIXE. Le Bourdonnec and colleagues note that the artifacts are represented by four distinct compositional groups, however, they were able to match only one of these groups to a geological source. The results show that one group, represented by two artifacts from Bondi Cave and two from Ortvale Klade, matches the geochemical composition of obsidian from Chikiani/Paravani flows (Le Bourdonnec, et al. 2012). Located some 170 km from the sites, Chikiani/Paravani seems to be the dominant raw material source utilized by the Upper Paleolithic inhabitants of these caves, however the sample size is too small to make any conclusive inferences.

3.1.2 Sourced Artifacts from the Mesolithic/Epipaleolithic

The Kmlo-2 rock shelter is the only securely dated Mesolithic site in the Southern Caucasus from which obsidian artifacts have been subjected to provenience. The blade-oriented lithic industry is predominantly obsidian and includes a high proportion of microliths, as well as artifacts with abrupt parallel and regular retouch known as ‘Kmlo tools’(Chataigner, et al. 2007). The analysis of 20 ‘Kmlo tools’ revealed that a number of sources were utilized with 50 percent of the samples matching the composition of Gutanasar (Chataigner and Gratuze 2014b).

Chataigner et al. analyzed an unspecified number of artifacts using a fission-track (FT) dating method from five sites in Armenia, which they ascribe to the Mesolithic/Neolithic period (Chataigner, et al. 2003). These sites are Akhourian 10a, Argishtikhinili E, Djoghaz 2, Kuchak1, and Sisian I 11c. They determined that FT is a viable method of discrimination of different source areas located in Armenia and Georgia. The number of artifacts from each site, their contextual information, and precise dating of the sites is not provided in the article.

3.1.3 Sourced Artifacts from the Neolithic and Chalcolithic

Before the present study, only around 389 artifacts had been analyzed from 24 Southern Caucasus Neolithic-Chalcolithic sites, spanning a 4,500-year period from about 8000 BCE to 3500 BCE. The analyses were conducted using NAA/INAA, XRF, and LA-IC-PMS and each site was represented by 6 to 69 artifacts (Table 2.1). The blade production oriented chipped stone assemblages of most Neolithic-Chalcolithic sites are predominantly of obsidian. The samples were analyzed in the late 1990s and early 2000s by J. Blackman (National Institute of Standards and Technology in Maryland, USA), J. Keller (Mineralogisch-Petrographisches Institut der Universität Freiburg, Germany), Palmieri and colleagues (University of Pavia, Italy), J. Keller (Mineralogisch-Petrographisches Institute der Universität Freiburg, BRD), E. Pernicka (Max-Plank Institute fur Kernphysik, Heidelberg, BRD), and G. Bigazzi (Instituto di Geochronologia e Geochimica Isotopica, CNR, Pisa, Italy). However, the results were either unpublished or only partially published by the researchers, and synthesis or summaries of their work was presented by Badalyan (2010) and Badalyan and colleagues (Badalyan, et al. 2002; Badalyan, et al. 2004a; Badalyan, et al. 2004b; Badalyan, et al. 2010; Badalyan, et al. 2007) in a number of publications.

Only seven out of the 24 sites can be securely dated to the Neolithic period, with a few sites, such as Aratashen and Aratashen, having ephemeral Chalcolithic occupation. Three out the

7 sites are located in Armenia (Aratashen, Aknashen-Khatunarkh, and Masis Blur) and four sites in Georgia (Anaseuli I, Arukhlo I, Dmanisi, and Khramis Didi gora). These sites are represented by 176 analyzed obsidian artifacts. The sites Anaseuli II and Kobuleti, which have a similar material culture to that of Anaseuli I, most likely also date to the Neolithic period, although radiocarbon dates are not yet available for these sites. If their Neolithic dates are confirmed then 12 more sourced obsidian artifacts, 8 from Anaseuli II and 4 from Kobuleti, can be added to the 176 analyzed artifacts.

Sixty-nine artifacts from Aratashen were sourced to Arteni (n=44), Gutanasar (n=14), Geghasar (n=3), Akhurian (n=4), Group 3a (n=1), and one artifact was not assigned to any source analyzed in the study. Fifty artifacts analyzed from Aknashen-Khatunarkh were assigned to 10 different chemical groups with three sources – Arteni, Gutanasar, and Hatis - providing 86 percent of the raw material (Badalyan, et al. 2010:194). The other raw material sources include obsidian flows of Geghasar, Kars-Akhuryan deposits, TCUNK-3 and three artifacts were unassigned. Twenty-nine artifacts analyzed from Masis Blur were attributed to six different sources, including Arteni (n=21), Gutanasar (n=3), Hatis (n=2), Geghasar (n=1), TCUNK-1 (n=1), and Kelbajar-2 (n=1) (Badalyan 2010). According to the results of these 29 artifacts, the inhabitants of Masis Blur used Arteni as the main source of raw material (over 72%) for their obsidian tools. However, the current study (discussed in detail in Chapter 6), based on the analysis of 854 artifacts from Masis Blur, shows that the raw material procurement at Masis Blur was far more complicated than indicated by Badalyan's initial results. In Georgia, Neolithic sites are represented by a mere 26 artifacts: Dmanisi and Khramis Didi gora are represented by 8 artifacts each, and Arukhlo I (also spelled as Aruchlo) and Anaseuli I by 6 artifacts each. Unlike the Neolithic settlements in Armenia, most Georgian sites utilized a single obsidian source. All artifacts from Arukhlo I, Anaseuli I, Kobuleti, and Dmanisi come from Chikiani in Georgia. In contrast, the 8 artifacts analyzed from Khramis Didi gora and 8 artifacts from Anaseuli II come from 5 different sources. These sources include Chikiani, Geghasar, Bayazet, TCUNK-2, and an unidentified source represented by a single artifact from each site (Badalyan, et al. 2004a).

Two-hundred and ten obsidian artifacts have been analyzed from 19 Neolithic-Chalcolithic and Chalcolithic sites of the Southern Caucasus. Four sites represented by 96 artifacts are located in Armenia, 8 sites represented by 82 artifacts are located in Azerbaijan, and 3 sites represented by 20 artifacts are located in Georgia. With the exception of site KP408 (Azerbaijan), according to published data all the sites in this group utilized between 2 to 4 different obsidian sources (Badalyan, et al. 2004a; Badalyan 2010; Cherry, et al. 2010). The artifacts from Adablur were sourced to Arteni (n=15), Gutanasar (n=2), Geghasar (n=2), TUUNK-3 (n=1), and Bayazet (n=1). Artifacts from Mashtoc Blur were attributed to Arteni (n=16), Gutanasar (n=2), Geghasar (n=2), and TCUNK-3 (n=1). Artifacts from Artashat were attributed to Gutanasar (n=7), Hatis (n=5), and Damlik (n=1). Obsidian artifacts from Kül Tepe, Leila Tepesi, Alikemek Tepesi, Chinar, Chalagan Tepe, and Uchoglan sites in Azerbaijan were ascribed to Arteni, Hatis, Geghasar, Sevkar/Satanakar, Kelbajar, Chikiani, and TCUNK-5. Artifacts from Georgian sites of Anaseuli II, Naomari gora, Khramis Didi gora, and Tsiteli Gorebi were sourced to Chikiani, Geghasar, Damlik, Bayazet, TCUNK-2, TCUNK-4, and 2 were unassigned. In contrast, all artifacts analyzed form Arukhlo I, Dmanisi, Berikldebi, Tsikhia-gora, Anaseuli I and Kobuleti in Georgia were sourced to Chikiani, diverging from the multi-source use pattern of all other analyzed sites in the Southern Caucasus. The emerging pattern, although based on only a handful of artifacts from each site, indicates that most Neolithic and Chalcolithic communities of the Southern Caucasus were procuring obsidian from multiple raw material sources located at varying distances from the site even when the nearest source could provide the settlement with high quality obsidian.

3.1.4 Sourced Artifacts from the Bronze Age and Iron Age

The number of sourced obsidian artifacts from Bronze Age sites in the Southern Caucasus and the number of sites used in these studies parallels those from the Neolithic period. In total, 328 obsidian artifacts representing 27 sites have been included in various sourcing studies for the region. Twenty-two of the 27 sites are located in Armenia, 4 in Georgia, and 1 in Azerbaijan. Most artifacts come from either single period Early Bronze Age (EBA) sites or the EBA layers of multi-period sites (e.g. Dvin and Keti). Badalyan et al. reported on the analyses of 270 artifacts from 21 sites (Badalyan, et al. 2004a), while 1 artifact from Kamakar and 1 from Lusaghbyur were analyzed by Chataigner et al. (Chataigner and Gratuze 2014b; Chataigner, et al. 2014). The EBA sites, represented by 272 analyzed obsidian artifacts, are as follows: Anushavan (n=10), Armavir (n=8), Aygevan (n=17), Dvin (n=15), Harich (n=10), Hormom (n=24), Joghaz (n=1), Jrahovit (n=24), Kamakar (n=10), Karnut (n=35), Keti (n=18), Lusaghbyur (n=1), Metsamor (n=9), Mokhrablur (n=15), Shirakavan (n=10), and Verin Naver (n=20) in Armenia; Akhali Zhinvali (n=7), Berikledebi (n=14), Naomari-gora (n=16), and Tsikhia-gora (n=8) in Georgia. The tree Middle Bronze Age (MBA) sites, represented by 58 artifacts, and the three Late Bronze Age (LBA) sites, represented by 44 artifacts, from which obsidian artifacts were analyzed, are located in Armenia. The MBA sites are: Berdashen (n=17), Lori berd (n=5), and Shaghat 1 (n=22). And the LBA sites are: Gegharot (n=8), Hnaberd (n=unspecified), and Nor Getashen (n=2). Finally, Gratuze (2007) analyzed 2 obsidian artifacts using LA-IC-PMS from the site of KP316 in Azerbaijan, which was discovered during a survey and dated to the Bronze Age based on surface materials. With the exception of Berikldebi and Tsikhia-gora, all the Bronze Age sites procured artifacts attributed to multiple obsidian sources located at various distances from the sites.

In contrast, Iron Age (IA) sites are very poorly represented in obsidian sourcing studies from the Southern Caucasus. This is in part due to the diminishing importance and presence of obsidian in IA sites. In sum, 47 artifacts were analyzed from 5 sites in Armenia. Badalyan et al. analyzed 34 artifacts from Nerkin Getashen, Noratus, and Tsaghkahovit in Armenia (2004a). Additionally, 12 artifacts from Aghitu and 14 from the IA layers of Shaghat 1, both in Armenia, were analyzed by Cherry et al. (2010). Badalyan et al. sourced 9 artifacts from Nerkin Getashen to Geghasar and 1 to Gutanasar; the ten Noratus artifacts were all sourced to Geghasar, and Tsaghkahovit artifacts were sourced to Damlik/Ttvakar (Badalyan, et al. 2004a). The artifacts of Shaghat 1 were sourced to Sevkar (Cherry, et al. 2010:157). These artifacts, to the best of my knowledge, are the only sourced obsidian artifacts from the Southern Caucasus sites.

3.2 South Caucasian Obsidian in Mesopotamia and Levant

The Neolithic Revolution, especially the origin and spread of agriculture, has always been a topic of considerable interest in Old World archeology. Thus, the advent of obsidian sourcing research quickly gained prominence among scholars of the Near East, as they hoped that the distribution of obsidian across the Near East may reflect the spread of agriculture in the region. The appearance of obsidian in Neolithic settlements located far outside of the raw material sources showed that these settlements were not isolated, as was believed at the time, and suggested that, along with obsidian, ideas, such as agriculture, could have moved along the same communication networks. Soon, as proposed by James Mellaart and supported by others, large Neolithic villages as Çatal Höyük were seen as obsidian trading centers. The existing interest in the rise of agriculture and interactions of human groups during the transition from nomadism to sedentary agricultural communities and the interconnectedness of these communities, which could be explored through obsidian, made obsidian sourcing research popular.

Even prior to the development of obsidian sourcing research, as early as the 1880s, Jacques Jean de Morgan, a French mining geologist turned archaeologist, surveyed obsidian outcrops in Armenia and eastern Turkey, visually inspecting them for differences. Comparing Armenian obsidian to Mexican, he noted that Armenian obsidian is more transparent and sharper than that of Crete, making it better in quality and characteristics (de Morgan 1917:31). He later asserted that it is more likely that obsidian artifacts uncovered in Iran and Mesopotamia came from Armenian and Turkish sources and arrived there via exchange (de Morgan 1927). However, sourcing research of obsidian artifacts from Mesopotamian and Levantine sites shows that obsidian originating from Southern Caucasus sources is very rare in lithic assemblages of the Near East. Below is a summary of all published obsidian studies that attribute artifacts to sources in the Southern Caucasus.

Table 3.2 presents the list of obsidian artifacts discovered in Near Eastern sites and attributed to South Caucasian sources. Fornaseri, et al. (1975) analyzed 38 obsidian artifacts from the Late Chalcolithic strata of Arslantepe in Turkey and attributed 17 of these either to a "Erevan" source in Armenia or Ziyaret (another name for Meydan Dağ) in Eastern Turkey. From Tal-i Malyan in southern Iran, Blackman (1984) analyzed 44 Bronze Age artifacts, attributing two artifacts to "Lake Sevan" source in Armenia. In a later study, Blackman et al. (1998) matched nearly 30 percent, or 13 artifacts, of the analyzed artifacts from Tal-i Malyan to three sources in Armenia: Gutanasar, Pokr Arteni, and Sevkar/Satanakar. Blackman also analyzed a "small sample" of Late Chalcolithic obsidian artifacts form Hacınebi Tepe in southeast Turkey with some of the artifacts attributed to Gutanasar in Armenia (in Edens 1999). Francaviglia and

Palmierie (1998) sourced 50 obsidian artifacts dating to the Late Neolithic period from four archaeological sites in Syria. At Tell Barri, two artifacts are ascribed to “Armenia” and at Tell Halaf and Tell Brak one artifact each. It is unclear specifically to which source in Armenia the artifacts were attributed. Healey (2007) reported that obsidian from Arteni was identified among some of the artifacts analyzed from Neolithic Domuztepe in Turkey. Ghorabi, et al. (2010 sourced 53 obsidian artifacts from the Chalcolithic through the Iron Age layers of Kül Tepe in Iran, attributing 46 of these to sources in Armenia (Syunik/Sevkar, Bazenk, Geghama, Khorapor, and Gutanasar) (also inKhazaee, et al. 2011; Nadooshan, et al. 2013). Finally, Biagi et al. (2014) analyzed 6 Neolithic obsidian blade fragments from Lysa Gora in Ukraine. They attributed four of these artifacts to the Syunik sources of Armenia (Sjunik[3] 3, Mets Sevkar, and Pokr Sevkar). If the attribution of these artifacts to one or another Armenian source is correct, then 84 artifacts out of the thousands analyzed come from Southern Caucasus sources. However, I must note that the attribution of some of these artifacts, such as those attributed to “Erevan” by Fornaseri et al. (1975) and artifacts attributed to “Erevan” by Francaviglia and Palmierie (1998) to Armenian sources has been questioned by Frahm, et al. (2016). A more through and nuanced characterization of Armenian sources in recent years has allowed Frahm et al. to evaluate the published data and reattribute some of the artifacts to obsidian sources in Eastern Turkey. Thus, the total number of Near Eastern artifacts which can be securely attributed to Armenian obsidian sources is notably smaller.

[3] In publications by French scholars Syunik is spelled as “Sjunik.”

3.3 Summary

In this chapter I presented the current state of obsidian sourcing research in the Southern Caucasus, while discussing its beginnings, progress, and current issues. Decades after the initial obsidian sourcing research undertaken by Renfrew, Cann, and Dixon, the obsidian distribution maps for the Southern Caucasus are still represented by only a handful and at times as few as a single artifact. As a result, the Neolithic through the Iron Age periods, a 10,000-year-long period, is represented by less than 1200 analyzed artifacts from 74 sites. On a regional scale, this is an insignificant number. Even if we add to these the sourced artifacts from Mesopotamia and the Levant, this number is still under 3000. In comparison, a regional-scale study in the New World done in the 1990s included over 9000 obsidian artifacts from only 130 sites in Oregon, California, and Idaho (Skinner 1995). Altogether, some 100,000 obsidian artifacts have been analyzed thus far from the New World (Frahm 2012b). In the Southern Caucasus, a region replete with easily accessible, high quality obsidian sources and lithic assemblages predominantly of obsidian, a far more rigorous program of obsidian sourcing must be undertaken. More obsidian data are needed, particularly statistically significant numbers of sourced artifacts from major prehistoric sites, if we hope to use these data to investigate larger socio-economic questions trough insight on human mobility, resource procurement and management, exchange, and interactions within and between communities.

Period	***Country***	***Site***	***Reference***	***No.***
Neolithic	Armenia	Aknashen-Khatunarkh	Badalyan et al. 2010	50
Neolithic	Armenia	Aratashen	Keller et al. 1996	5
			Badalyan et al. 2004	2469
			Badalyan et al. 2007	67
			Badalyan 2010	30
			Chataigner & Gratuze 2014	30
Neolithic	Armenia	Masis Blur	Badalyan et al. 2004	29
Neolithic	Azerbaijan	Arukhlo I	Badalyan et al. 2004	6
Neolithic	Georgia	Anaseuli I	Badalyan et al. 2004	6
		Anaseuli II	Badalyan et al. 2004	8
Neolithic	Georgia	Dmanisi	Badalyan et al. 2004	8
Neolithic	Georgia	Khramis Didi gora	Badalyan et al. 2004	8
Neolithic	Georgia	Kobuleti	Badalyan et al. 2004	4
Neolithic-Chalcolithic	Armenia	Artashat	Badalyan et al. 2004	13
Neolithic-Chalcolithic	Azerbaijan	Kül Tepe	Badalyan et al. 2004	13
Neolithic-Chalcolithic	Azerbaijan	Leila Tepesi	Badalyan et al. 2004	16
Chalcolithic	Armenia	Adablur	Badalyan et al. 2004	19
Chalcolithic	Armenia	Godedzor	Cherry et al. 2010	22
			Chataigner & Gratuze 2014	21
Chalcolithic	Armenia	Mashtoc Blur	Badalyan 2010	21
Chalcolithic	Azerbaijan	Alikemek Tepesi	Badalyan et al. 2004	7
Chalcolithic	Azerbaijan	Chalagan Tepe	Badalyan et al. 2004	6
Chalcolithic	Azerbaijan	Chinar	Badalyan et al. 2004	1
Chalcolithic	Azerbaijan	KP408	Gratuze 2007	9
Chalcolithic	Azerbaijan	Uchoglan	Badalyan et al. 2004	13
Chalcolithic	Azerbaijan	Unnamed	Badalyan et al. 2004	6
Chalcolithic	Georgia	Tsiteli Gorebi	Badalyan et al. 2004	7
Chalcolithic	Georgia	Samele-Kldé	Badalyan et al. 2004	6
Chalcolithic-Bronze Age	Azerbaijan	KP361	Badalyan et al. 2004	11
Chalcolithic-Bronze Age	Georgia	Zhinvali	Badalyan et al. 2004	7
			Sum	*389(415?)*
Bronze Age	Azerbaijan	KP316	Gratuze 2007	2
Early Bronze Age	Armenia	Anushavan	Badalyan et al. 2004	10
Early Bronze Age	Armenia	Armavir	Badalyan et al. 2004	8
Early Bronze Age	Armenia	Aygevan	Badalyan et al. 2004	17
Early Bronze Age	Armenia	Dvin	Badalyan et al. 2004	15
Early Bronze Age	Armenia	Harich	Badalyan et al. 2004	10
Early Bronze Age	Armenia	Horom	Badalyan et al. 2004	24
Early Bronze Age	Armenia	Joghaz	Badalyan et al. 2004	1
Early Bronze Age	Armenia	Jrahovit	Badalyan et al. 2004	24
Early Bronze Age	Armenia	Kamakar	Chataigner et al. 2013	10
Early Bronze Age	Armenia	Karnut	Badalyan et al. 2004	35
Early Bronze Age	Armenia	Keti	Badalyan et al. 2004	18
Early Bronze Age	Armenia	Lusaghbyur	Chataigner & Gratuze 2014	1

Early Bronze Age	Armenia	Metsamor	Badalyan et al. 2004	9
Early Bronze Age	Armenia	Mokhrablur	Badalyan et al. 2004	15
Early Bronze Age	Armenia	Shirakavan	Badalyan et al. 2004	10
Early Bronze Age	Armenia	Verin Naver	Badalyan et al. 2004	20
Early Bronze Age	Georgia	Akhali Zhinvali	Badalyan et al. 2004	7
Early Bronze Age	Georgia	Berekldebi	Badalyan et al. 2004	14
Early Bronze Age	Georgia	Naomari Gora	Badalyan et al. 2004	16
Early Bronze Age	Georgia	Tsikhia-gora	Badalyan et al. 2004	8
Middle Bronze Age	Armenia	Berdashen	Badalyan et al. 2004	17
Middle Bronze Age	Armenia	Lori berd	Badalyan et al. 2004	5
Middle Bronze Age	Armenia	Shaghat 1	Cherry et al. 2010	22
Late Bronze Age	Armenia	Ghegharot	Chataigner & Gratuze 2014	8
Late Bronze Age	Armenia	Hnaberd	Chataigner & Gratuze 2014	ND
Late Bronze Age	Armenia	Nor Getashen	Chataigner & Gratuze 2014	2
			Sum	324
Iron Age	Armenia	Aghidu	Cherry et al. 2010	12
Iron Age	Armenia	Nerkin Getashen	Badalyan et al. 2004	10
Iron Age	Armenia	Noratus	Badalyan et al. 2004	10
Iron Age	Armenia	Shaghat 1	Cherry et al. 2010	14
Iron Age	Armenia	Tsaghkahovit	Badalyan et al. 2004	1
			Sum	47

Table 3.1 – Previously Sourced Neolithic to Iron Age Artifacts from the Southern Caucasus.

Period	*Country*	*Site*	*Reference*	*No.*
Neolithic	Syria	Tell Barri	Francaviglia and Palmierie 1998	2
Neolithic	Syria	Tell Brak	Francaviglia and Palmierie 1998	1
Neolithic	Syria	Tell Halaf	Francaviglia and Palmierie 1998	
Neolithic	Turkey	Domuztepe	Healey 2007	ND
Neolithic	Ukraine	Lysa Gora	Biagi et al. 2014	4
Chalcolithic	Iran	Kül Tepe	Ghorabi et al. 2010	46
Chalcolithic	Turkey	Arslantepe	Fornaseri et al. 1975	17
Bronze Age	Iran	Tal-i Malyan	Blackman et al. 1998	13
			Sum	*83*

Table 3.2 Near Eastern Obsidian Artifacts attributed to sources in Southern Caucasus (all artifacts were attributed to one of the Armenian sources). Note that some of these attributions have been questioned.

CHAPTER 4: REGIONAL AND ARCHAEOLOGICAL CONTEXT OF MASIS BLUR

4.1 Views on the Neolithization of the Southern Caucasus

Neolithization is defined as the process by which small groups of mobile hunters and foragers began to domesticate plants and animals, create permanent settlements, and to mold new community identity and social relations. The rich ecological diversity of the Southern Caucasus with its natural habitats of cereal and animal species that were among the first to be domesticated in the Near East, led some scholars to identify the region as a possible center of independent development of farming. Vavilov (1932), Munchaev (1975) and Kushnareva (1997), for instance, argued that the Neolithic in the Caucasus developed out of the Paleolithic and Mesolithic cultures of the region and they saw the domestication of many cereals and ovicaprids as an independent local process. Vavilov (1932:12) argued that the Southern Caucasus is a unique area of high quality wild grains. He suggested that the sub-tropical and tropical mountainous zones, plateaus and valleys of Southern Caucasus, which host more than 6000 plant species (Grossgeym 1984 in Kushnareva 1997), offered the optimal conditions for human occupation and thus, domestication of grains.

The discovery of the Neolithic settlement of Chokh in mountainous Dagestan with a mixed economy based on hunting, herding, and agriculture, alongside pottery and sickle blades (Amirkhanov 1987; Kushnareva 1997), strengthened Vavilov's hypothesis. Furthermore, through micro-wear analysis Korobkova (1996) identified sickle gloss on flint blades from Chokh, lending further support to the idea of a local independent center of domestication. Thus, for Munchaev, similarities in the material assemblages (pottery styles, architecture, lithics) of later Neolithic cultures of Southern Caucasus with those of Mesopotamia was a result of cultural contact and borrowing rather than physical movement of Mesopotamian and Anatolian groups into the Southern Caucasus (1975:131).

The argument for a local and independent domestication process is based largely on the ecological characteristics of the Southern Caucasus and hypothetical developmental phases. As of today, reliable data for early Neolithic settlements is still missing. Furthermore, domestication processes of the species mentioned above have not been identified in any of the Southern Caucasus Neolithic sites. The various plant and animal species, such as *Triticum turgidum* and *aestivum* (Hamon 2008), *Tr. Spelta*, *Panicum miliaceum*, and *Capra caucasica* (Badalyan, et al. 2007), occur in Neolithic sites of the Southern Caucasus fully domesticated. Additionally, certain flaked-stone tool types from Mesolithic sites in Armenia and Georgia (Arimura, et al. 2010; Chataigner, et al. 2014) and pottery fragments found in early Neolithic layers in the Southern Caucasus (Badalyan, et al. 2010; Badalyan, et al. 2007) have been identified as belonging to Near Eastern Late Neolithic groups. Masson was the first to suggest that the development of the agro-pastoral economy was the result of Near Eastern cultural influences (1971:124). Material culture similarities found in a number of Shulaveri-Shomu sites, the first Neolithic settlements of the Southern Caucasus (discussed in detail below), to those found in the earlier layers of Hacilar in Turkey supported Masson's hypothesis (Kiguradze 2001). Thus, Kiguradze (2001 identified the Shulaveri-Shomu sites as "Late Neolithic" settlements, which represent the first occurrence of agro-pastoral communities in the region (Badalyan, et al. 2010; Martirosyan-Olshansky, et al. 2013). Due to the existence of local variation between the Neolithic settlements in the Ararat Plain and Shulaveri-Shomu type sites in Georgia and Azerbaijan, Badalyan et al. (2010:204) have proposed the term Aratashen-Shulaveri-Shomu types sites, to identify the Neolithic culture of Southern Caucasus. Initially, it was believed that the Shulaveri-Shomu type sites predate the early agro-pastoral settlements in the Ararat Plain; however resent research and radiometric dates obtained from Aknashen-Khatunarkh and Masis Blur suggest that these sites were established a few hundred years earlier than Shulaveri-Shomu type sites in Georgia and Azerbaijan. Reviewing the recent literature, Kohl and Trifonov conclude that:

"The Shulaveri-Shomu horizon possibly represents something intrusive from farther south on the Ararat Plain of southern Armenia, and ultimately perhaps from Anatolia and northern Mesopotamia, consisting of small colonies of early food producers who lived in this area for several centuries before returning perhaps to their southern homelands and/or possibly assimilating with the local highlanders and disappearing from the archaeological record" (2014:1576).

While the origin of the Neolithic inhabitants of the Southern Caucasus is still under debate and nature of their connections to the Near east still unclearly, recent archaeological work has significantly advanced our understanding of the first domesticated food producing communities in the region.

4.2 Defining Early Holocene periods in the Southern Caucasus

Figure 4.1 – Map of select Late Neolithic sites in the Southern Caucasus.

4.2.1 Mesolithic/Epipaleolithic

Various terminologies have been used to describe the period between the end of the Upper Paleolithic and the appearance of food producing communities in Southern Caucasus: Mesolithic (Arimura, et al. 2010; Childe 1942; Hamon 2008; Korobkova 1987; Kushnareva 1997; Munchaev 1975; Piotrovsky 1949); Epipaleolithic (Arimura, et al. 2012; Chataigner, et al. 2012; Golovanova, et al. 2014); Early Neolithic (Korobkova 1996); and *Post-Mesolithic/Proto-Neolithic* (Kiguradze and Menabde 2004). The variables that define each of these periods have changed through the decades. The changes stemmed from both the evolution of our understanding of a specific period and the need to integrate one's research into an existing research tradition.

The term Epipaleolithic is most commonly used in modern Near Eastern studies, whereas Mesolithic is more prevalent in European archaeological tradition. With archaeological research in USSR being more integrated into the European sphere, the term Mesolithic took hold and the post-Paleolithic Caucasus sites were compared to other Mesolithic cultures in north-western USSR and Europe (Kozlowski 2009). The term was introduced by H. Westropp in the 1880s to add a transitional period between Lubbock's three-stage classification. Thereafter, the definition was advanced by European archaeologists to describe post-glacial hunter-gatherer groups that had adapted to a new environment and whose evolution would eventually lead to an agro-pastoral way of life (Kozlowski 2009).

Emphasizing the continuity between Late Paleolithic groups and post-glacial groups, Golovanova et al. (2014) suggest that after the Last Glacial Maximum (LGM), ca. 18, 000 cal. BP, a new Epipaleolithic (henceforth 'EPP') industry appeared in the Caucasus and the southern Russian plains, which lasted until around 10, 000 cal. BP. These groups had a developed bladelet industry similar to the Early Ahmarian in Levant and a diverse bone tool industry which they see as a predecessor to the Later Neolithic bone tool industry in the region. Despite the absence of well stratified and well dated sites, the authors argue that:

> "Although homogeneous EPP assemblages are rare in the Caucasus, these assemblages contain tool types characteristic of EPP industries in Europe (Gravette and micro- Gravette points, Vashon points, and backed pieces) and geometric micro-lithics (lunates, low symmetric and asymmetric trapezoids, triangulars, and asymmetric triangulars) typical of EPP industries in the Near East" (Golovanova 2012:33).

In the Caucasus, the Mesolithic is defined as a period with early Holocene hunter-gatherer cultures that have adapted to their new environment but do not show evidence of food production (Chataigner, et al. 2014; Kiguradze and Menabde 2004). Chataigner et al. (20014) proposed a two-stage chronology for the Mesolithic of the Southern Caucasus: an Early Mesolithic from 11th to 9th millennium BC represented by Kotias Klde, Kmlo-2 and a Late Mesolithic period, most likely represented by sites which have been attributed to the Early Neolithic.

4.2.2 Early Neolithic or Aceramic Neolithic

In the Southern Caucasus, the Early Neolithic or Aceramic Neolithic is used to describe sites with seem to present certain Neolithic attributes, such as polished stone tools, sickle hafts, or specific chipped stone tool assemblages, but lack ceramics (Lioubin 1966). Furthermore, sites that lack food processing artifacts, such as grinding stones, have been attributed to a proto-Neolithic (Kiguradze and Menabde 2004:352). Thus, the definition of the Early Neolithic is exclusively based on certain technological specificities of the lithic assemblage and the absence of pottery. The lack of systematically excavated sites and radiocarbon dates, combined with a tendency to fit South Caucasian early Holocene sites into well-defined stages of the Neolithic in the Near East, has created some confusion.

Described as single component, open-air sites lacking any traces of dwellings, the so-called Early Neolithic or Aceramic Neolithic sites (Anaseuli I, Hitzubani, Kobuleti, Darkveti, Kodias Klde) are defined on the bases of their similarities to Late Neolithic sites with the exception of pottery, which is absent in the so-called Early Neolithic sites (Korobkova 1996). Most of these sites are located in Georgia, a few have been identified in Armenia and Azerbaijan. A vast majority of these sites lack secure context and radiocarbon dates (Varoutsikos, et al. 2017). Anaseuli I is a supposed open-air site located in south-eastern Georgia identified largely through a concentration of surface artifacts. Based on Nebieridze's lithic analysis, the site is considered a key one in the study of the Neolithic in the region (Kiguradze and Menebde 2004, Kushnareva 1997, Korobkova 1996). The discovery of grinders and sickle blades alongside a lithic industry showing parallels with Mesolithic assemblages led them to conclude a transitional phase between the Mesolithic and the Late Neolithic (Chataigner, et al. 2011). However, recently obtained radiocarbon dates from the site gave a date between 11,287-6,840 BP for a cultural layer that is only 2.5 cm thick, suggesting mixing of the deposits (Meshveliani 2013). Similarly, recent archaeological research at Kotias Klde obtained two radiocarbon dates for two cultural layers dating between 10, 850-8240 BC (Mesolithic) and 7690-7300 BC (Early Neolithic) (Meshveliani, et al. 2007). The lithic industry is distinctly Mesolithic and no domesticated animals or plants have been found at the site and pottery is entirely absent (Varoutsikos, et al. 2017). These findings indicate that the attribution of these sites to the Early Neolithic on the evolution of lithics alone is highly problematic.

Numerous sites in Armenia have been attributed to the Mesolithic based on typological studies of lithics from either surface scatters or undated excavations (Gasparyan 2001; Gasparyan 2007; Gasparyan and Sargsyan 2003; Gasparyan, et al. 2005; Sardaryan 1967).

However, to date, only three Mesolithic sites have been excavated and only one has radiocarbon dates: Kmlo-2, Kuchak-1, and Gegharot-1. Among these only Kmlo-2 has been dated with radiocarbon. Kmlo-2 (initially named Apnagyugh-8) is a small rock shelter located in the Aragats region. Initial excavations conducted at the site in 2002 revealed a substantial obsidian assemblage, typologically akin to pre-Neolithic cultures (Arimura, et al. 2009). Further archaeological work and a series of radiocarbon dates identified five occupational phases located in various but at times overlapping areas of the cave. The phases include a Medieval presence between the 10th –11th c. AD, a Chalcolithic presence dated to late 6th – early 5th millennium BC, two early Holocene presence from the mid-9th – mid-8th millennium BC and from the 10th – mid-9th millennium BC, and a late Pleistocene presence dating from 12th – 11th millennium BC (Arimura, et al. 2009; Arimura, et al. 2012). However, numerous post-depositional processes complicated the stratigraphy. Likewise, issues of sample contamination and mixing warrant some caution.

The plant and animal species found at Kmlo-2 have all been identified as wild (Chataigner, et al. 2014). The lithic industry at the site is blade oriented and notable for the abundance of microliths, such as lunates, trapeze-rectangles, backed bladelets (Arimura, et al. 2009). The study of the lithic assemblages from the site allowed the authors to suggest two main cultural stages: an earlier phase in which the lithic assemblage is dominated by backed blades, and a latter phase which is distinguishable by the appearance of the "Kmlo tools." The Kmlo tools (Fig. X) are most often made on blades, although examples on flakes exist. They are characterized by invasive, continuous and parallel retouch of one or both lateral edges, the distal and proximal ends of the tools are often snapped (Arimura, et al. 2009). This tool type morphologically is similar to obsidian tools called "Çayönü tools" found on southeastern Turkish sites dating to the

8th – 7th millennium BC (Arimura, et al. 2010). However, use-wear analysis showed a clear differentiation both in terms of technology and use between these tools (Arimura, et al. 2010). Chataigner and colleagues suggested that the lithic categories present at Kmlo-2 are possible representations of the Early Neolithic, matching Darkveti (layer IV) or Kotias Klde (layer A2) (Chataigner, et al. 2014).

Kuchak-1 is rock shelter located on the western slope of Mount Aragats in northern Armenia. Four cultural layers were identified during three seasons of excavations between 2007-2010 by a joint Armenian-French mission. Layer 1 contains Medieval and Late Bronze Age pottery, as well as modern intrusions and midden; Layer 2 and 3 are identified as Mesolithic or proto-Neolithic, and Layer 4 is Middle Paleolithic (Petrosyan, et al. 2014). The Early Holocene and Middle Paleolithic layers are represented mostly by flaked stone tools. The Mesolithic/proto-Neolithic lithic industry is largely obsidian-based and is composed of retouched flakes and blades, various points, arrowheads, burins, and geometric microliths; however, most significant is the presence of Kmlo tools and the Kmlo retouch on arrowheads (Petrosyan et al. 2014). The faunal remains were few and poorly preserved, all identified species were wild.

Ghegharot-1 is an open-air site located on the southern slopes of the Pambak Range and excavated by the same Armenian-French team. Due to slope activities, the site is poorly preserved. The lithic artifacts recovered from the surface are mainly of obsidian and techno-typologically very similar to finds from Kmlo-2 and Kuchak-1 (Petrosyan, et al. 2014). Based on the techno-typological analysis of the lithic assemblage, the site is attributed to the Mesolithic/proto-Neolithic period.

The assumption of an Early Neolithic or Aceramic Neolithic, largely stemming from the desire to integrate the Neolithization of the Southern Caucasus into the greater Near Eastern frame of reference, led Soviet archaeologist to attribute the first phases of the Shulaveri-Shomu culture to the Late Neolithic and the later phases to the Eneolithic (or Chalcolithic). The Shulaveri-Shomu archaeological culture, discussed in detail below, is the first expression of food producing societies in the Southern Caucasus.

4.2.3. Late Neolithic

In the Southern Caucasus, agricultural societies were first identified by Kuftin in the early 1940s as a result of archaeological work in Beshtashen, which he attributed to the Eneolithic, a term preferred by Soviet scholars in place of Chalcolithic. Kuftin coined the term "Kura-Araxes Eneolithic" and described the complex as the first occurrence of metal producing cultures in the region. Kuftin's chronological assessment dominated the periodization of prehistoric Southern Caucasus until the 1960s, when new discoveries in the Mil' and Karabakh steppes enabled scholars to attribute Kuftin's "Kura-Araxes" complex to the Early Bronze (Iessen 1963; Munchaev 1975).

The first Late Neolithic sites were identified by Narimanov in 1961 during excavations of Shomutepe, Tojre-Tepe, Babadervish, and others in western Azerbaijan (Munchaev 1982; Narimanov 1963) . In the early 1960s Dzhavakhishvili and Chubinashvili excavated a number of sites, including Shulaveris Gora, Imiris Gora, Khramis Didigora, Arukhlo, and others, in Eastern Georgia having similar material assemblages as the Shomu type sites in Azerbaijan (Kushnareva 1993; Munchaev 1982). These multi-layer anthropogenic mound sites became known as Shulaveri-Shomu type sites. In certain publications, Shulaveri-Shomu sites are still attributed to the Chalcolithic to account for the presence of small copper artifacts and the lack of pottery (Masson and Merpert 1982; Munchaev 1982; Trifonov 1994). The similarities between sites that today are identified as Neolithic and Chalcolithic is striking, thus it is no surprise that the initial investigations attributed these sites to both periods identifying them as Neolithic-Chalcolithic. Archaeological research in the Southern Caucasus during the last two decades has clarified the attribution of various sites and their layers to either the Neolithic or Chalcolithic period. New calibrated dates have established that the Shulaveri-Shomu sites belong to the Late Neolithic and originates in the 6th millennium BC.

Shulaveri-Shomu sites are distributed in three areas (Figure 3.1): the mid-Kura Valley (north-western Azerbaijan and southern Georgia); the Kura plain in Azerbaijan, and the Araxes River Valley in Armenia and Nakhichevan (Chataigner, et al. 2014). The sites are located on alluvial fans of rivers with abundant arable land and water. The long-term occupation at these sites with successive building phases has left behind small mounds (*tell, tepe,* or *blur*), which stand above the surrounding plain or valley floor. They are recognizable by their closely set, circular mud-brick or pisé architecture, sparsity of pottery, particularly in the earlier layers, well-developed bone tool industry, blade-based obsidian industry and the presence of microliths, and the presence of fully domesticated animal and plant economy. A small number of painted pottery fragments of the Halaf and Hassuna cultures (Badalyan, et al. 2010; Badalyan, et al. 2007; Lyonnet, et al. 2012; Munchaev 1975; Munchaev 1982; Palumbi 2007; Palumbi, et al. 2014) attests to interactions with Mesopotamian Neolithic communities. Similarly, several anthropogenic figurines found at Khramis Didi Gora are reminiscent of Mesopotamian cultures (Hamon 2008:88). The areas along the middle reaches of the Kura River boast the highest concentration of Late Neolithic sites in the Southern Caucasus. The best-known sites are Shulaveri Gora, Imiris Gora, Arukhlo, Khramis Didi Gora in Georgia, and Shomutepe, Göytepe (or Göy Tepe), and Menteshtepe in Azerbaijan. A comprehensive review of all Shulaveri-Shomu sites is beyond the scope of this work, thus only a few key sites are discussed below in detail.

4.2.3.1 Western Azerbaijan

Shomutepe (also written as Shomu Tepe) was the first Neolithic site to be identified in the Southern Caucasus. The site was discovered in the late 1950s by I. Narimanov. Due to the rich material assemblage and the densely constructed architecture, Narimanov attributed the site to the Eneolithic period (Narimanov 1963). The excavations revealed a dens network of circular buildings and adjoining smaller structures made from mud-brick. The larger buildings, likely dwelling units, were on average 3m in diameter and some were semi-subterranean. The material culture is composed of a rich bone tool industry, a great number of various gridding stones and mortars, as well as a blade-based obsidian lithic industry (Narimanov 1987). Following the excavations at Shomutepe, a team of archaeologists, under the direction of Narimanov, carried out a series of surveys and test excavations between 1960s through the 1980s. They identified some 20 mound sites, which they attributed to the Neolithic-Eneolithic period based on artifact typologies (Narimanov 1987). The homogeneity of the materials collected from these sites, led him to propose the existence of a Shomutepe culture in western Azerbaijan.

Menteshtepe (or Menteshtepesi) is an important mound site investigated by Narimanov and his team during the 1960s. A joint Azeri-French expedition resumed excavations at the site in 2007. The mound was completely leveled in the 1970s to make room for cultivation of the land, yet intact cultural layers belonging from the Neolithic to the Bronze Age, are preserved below the surface of the valley (Lyonnet and Guliyev 2012). The excavations uncovered circular mud-brick architecture 3 – 6 m in diameter, Neolithic burials, blade-based obsidian lithic assemblages, hand-made local pottery and imported pottery fragments belonging to the Halaf culture, as well as domestic faunal and botanical remains. The earliest occupational phase has been dated to 5700 BC (Lyonnet and Guliyev 2012). The most impressive discovery at

Menteshtepe are its burials, which are very rare in Neolithic sites of the Southern Caucasus. Four burials were discovered dating to the Neolithic period; all were primary inhumations, three were individual infant burials and the fourth was a mass burial with 31 individuals (Lyonnet, et al. 2016). Both males and females of various ages are represented in the mass grave.

Göytepe, is a small mound site in mid-Kura Valley, which stands 8 m above the surrounding valley floor. Originally investigated by Narimanov, it was excavated between 2008 and 2011 by a joint Azerbaijan-Japanese mission. The excavations revealed an 11 m-thick cultural deposit, which were divided into 14 building horizons (Guliyev and Nishiaki 2012; Guliyev and Nishiaki 2014; Kadowaki, et al. 2015). The radiocarbon dates show that the site was occupied between 6700 – 6500 cal. BP (Guliyev and Nishiaki 2012). Similar to Shomutepe, Göytepe is also composed of densely clustered round mud-brick house and attached to these, smaller storage units and hearths. The architecture is exceptionally well preserved, reaching a height of over 1.5 m (Figure 4.2), and the material remains were abundant. In contrast to many Shulaveri-Shomu sites, hand-made pottery was found from all the levels of the settlement and painted fragments are rare. The subsistence economy at Göytepe was based on domesticated crops and animals (Guliyev and Nishiaki 2012). The flaked-stone industry is dominated by blades made of obsidian; grinding stones, bone and antler tools, and polished axe-heads were common in all layers of the site. Guliyev and Nishiaki (2012) suggest some parallels between microlithic arrowheads (also called trapeze) with Syrian Neolithic assemblages, such as those from Sabi Abyad (Copeland 1996). These lithics offer more evidence for potential connections between the Southern Caucasus and Mesopotamia during the Neolithic.

Hacı Elamxanlı Tepe is the most recent Neolithic site to be excavated in western Azerbaijan. Located only 1.5 km from Göytepe, this small mound site measures 60 x 80 m with a total height of 1.5 m above the surrounding area (Kadowaki, et al. 2016). The excavations revealed round mud-brick structures with adjoining smaller storage bins and hearts, as well as they typical Southern Caucasus Neolithic material assemblages: blade-based obsidian industry, well developed bone tool industry, grinding stone, scarcity of pottery but still containing several painted fragments reminiscent of Samarra or early Halaf wares (Kadowaki, et al. 2016). A series of radiocarbon dates put the occupation of the site between 5950 – 5800 cal. BC, seemingly ending when occupation at Göytepe begins. Based on these data, the authors suggest that Hacı Elamxanlı Tepe and Göytepe represent two successive occupations by the same Neolithic community (Kadowaki, et al. 2016:712).

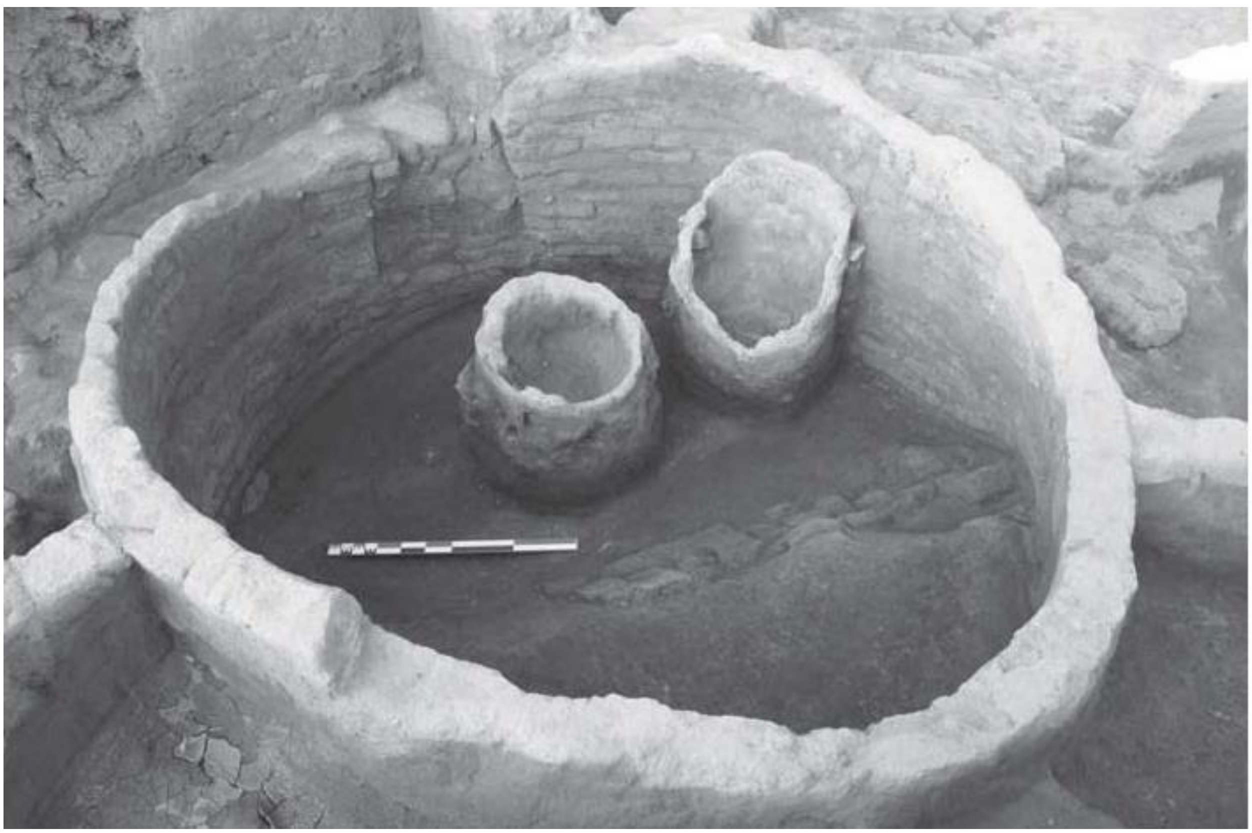


Figure 4.2 – Neolithic mudbrick structure with an entrance at Göytepe, Azerbaijan. In Guliyev and Nishiaki 2014.

4.2.3.2 Georgia

In Georgia, the Shulaveri-Shomu culture is concentrated in the Kwemo-Kartli plain forming four main centers: Arukhlo, Shulaveri, Tsiteli-Sopeli, and Kachagani. Shulaveris Gora, Khramis Didi Gora, Imiris Gora, and Arukhlo represent some of the best investigated sites in Georgia. Neolithic sites found in these centers share a similar architectural history and material culture. The architecture is circular and built with mud-brick, pottery is mostly absent in the earlier layers, the obsidian lithic industry is blade oriented with a high proportion of burins, scrapers, drills, and denticulates (Hamon 2008). Their subsistence economy was based on domesticated crops and animals. At several of the sites, but in particular at Khramis Didi Gora, fragments of anthropometric figurines, likely representing seated women (Hamon 2008), have been discovered. In the Neolithic layers at Arukhlo and Khramis Didi Gora, several small objects made from arsenical copper were discovered (Narimanov 1987).

Shulaveris Gora is small mound site (100 x 40 m) with a height of 2 m above the surrounding plain. Located on the Khrami River, within easy access to water supply, Shulaveris Gora was long considered to be the earliest Neolithic settlement in the area (Narimanov 1987, Kushnareva 1997). The architecture is represented by densely built round mud-brick structures, many containing several occupation floors (Figure 4.3). The earlier layers lack ceramics and in the later layers the ceramic assemblage is composed of largely undercoated, straw-tempered, handmade pottery (Kushnareva 1997:23). The bone and lithic industry is akin to other Neolithic assemblages discussed in earlier. Four primary burials were discovered in the upper layers of Shulaveris Gora, however, however it is unclear if they belong to the latest Neolithic occupation layers or if they are intrusive (Hamon 2008:90).

Khramis Didi Gora is the largest site of the group, about 5 ha in size. Nine building horizons have been identified at the settlement, with its earliest layers contemporary with the upper levels of Shulaveris Gora (Hamon 2008; Kavtaradze 2004). The bone tool industry is very rich and varied, in comparison to Shulaveris Gora; it contains tool types such a perforated axes and mace heads, which are not found at Shulaveris Gora (Narimanov 1987) or other Neolithic sites of the Southern Caucasus. A complete barrel-like vessel found at the site has parallels with vessels from Hassuna, while several similar anthropomorphic figures are found in Hassuna and Halaf (Kushnareva 1997: 25, Kavtaradze 2004, Hamon 2008).

Arukhlo I is located in the lower Kartli region and was first excavated by Kubinishvili and Gogeli between 1966 and 1985. Renewed excavations began in 2005 under the direction of G. Mirtskhulava and S. Hansen, a joint Georgian-German mission. A series of radiocarbon dates show that the site was occupied from 5600 cal. BC to 5400 cal. BC. Small storage bins and hearths have been found adjacent to the structures. Two ditches surround the mound. Five building horizons have been identified at the settlement based on ceramic typology. The site shows the typical circular mud-brick structures (Figure 4.3) ranging between 1.8 to 4.6 meter in diameter (Chelidze and Gogelia 2004). The pottery is rather coarse and ovoid in shape, which was replaced by mineral and chaff-tempered ware in the later phases. The only decorations are perforations, small knobs, and projecting handles. Some fragments of burnished ware have been interpreted as imports (Hansen, et al. 2007). The material culture includes obsidian tools made on blades and blade fragments, bone tools, grinding stones, and beads. The bone tool industry is notable for its biconical needles and perforated antlers (Hansen et al. 2007). The subsistence economy was based on domesticated crops and animals, much like at Neolithic sites in western Azerbaijan and Armenia.

Excavations at Godachrili Gora, located in the lower Kartli region, began in 2012 under the direction of Jalabadze and Hamon. The tributary of the river Khrami has cut a deep canyon through the middle of the site, thus the central part of the settlement has been destroyed. Radiocarbon dates place the occupation of the site between 5900 – 5600 cal. BC (Hamon, et al. 2016). The architecture is typical of Shulaveri-Shomu type sites. It is round in plan and made from mud-brick bound together with a clay mortar. Two main architectural horizons have been identified at the site: Horizon I (lower layers) with more numerous but smaller buildings, which are more complex in their arrangement, and Horizon II (upper layers) with several large buildings, ca. 6.0 m in diameter. The two horizons are separated by a thick sterile clay layer (Hamon et al. 2016). The scarcity of material remains at Godachrili Gora is striking. The very limited number of ceramic and lithic artifacts belong to the known Shulaveri group. The scarcity of finds in comparison to all other Shulaveri-Shomu sites leads the excavators to conclude that the inhabitants had planned their departure and taken their tools with them (Hamon et al 2016:168).

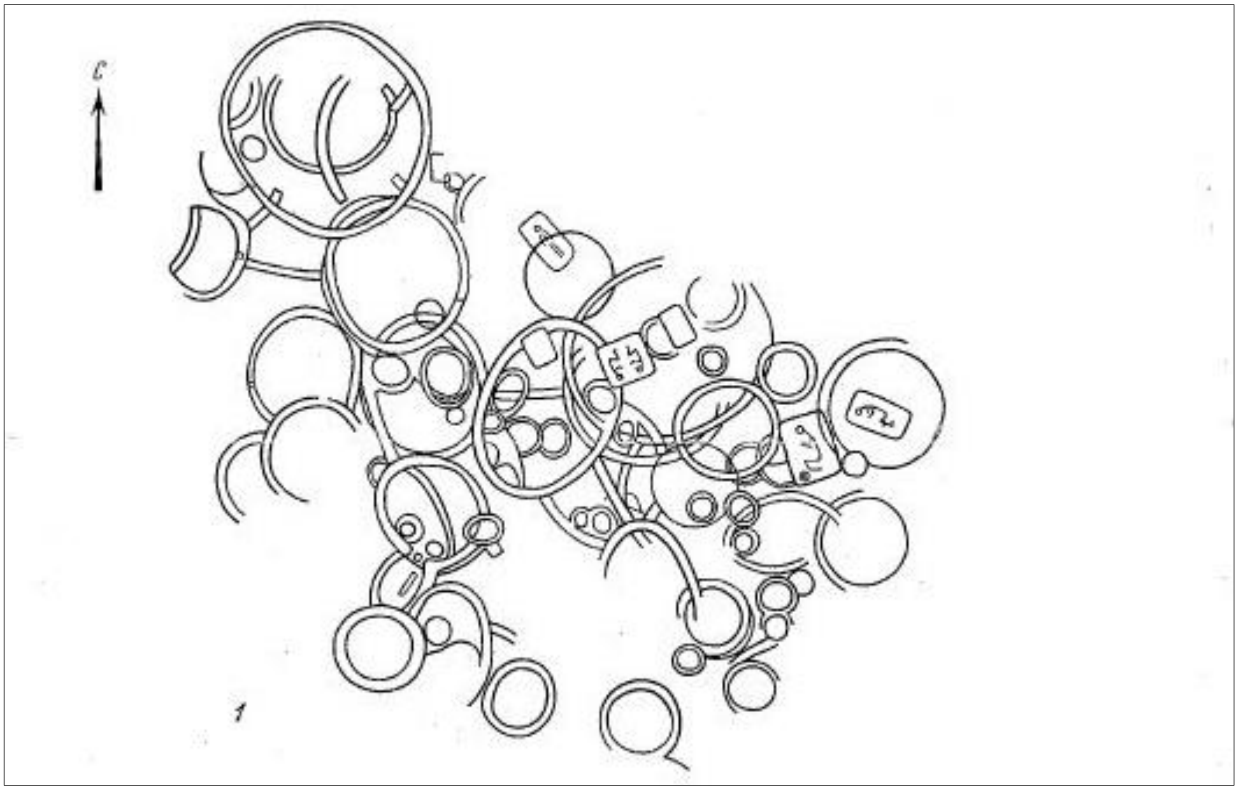


Figure 4.3 – Architectural plan from the excavations of the Neolithic settlement of Shulaveris Gora, Georgia, in Munchaev 1982.

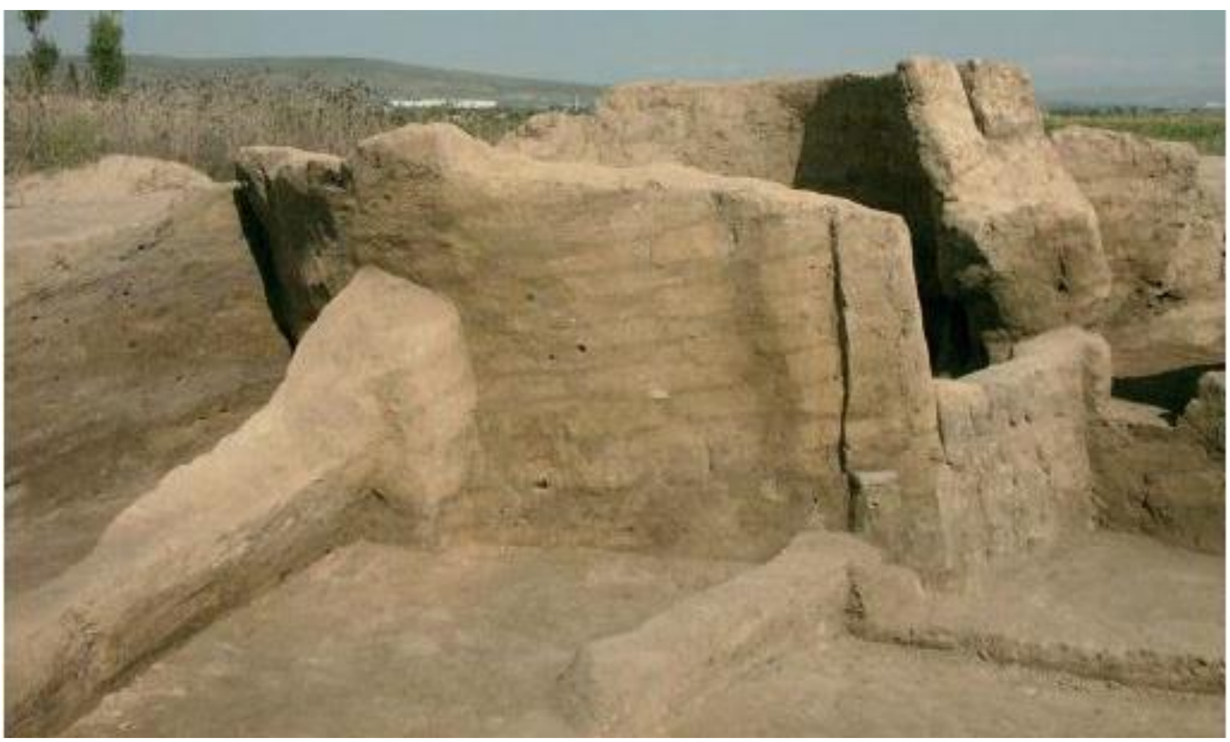


Figure 4.4 – Close up of a circular mudbrick building from the Neolithic Settlement of Arukhlo I, Georgia, in Hansen et al. 2007.

4.2.3.3 The Mil' Steppe

Archaeological research carried out by Iessen in the 1950s identified several mound sites in the Mil' Plain (south-western Azerbaijan), which yielded painted pottery called Mil Steppe Painted Ware (Iessen 1965, Narimanov 1987). Based on the pottery, the sites were dated to the Chalcolithic period. Recent archaeological research at Kamiltepe and Shahtepe have identified the presence of a Neolithic culture at these sites that seems to be distinct from the Shulaveri-Shomu and Aratashen cultural complexes identified in Armenia, Georgia, and western Azerbaijan.

Renewed excavations at Kamiltepe began in 2009 and identified two phases at the site (Aliyev and Helwing 2009). The settlement was organized around a monumental mud-brick platform built in the center of the village that was surrounded by domestic and storage structures. The site is dated to the middle of the 6^{th} millennium BC. Evidence suggests that structures were erected atop the platform (Ricci et al.2012). The faunal assemblage consists of domesticated animals and a small number of wild mammals and fish; the pottery is chaff-tempered with black or red decorations; the lithic assemblage is blade-oriented and made on obsidian, though other stone types, such as dacite and quartz, were used also (Aliyev and Helwing 2009).

A survey in the vicinity of the Kamiltepe, identified eighteen Neolithic mound sites ranging from 0.5 to 1.0 ha. All the sites contain a significant number of Neolithic material goods, though they lack in architecture (Ricci et al. 2012). Semi-subterranean round structures built with mud-brick have been uncovered at nearby sites MPS 4 and MPS 5 showing evidence of shell bead production (Lyonnet et al. 2012). The density of small closely clustered mound sites has led the authors to suggest that these were occupied by several mobile groups conducting short-term but frequent visits to the area, while Kamiltepe with its monumental platform served as a central gathering place (Ricci et al. 2012). While provenance analysis of some of the obsidian tools indicates that the raw material is coming from sources located in Armenia (Astruc et al. 2012) , the analysis of the material culture, as a whole, did not reveal any parallels with the Shulaveri-Shomu groups, but potentially could be connected with cultures of northwestern Iran (Guliyev and Lyonnet 2012).

4.2.3.4 Ararat Plain, Armenia

Thus far, only three Neolithic mound sites, known as *blur* in Armenian, have been discovered in the Ararat Plain: Aratashen, Aknashen-Khatunarkh, and Masis Blur. All three are *blur* sites located between 6 to 13 km from one another and under 1 ha in size. All three were excavated during the last years of the USSR, but few were published. The obsidian industry of Masis Blur forms the bases of this dissertation research and will be discussed in more detail.

Aratashen is located near the river Kasakh, amidst the agricultural fields of the Ararat Plain. It is about 90 x 60 m wide and 3.5 m high. The site was initially explored by Sardaryan in the 1970s and small-scale excavations were undertaken by Aslanyan between 1988 and 1990, but no publications are available for these excavations. Excavations at Aratashen were resumed in 1999 under the direction of R. Badalyan and P. Lombard and lasted for six seasons (Badalyan, et al. 2004a; Badalyan, et al. 2004b; Badalyan, et al. 2007). Three main horizons have been identified at Aratashen, Horizons I-III all dating to the Neolithic period with absolute dates ranging from 5663-5481 to 5905-5711 cal. BC.

A clear shift in architecture and material culture has were observed between Horizon I (Level 1) and Horizons II (Level 1a) (Badalyan, et al. 2007). In Horizon I, the structures, built with sun dried mud-brick, are larger, relatively simple, and not densely placed. This level also contained a significant amount of pottery associated with Shulaveri-Shomu culture. In Horizon

II, the houses are smaller, more complex and more densely placed (Figure 4.5). The earlier layers, that is Horizon II and III, are richer in faunal and obsidian remains. Although very few pottery fragments were recovered from these earlier layers, five fragments of Halaf ware are noteworthy and suggest connections with Mesopotamia (Badalyan, et al. 2007; Palumbi 2007). The blade oriented flaked stone assemblage is predominantly of obsidian and the scarcity of cortical flakes and production waste (Badalyan et al. 2007) suggests that initial knapping activity took place outside of the habitation areas. The subsistence economy at Aratashen was based on herding of small domesticates and cultivation of domesticated crops, with very few wild species present (Badalyan, et al. 2007; Bălăşescu, et al. 2010). Along with various beads and pendants, common to Neolithic cultures of the Near East, a copper bracelet with 57 beads was recovered from Horizon II (Level IIB).

Aratashen is a Neolithic site which was inhabited year-round by agro-pastoralists who already had fully domesticated animals and crops. The non-local artifacts discovered among the material assemblage of Aratashen suggests links both with the Shulaveri-Shomu culture in the north and the Near Eastern influences of Halaf and Hassuna cultures.

Aknashen-Khatunarkh, often simply called Aknashen, is located 6 km southeast of Aratashen. The site was first identified by Torosyan and excavated between 1969-1972, 1974-1977, and 1980-1982 (Torosyan 1968; Torosyan 1976; Torosyan, et al. 1970). Excavations at Aknashen resumed in 2004 under the direction of R. Badalyan and C. Chataigner, a joint Armenian-French mission, and are still ongoing. A test pit placed at the site revealed 4.15 m of cultural layers below the surface of the mound, however the excavators were unable to reach virgin soil due to a high-water table. A series of 24 radiocarbon dates place the initial occupation of the site around 6085-5717 cal. BC (Badalyan, et al. 2010). The last occupation date of the site is not clear, as the upper layers were highly disturbed and contained modern samples; nevertheless, two samples dating to 5511-5054 and 5487-5299 cal. BC. were obtained from the uppermost layer (Badalyan, et al. 2010). Overall, the stratigraphic sequence was divided into seven Horizons. Horizon I, highly disturbed by Late Bronze Age and Medieval burials, has been dated to the Chalcolithic period based on pottery. Horizons II to VII belong to the Neolithic (or Late Neolithic).

The architecture of Aknashen-Khatunarkh differs in construction technique from that of Aratashen. While at Aratashen mud-brick was used, at Aknashen-Khatunarkh the structures are made mostly of pisé (Badalyan, et al. 2010). The ceramic finds are numerous, though the vast majority belong to the Chalcolithic period. Pottery fragments from the Neolithic layer are mostly grit-tempered and of poor quality, some pottery types show similarities with the Shulaveri-Shomu ceramic assemblages. Among the pottery finds are high quality decorated fragments showing parallels with Samarran ware (Badalyan, et al. 2010). Similar to Aratashen and Masis Blur (discussed in detail below), the flaked stone assemblage at Aknashen is blade-oriented and predominantly made of obsidian. Other artifacts that are common to Neolithic settlements, such as grinding stones, flaked stone tools, bone tools, faunal and botanical remains, abound at Aknashen. Other finds include small copper ornaments, beads, and perforated and grooved animal teeth (Badalyan, et al. 2010). The subsistence economy at Aknashen was based on domesticated animal husbandry and plant cultivation. However, at Aknashen the lack of very young and old animals has been interpreted as evidence of a seasonal occupation (Badalyan, et al. 2010). This difference is striking, both Aratashen and Masis Blur, were occupied year-round. Excavations are Aknashen-Khatunarkh are ongoing and further research may clarify the occupation pattern and seasonality.

Figure 4.5 – View of the Neolithic settlement Aratashen, Armenia, in Badalyan et al. Image by R. Badalyan.

4.3 Masis Blur, Ararat Plain

The Neolithic settlement of Masis Blur is situated along the left bank of the presently dry bed of Hrazdan River in the Ararat Plain. During the Neolithic times, the Hrazdan River, which connects Lake Sevan to the Araxes River along the border of Turkey, ran a few tens of meters west of Masis Blur and provided its inhabitants with a year-round water supply. A series of radiocarbon dates obtained from the site suggest that Masis Blur currently is one of the earliest recorded sedentary settlements in the Southern Caucasus. It was occupied continuously from the early Late Neolithic period through the Chalcolithic period. The cultural-chronological attribution of materials finds close parallels with the Late Neolithic materials found at the settlements of Aratashen and Aknashen-Khatunarkh (Badalyan, et al. 2004b; Badalyan, et al. 2007; Chabot, et al. 2009) and a more general similarity to materials found in Late Neolithic settlements in Georgia and Azerbaijan (Abibulayev 1953; Abibulayev 1959; Hansen, et al. 2013; Korobkova 1996; Korobkova 1987; Lyonnet, et al. 2012). Masis Blur was first surveyed in the spring of 1969 independently by Gregory Areshian and S.H. Sardaryan, both from Yerevan State University (Martirosyan-Olshansky, et al. 2013). Areshian recorded a 2.5-meter-high mound, about 1 hectare in size, with dense ceramic scatters. At the base of the mound, Areshian noted small canals and potholes, which he interpreted as remnants of a prehistoric irrigation system (Areshian 1986). The handmade, chaff-tempered pottery fragments with grit inclusions and a gray core recorded by Areshian are typical of the Chalcolithic period. Today, Masis Blur is a mound site only in name; in 1971 parts of the 2.5-meter-high cultural layers, which formed the mound, were used for the construction of greenhouses located just north of the site, the remaining sections were leveled and the land was used for agriculture (Martirosyan-Olshansky, et al. 2013) (Figure 4.6).

Figure 4.6 – General view of the Masis Blur Neolithic settlement before the start of excavations, Ararat Plain, Armenia.

4.3.1 History of Excavations

Small scale, exploratory excavation at Masis Blur was undertaken by S. Amiryan immediately following the destruction of the mound (Areshian 1986). The results were not published, and no field reports could be located in the archives of the Institute of Archaeology and Ethnography in Yerevan (IAEY) or at the Yerevan State University (YSU).

The first large exposure excavations were undertaken by Gregory Areshian in 1985 and 1986 under the auspices of the Center for Archaeological Research at the Yerevan State University. His work confirmed the existence of well-preserved Neolithic layers below the modern surface of the plain. The results of the excavations were not published, though details of the excavations can be found in the field reports submitted by Areshian to the Yerevan State University. In 1985 Areshian and his team excavated a 12 x 10 m area (Figure 4.7). The area was reported to include L-shape remains of a rectilinear mud-brick structure, measuring 4.20 m and 2.42 m in length, and an oval stone-lined hearth 1.17 x 1.00 m in diameter in the center of the structure. In 1986 the excavations continued in the same area. Another stone-lined oval hearth was found directly underneath the hearth excavated in 1985; continuity of other architectural elements is not mentioned. The excavations of 1986 also revealed two burials, both primary inhumations, under the floors and walls of the first building horizon. The burial pits were dug into the remains of the previous building horizon.

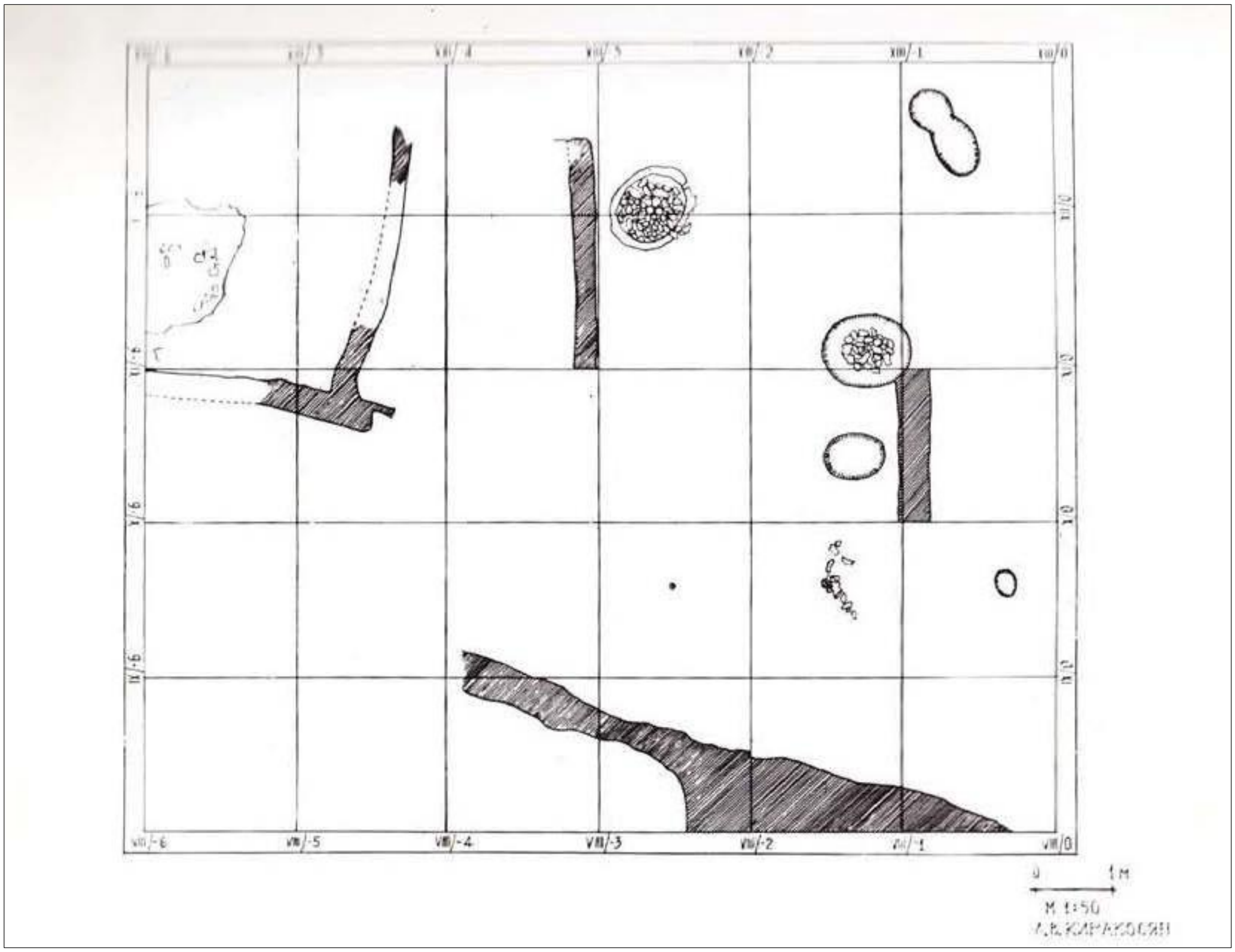


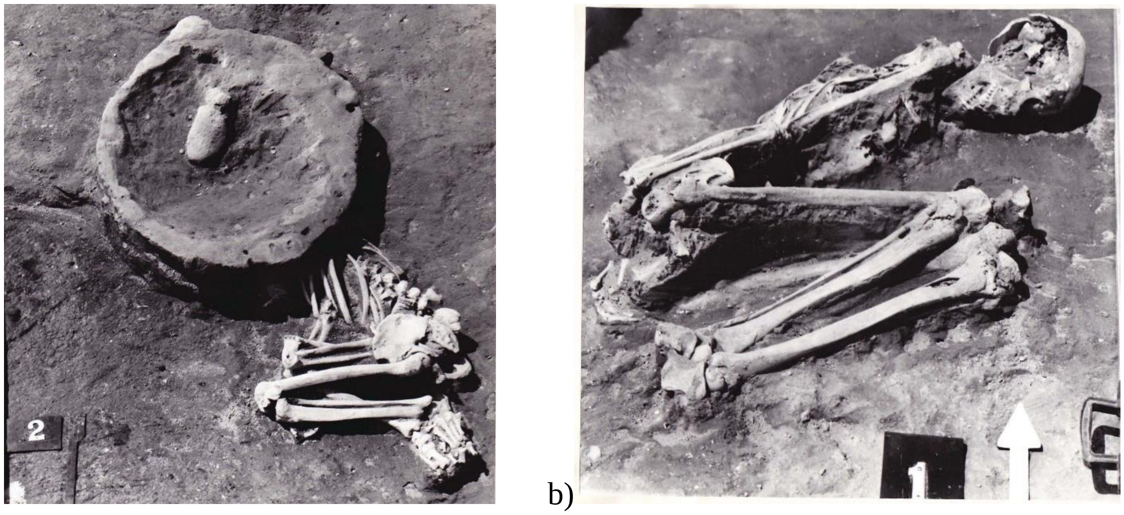
Figure 4.7 – Excavation plan from G. Areshian’s 1980’s excavations at Masis Blur.

Burial 1 (Figure 4.8a) – located between excavation units XIII/-5 and XIV/-6. The adult female was buried in a fetal position on her left side, her arms were placed alongside the body. She was oriented north-east. One obsidian blade was placed on her abdomen and another under her back. Blue mineral fragments, likely azurite, were placed under her head and a fragment of red ochre in her mouth. Red stains on the skull indicated that her head was covered with ochre during the burial ceremony. She was wearing a beaded necklace and a bone tool around her neck.

Burial 2 (Figure 4.8b) – located between excavation units XI/-3 and XII/-4. The upper half of the body was located under a circular fire pit. The adult male was buried in the fetal position on his right side, his arms were placed under his legs. He was oriented south-east. The skull of the deceased was not buried with the body and was not found during excavations. Numerous obsidian blades, blade fragments, and flakes were placed around his body. His rib bones were covered with red ochre.

The walls of architectural remains of the second building horizon were preserved to various heights, ranging from 0.25 cm to 0.68 cm, which indicates that the older buildings were not leveled during a new construction phase. Areshian (1987) believes that there must have been a hiatus between the first and second building horizons. The structures of the second building horizon were built from light yellow-brown unbaked mudbrick and covered by brown plaster. Burned reed matt remains inside one of the structures indicate that the roof was likely made from timber beams with reed thatch covering (Areshian 1987).

The material remains included numerous obsidian and bone tools, various grinding stones, beads and pendants from various stones and animal teeth, as well as faunal remains. While a few coarse pottery fragments were found in the first building horizon, the second building horizon was devoid of pottery (Areshian 1987). Based on the architecture and the material remains, Areshian (1986) dates the first cultural horizon no later than the middle of the 5th millennium BC but does not exclude the possibility of an earlier date.



a) b)

Figure 4.8 – (a) Adult male and (b) female Neolithic burials recovered at Masis Blur in 1986.

From 2012 through 2014 a joint Armenian-American mission under the auspices of the University of California, Los Angeles (UCLA) and the IAEY, conducted three seasons of systematic excavations at Masis Blur. The current research incorporates the obsidian industry recovered from the 2012-2014 excavations. Excavations were carried out in eleven 5 x 5 m, two 2 x 2 m, and one 2 x 4 m units for a total exposure of 291 m^2. A 20 x 20 m grid system was superimposed over the extent of the site, as defined by the Ministry of Culture in Armenia and delineated by private agricultural land to the north and east, an irrigation canal in the west, and an irrigation ditch in the south. Each 20 x 20 m square further subdivided into 5 x 5 m trenches. Excavations were conducted in the following trenches: L10/4, L10/8, M9/5, M9/6, M10/2, M10/3, M10/5, M10/13, M11/1, O7/13SE, O8/1N, O10/13NW (Figure 4.9). A 1 x 2 m sondage (test pit) placed in the south-western part of the site, within Trench M11/1, (Fix X) revealed 2.75 m of uninterrupted cultural layers below the modern surface. The stratigraphy in the test pit contains successive occupation levels, including household floors or plastered outdoor areas, ash lenses, and desiccated dung layers. Structures and features were assigned a number and architectural type was indicated by the letters ST (for structure) and FT (feature) preceding the number. Sediments were assigned a locus number and recovered artifacts were given a bag number. Due to time and resource constraints, only sediments from secured and well-defined contexts (e.g. hearths, pits, house floors, burials) were collected for floatation and further analysis.

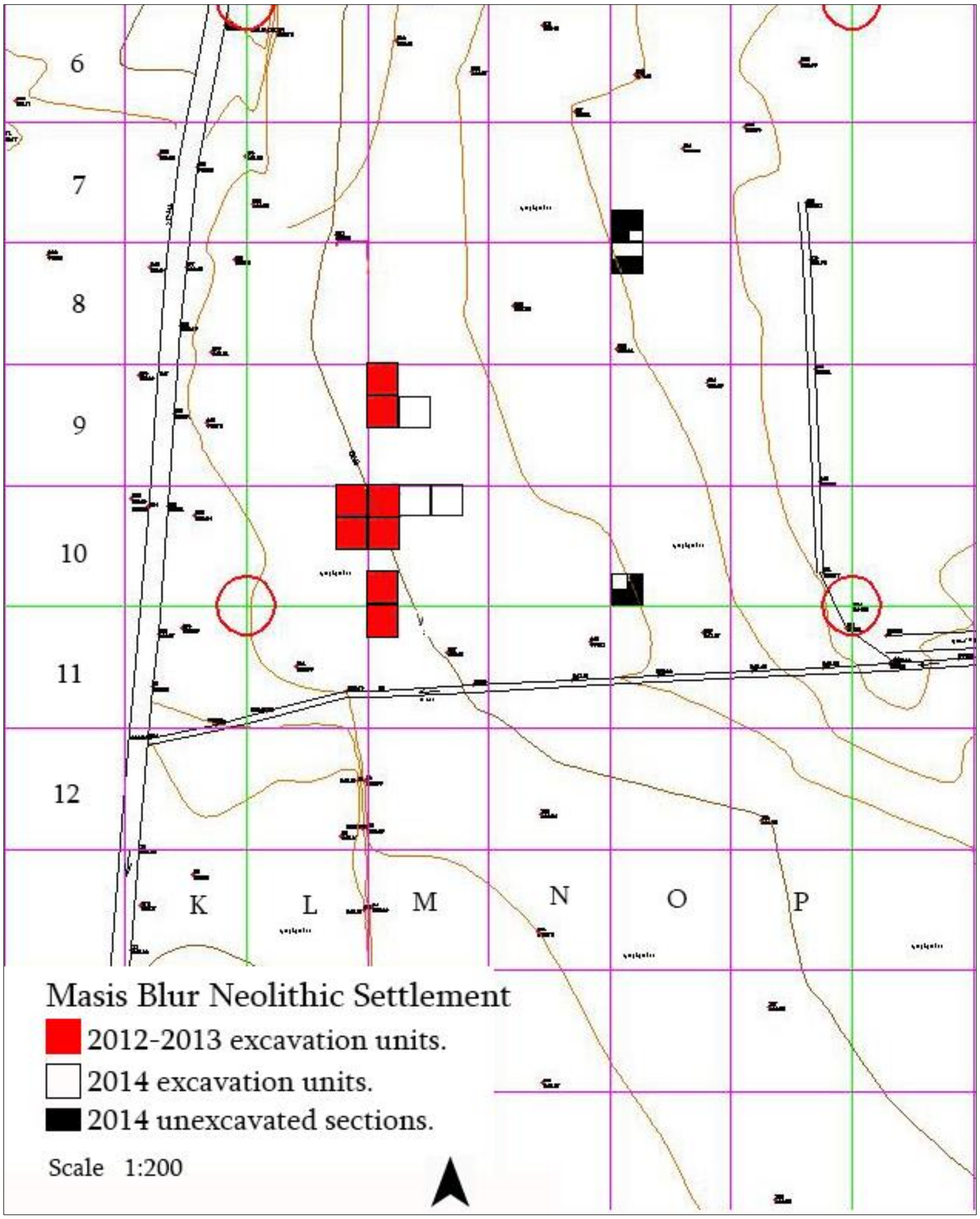


Figure 4.9 – Topographic map of the estimated area of the Neolithic settlement Masis Blur.

4.3.2 Chronology

The absolute chronology of Masis Blur is based on a series of 36 carbon dates. Due to the complete destruction of the uppermost layers of the settlement, the last phases of the Late Neolithic and the Chalcolithic occupation of Masis Blur is known only from pottery remains collected from the surface of the settlement. The occupation of the preserved layers can be divided into five major phases based on the carbon dates obtained from various contexts: Horizon I, 5475-5375 cal. BC; Horizon II 5615-5520 cal. BC; Horizon III, 5745-5660 to 5715-5630 cal. BC; Horizon IV 5780-5700 to 5765-5675 cal. BC; Horizon V 5895-5785 to 5835-5735 cal. BC; Horizon IV 5985-5880 to 5925-5835 cal. BC. Horizon III and IV are further subdivided into two sub-phases, A and B, Horizon V is subdivided into phases A, B, and C. A single radiocarbon date of 6245-6205 cal. BC was obtained from M9/5 and potentially represents Horizon VII at Masis Blur. This date should be taken with caution, as it was based on wood charcoal and can be reflective of the age of the tree more than the age of the occupational phase. However, if this date is collaborated by dates based on annual plants, the establishment of Masis Blur will predate all currently known Neolithic settlements in the Southern Caucasus.

4.3.3 Architecture

No clear public buildings are identified from the excavations thus far. The Neolithic houses consist of large, circular single-room units placed close together. The outdoor areas around and between the houses were prepared by compacting the earth. None of these houses appear to be divided by courtyard walls. While the houses of the earliest occupational phase (Horizon VI - Trench M9/1, M9/5, M9/6) seem to be larger, 5 – 6 m in diameter, and more spread out (Figure 4.10) in the later phases (Horizons III – V), the houses are generally small, measuring no more than 3 m in diameter and more closely clustered (Figure 4.11). The houses would be suitable for a single nuclear family. The uniformity in size, construction, and associated artifacts suggests no clear difference in status distinctions among the inhabitants of Masis Blur. The small size of most houses, the lack of internal smaller structures and well-defined courtyard areas, suggest that most production activities took place outside of the dwelling units in open areas.

The three seasons of excavations at Masis Blur conducted between 2012 and 2014 did not reveal a single rectilinear structure, which was reported by Areshian from his 1980s excavations. The rectilinear structures belong to the upper now destroyed layers of the mound and likely are preserved only as small fragments in certain areas of the site. Although it should be noted, that no rectilinear structures were uncovered from the well-preserved mound sites of Aratashen and Aknashen-Khatunarkh. In 2014, two smaller (2 x 2 m) trenches – O8/1 NW and O10/13NW – were placed in the north-eastern and south-eastern sections of the site with the hope of uncovering the rectilinear structures recorded by Areshian in the south-eastern section of the site and identifying the extent of the Neolithic occupation. Trench O10/13NW was excavated to a depth of 1.55 m below the surface but no *in situ* context were recorded. This area of the site seems to be greatly disturbed by modern activities. Traces of the bucket teeth of a backhoe were visible at various depths along the entire depth of the trench. In contrast, Trench O8/1NW was expended to the west and to the north the Trench O7/13SE was added after the discovery of a burial (discussed in detail below). No structures were recorded in these trenches (Horizon I). The individual was buried within a prepared surface that was compacted and leveled. The prepared floor and two pits, placed above the head and below the feet of the deceased, were the only anthropogenic features recorded in the trench. The sporadic and brief excavations at Masis Blur do not allow for a refined understanding of settlement layout and architectural changes over time. However, the existing data indicate that the Neolithic inhabitants of Masis Blur lived in densely populated single-room houses likely occupied by family units.

Figure 4.10 – Structures of Horizon I (younger), Trenches L10/4, M10/1, L10/8, M10/5, Masis Blur Neolithic Settlement.

Figure 4.11 – Structures of Horizon VI (older), Trenches M9/1 and M9/6, Masis Blur Neolithic Settlement.

4.3.4 Subsistence

The inhabitants of Masis Blur relied largely on domesticated plants and animals for their subsistence needs. The plant remains consist of domesticated free-threshing wheat (*Triticum aestivum*/*turgidum*), emmer (*T. turgidum* ssp. *dicoccum* [= *T. dicoccum*]), naked barley (*Hordeum vulgare* var. *nudum*), hulled barley (*Hordeum vulgare*), lentil (*Lens culinaris* ssp. *microsperma*), and bitter-vetch (*Vicia ervilia*), with predominance of naked wheat and barley (Hovsepyan 2015). The inhabitants also collected various oil-producing seed and fruit bearing plants which grew around the site. The presence of hygrophilous (moist soil adapted) plants points to the presence of bogs not far from the settlement.

More than 12,500 mammalian bones were discovered at Masis Blur, although only 5078 have been identified to taxonomic levels (40.5 % of the total number of remains). Another 798 bones belong to microfauna (fish, reptiles, and birds), out of which 609 (76.32% of the total) have been identified to taxonomic levels. The overall faunal remains at Masis Blur are dominated by caprines, approximately 85%[4] of all mammalian faunal remains (n=12545) determined with cattle raking second in importance at 11.4% (Bălăşescu 2015). The importance of cattle increases in the later phases of occupation, while caprine numbers decrease. Pigs are very rare during the entire span of the Neolithic occupation, accounting for only 0.5% of the total number of identified remains. Slaughter patterns indicated that animals were kept both for their primary and secondary products, that is both for meat consumption and milk and wool production. The number of caprines decreases towards the latter occupational phases, as the number of cattle increases (Bălăşescu 2015), perhaps indicating a change in preferences of food economy and animal herding practices .

[4] Faunal remains collected from the topsoil were not included in this study and are not reflected in the numbers presented.

Wild animals (wild aurochs, wild boar, horse, red deer, gazelle, hare, fox, hedgehog, and wild caprines) are also present in very low numbers, only around 2.1% with no preference for a particular species (Bălăşescu 2015), indicating that hunting was not an important part of their subsistence economy. The remains of fish and turtle, along with burn marks, gnawing traces, and fractures on the carapace of the turtles indicate that these animals were consumed by the Neolithic inhabitants at Masis Blur. The burn marks on many of the bones indicate that they were being cooked on open fires. While the turtles are represented by all ages and sizes, the fish, like the common carp, Transcaucasian barb, and catfish, are all of large sizes, suggesting that the inhabitants of Masis Blur either were using specialized tools for catching big fish (harpoons or toggle harpoons) or they captured the fish during vulnerable periods (spawning season, low water levels) when they are less prudent (Radu 2015). The fish and turtle added a significant amount of protein to the diet of the Neolithic inhabitants of Masis Blur and added to the diversification of their food economy.

4.3.5 Flaked-stone assemblage

The flaked-stone assemblage is a subject of several studies which focus on different aspects of the assemblage. Raw material acquisition and use is the subject of the current dissertation research and will be discussed in detail below. Other aspects of research focus on diachronic and synchronic techno-typological changes of the flaked-stone assemblage, as well as contextual and functional issues. These studies are on-going, thus the techno-typological summery presented here is preliminary. Nevertheless, some trends have emerged from the initial laboratory analyses.

Three seasons of excavations at Masis Blur have uncovered around 11,900 flaked stone artifacts (~60 kg), nearly all of these (97%) are made from obsidian. Non-obsidian flaked stones were made from andesite, basalt, dacite, and other unidentified stones. The non-obsidian tools are represented by unretouched flakes and flake fragments. Table 4.1 and Figure 4.14 present the inventories for each horizon of the lithic material from Masis Blur. The vast majority of Masis Blur tools were made on blade fragments and rarely complete blades or flakes. Blades and blade fragments (Figure 4.12) with various types of retouch and burins dominate the assemblage. Geometric microliths fashioned from blades, especially trapezoids and triangles, while not abundant, are still found at the site. Scrapers, borers, and perforators, and drills made on blade fragments also occurs at the site. Thus far, no obsidian artifacts with evidence of grounding have been found at Masis Blur. The inhabitants of settlement practiced various reduction techniques, including direct and indirect percussion, pressure with crutch, and pressure with lever. Most tools were only partially and not invasively retouched. Parallels can be drawn with Late Neolithic chipped stone assemblages of Aratashen and Aknashen-Khatunarkh (Badalyan, et al. 2007; Chabot, et al. 2009) in the Ararat plain. The near absence of cortical flakes (less than 1%) and a large amount of knapping debris indicates that initial core preparation was done outside of the settlement, likely at the raw material source. At the same time, the large number of cores in various stages of use (Figure 4.13), secondary flakes, and crested blades, indicated that blade knapping and final tool production was done at the site. The general distribution of obsidian blanks and tools suggests household level production activities of chipped stone. While obsidian cobbles have been found in every building horizon at Masis Blur, none of them seem to have been used for tool production, as their size was not sufficient for knapping the large obsidian blades preferred by the Neolithic inhabitants of the Ararat plain. Their function within cultural layers is yet to be identified.

Figure 4.12 – Obsidian tools on blades and blade fragments from Masis Blur Neolithic settlement.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2 cm

Figure 4.13 – Obsidian cores and core fragments from Masis Blur Neolithic Settlement.

Context	Non-obsidian	Obsidian	Total
Topsoil	27	1721	1748
Disturbed- Intrusive	57	4,939	4996
Horizon I	5	219	224
Horizon II	4	635	639
Horizon III	35	1115	1150
Horizon IV	9	641	650
Horizon V	179	1857	2036
Horizon VI	27	411	438
Total	**343**	**11538**	**11881**

Table 4.1 – Inventory of lithic artifacts of Masis Blur (excavations season 2012-2014) per horizon.

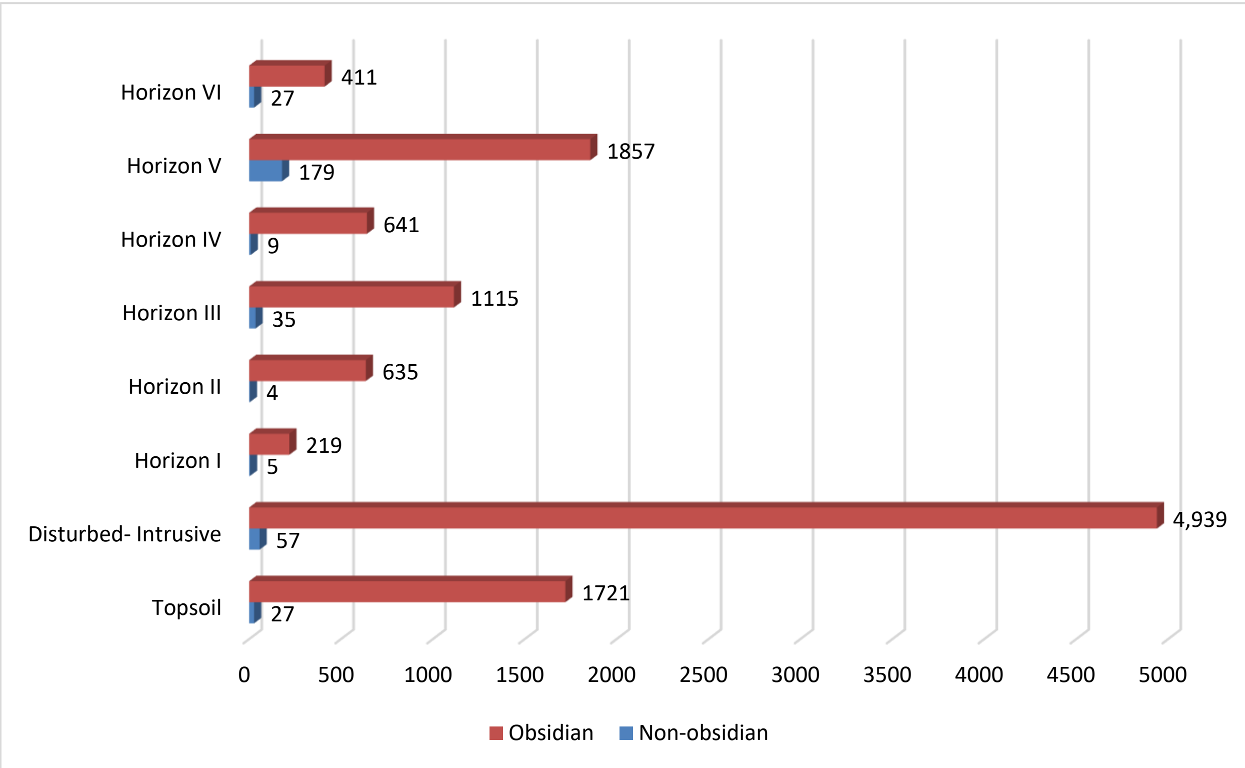


Figure 4.14 – Lithic artifacts excavated from Masis Blur during the 2012-2014 excavation season.

4.3.6 Other Tools

The flaked stone tools facilitated not only with harvest and butchering, but also the production and maintenance of other tools. Well preserved bone tools are abundant in all occupational phases of Masis Blur. During three seasons of excavations, 338 bone tools were recovered from the settlement. Awls of various sizes dominate the assemblage, however spatulas, polishers, projectiles, needles, spoons, picks, and several toothed (comb-like) tools on rib and scapula fragments are also present (Figure 4.15). Cutting tools, such as chisels and wedges used for cutting wood, from a very small percentage of the bone assemblage. The bone tool assemblage attests to a marked variability in the bone and antler toolkit of the inhabitants of Masis Blur.

Ground stone tools were abundant in the ploughzone layer; however, they are encountered in surprisingly low numbers from secure contexts. Ground stone tools consist of querns, few mortars, pestles, pounding and percussion stones, grinding slabs, grooved abraders in various sizes, and fire damaged rocks. The *in situ* artifacts were found in association with buildings or small storage units. Locally available basalt, tuff, and pumice were used for making the various grinding implements, whereas sedimentary and metamorphic stones (e.g. sandstone, limestone) played a secondary role. Dark green and black color stones were mostly used for making polished axe-heads and adzes (Figure 4.16). Several circular shaped (donut-like) artifacts with a double-beveled perforation were also recovered from the settlement. The smaller ones were likely loom weights, while the larger ones were used with digging sticks.

Figure 4.15 – A selection of bone tool implements form Masis Blur Neolithic settlement.

Figure 4.16 Examples of ground stone industry form Masis Blur Neolithic settlement.

4.3.7 Ornaments and Small Finds

Beads and pendants from various materials have been found in all occupational phases of Masis Blur (Figure 4.17). These are made out of stone, shells, and animal bones. Small discoid beads of whitish and dark gray color predominate the assemblage, however teardrop-shaped pendants are also present. Several blanks and partially-finished pendants, as well as the presence of obsidian drills, suggests that bead manufacturing was done by the inhabitants of Masis Blur. These artifacts are awaiting analysis; thus, a more detailed technological and typological summary cannot be presented at this time.

Small fragments of malachite and azurite, which often occur together, found in various levels suggest that the inhabitants of Masis Blur may have crushed these to use as pigment. This interpretation is supported by the presence of a large (ca. 2.0 x 1.50 m) concentration of powdered pigments (mostly limonite and hematite) in Trench M10/13 and the discovery of a large mortar with pinkish-red pigment still visible on the interior walls.

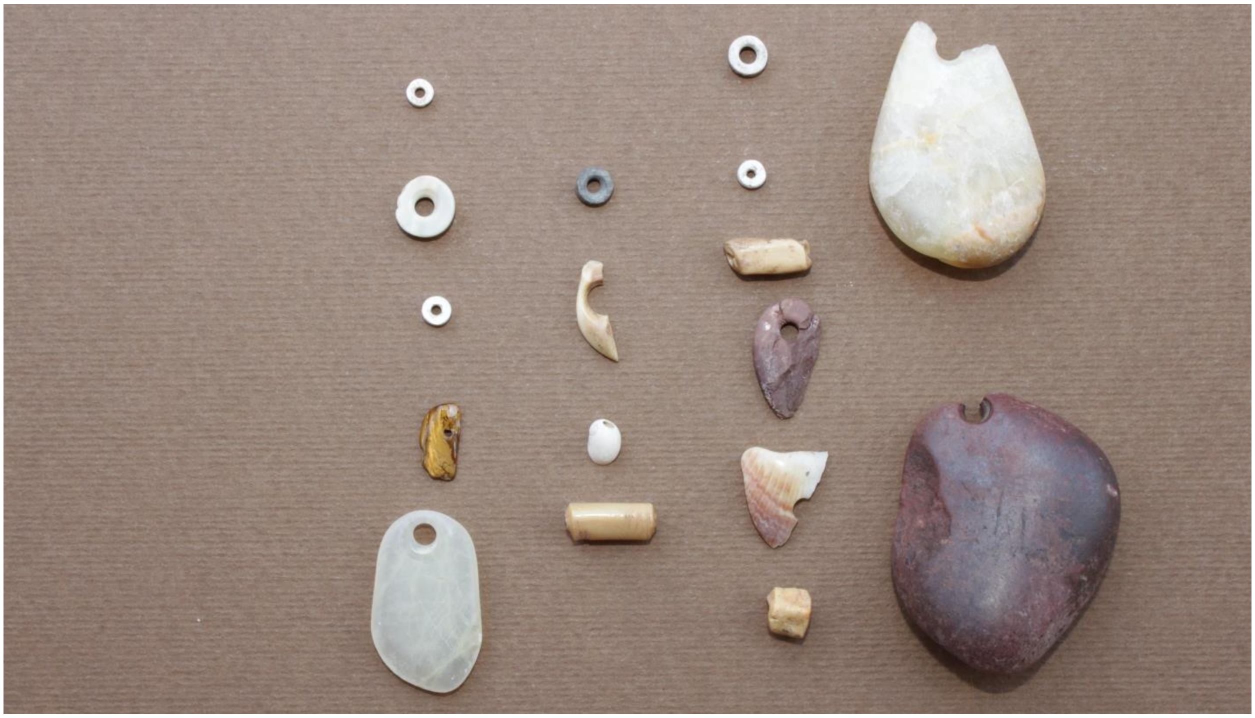


Figure 4.17 – Personal adornment objects from Masis Blur Neolithic settlement.

4.3.8 Mortuary Practices

Burial practices of Neolithic inhabitants of the Southern Caucasus are very poorly understood. Burials at Neolithic sites are rare and, in many sites, where burials are recorded, their stratigraphic position is not always clear. Further, the available information is characterized by a lack of ^{14}C dates, making it difficult to obtain a fuller picture of funerary practices during the Neolithic. In the Southern Caucasus, Neolithic burials have been found only at five sites: Aknashen-Khatunarkh and Masis Blur in Armenia, Kamiltepe and Menteshtepe in Azerbaijan, and Arukhlo in Georgia. At Aknashen-Khatunarkh three individual burials were discovered, all three were dated to the 6th millennium BC through ^{14}C dating. The burials were of 2 adults and a prenatal individual. All three were primary burials and due to disturbance represented by only a few skeletal remains (Poulmarc'h and Le Mort 2016).

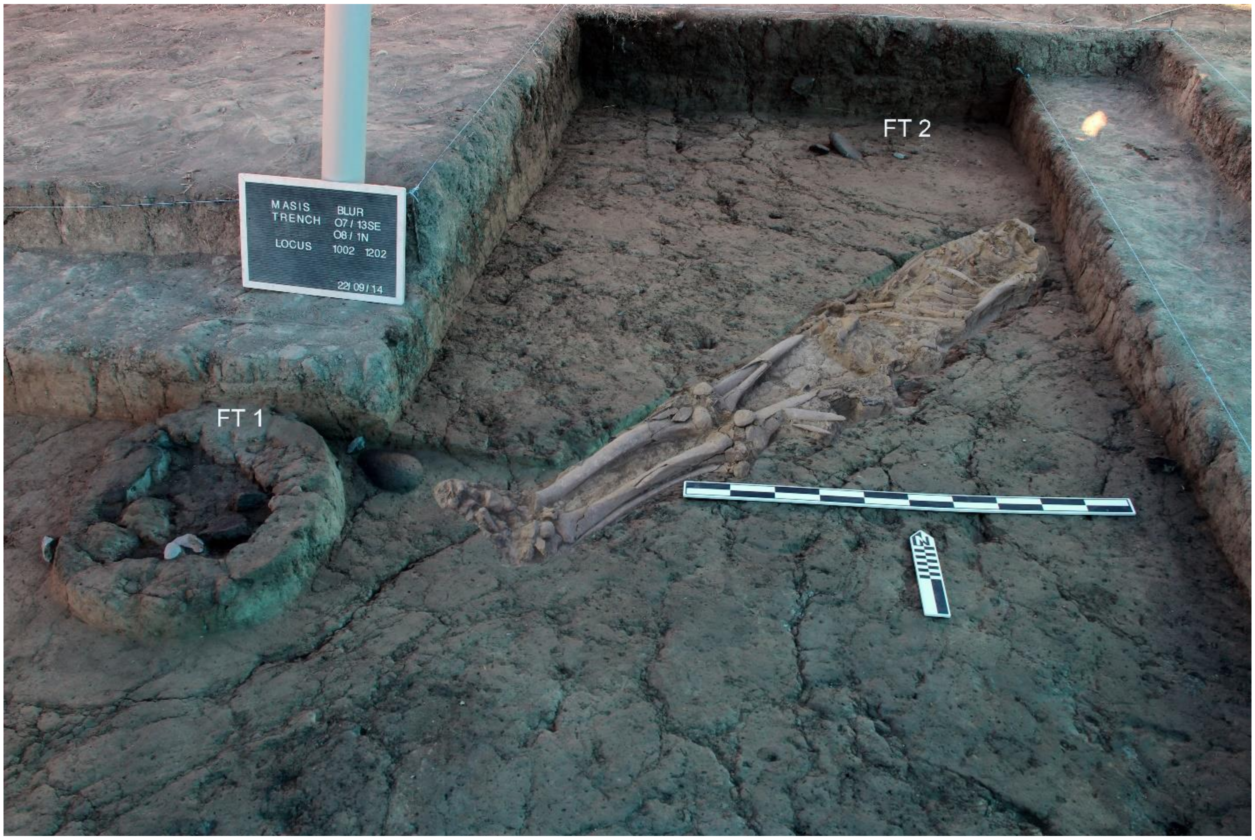
The two burials discovered at Masis Blur by Areshian in 1986 were discussed above. The third burial, also a primary inhumation, discovered in 2014 between Trenches O8/1N and O7/13SE dates to the Late Neolithic, ca. 5615 – 5495 ca. BC (Figure 4.18a-b). The burial was found 30-35 cm below the modern surface (848 masl) and was the first *in situ* cultural layer discovered in the excavation unit. The deceased is a male between the age of 30-40 (Aghikyan 2014). Unlike the burials discovered earlier, this individual was buried stretched out on his back, slightly leaning on his right side. His left arm was placed across the abdomen, resting on the right arm, which was outstretched with the palm placed on the hip. His left hand was in a fist. His head was oriented north-west. The bones were highly fragmented, likely as a result of compressing pressure from heavy machinery used to till the land.

The deceased was buried within a prepared surface, possibly a courtyard area. The yellowish brown (Munsell 10 YR 5/4) clay was cleaned from any large inclusions and compacted over the burial. While at this time is not possible to know the actual extent of the prepared surface, since due to time constraints the adjacent areas were not excavated, it does cover a 2 x 4 m area to the south and nearly the entire 2 x 2 m area north. The deceased was buried with obsidian blades around the body; two blade fragments were placed on either side of his left femur, two against his right tibia, one above his head, and two more medial blade fragments of equal length placed inside his left clenched hand were discovered after removing the metacarpals.

Two features containing additional burial goods were placed above the head and bellow the feet of the deceased. Feature 1 (FT1) was a small hearth ca. 65 cm in diameter, 10-12 cm thick, and 4-5 cm deep. The hearth was filled with ash and fish bones (Figure 4.18a). Feature 2 (FT2) was a shallow pit, distinguishable from the prepared floor by soil color and consistency. It contained a grinder, several stone fragments, and a bone awl (Figure 4.18b). Upon removing FT1 another layer of burial goods was discovered directly under the hearth (FT3), which did not have an associated structure but followed the same outline as FT1. This layer contained a large grinding stone, fragment of an abrasive, bone tools, a few faunal remains, obsidian flakes, a blade, and an obsidian flake core. Yet another layer of artifacts was discovered a few centimeters below these. Feature 4 was slightly wider in diameter. A large spatula with two teeth was placed into a quern, the artifacts were sitting at an angle and were followed by two unworked stones. An incised pendant made out of an animal tooth was the only other artifact found in this feature.

A tight scatter of highly disturbed human remains (fused frontal and parietal, fragments of longs bones, rib fragments) was discovered in Trench M11/1 at a depth of 23 cm below the modern surface. The human bones were in association with a skull of an ovicaprid. The remains are most likely remnants of a burial, which was destroyed during modern agricultural activities. During the study of the faunal remains, Adrian Bălăşescu discovered 18 more human skeletal remains from the ploughzone immediately above this locus, likely belonging to the same individual. The first *in situ* context in Trench M11/1, a collapsed mud-brick wall (FT1) was discovered right below the human remains and dates to 5725 - 5665 cal. BC.

The limited number of Neolithic burials does not allow us to gain a better understanding of the funerary customs or observe the changes in mortuary practice between the early and late Neolithic periods. Based on current data, it seems that the most common burial form was a



a)

b)

Figure 4.18 – (a) General view of the adult male burial with accompanying Features 1 and 2 containing burial gifts. Trenches O7/13SE and O8N, Horizon I, Masis Blur Neolithic settlement. (b) Closer view of Burial-1.

primary interment, either under house floors or foundation deposits. Both flexed and supine burials have been discovered either with the skull or without. One constant among all the burials discovered in the Southern Caucasus is the presence of burial goods, mostly in the form of obsidian and bone tools, and objects of personal adornment.

4.4 Past Environment and Climate

Bordered by the Black Sea in west and the Caspian Sea in the east, the Southern Caucasus has an extremely varied topography ranging from subtropical forests to dry desert-steppes. Armenia is the most mountainous country in the Southern Caucasus with around 90% of the country located above 1000 m above sea level (Aslanyan and Beguni 1970:14). Today the northeast and southeast regions of Armenia are covered with small forest environments, whereas in the central and southwestern regions drier open steppe environments predominate. Only 8% of the total area of Armenia is covered by forests (Leroyer, et al. 2016), which continue to be exploited. The complex mountainous terrain and abrupt differences in elevation result in the exceptional diversity and vertical zoning of climate in Armenia, characterized by a dry and continental climate (Aslanyan and Beguni 1970). The annual precipitation ranges between 200 and 800 mm, with more than 50% of the territory getting above 500 mm of annual precipitation; however, the Ararat plain receives only between 200-300 mm of precipitation (Aslanyan and Beguni 1970:18). Armenia is drained mainly by the Araks River, which divides the Ararat plain into northern (in modern day Armenia) and southern (in modern day Turkey) sections. The affluents of the Kura River contribute to the drainage system of the country to a lesser extent.

During the mid-Upper Quaternary period the differential movements of tectonic plates lead to the development of the Middle Araks depression. As a result, the lacustrine basin of the Ararat plain narrowed and gradually dried up, forming small ponds and lagoons (Aslanyan and

Beguni 170:209) still visible today in the Ararat plain. Faunal remains found in the lacustrine sediments of the Ararat plain are remarkably similar to those found in the Gyumri basin, leading Aslanyan and Beguni (1970) to suggest that the continuation of Leninakan (modern day Gyumri) Lake was the Ararat Lake, which existed until the Upper quaternary period (ca. 12,000 BC). Interestingly, all currently known Neolithic settlements of Armenia are located along what would have been the last shoreline of Lake Ararat.

4.4.1 Environmental Reconstruction

Paleoenvironmental reconstructions of the Southern Caucasus, largely based on paleobotanical remains, began during the 1970s, though these studies were not associated with radiocarbon dating and many did not account for issues of contamination (Lyonnet 2007:12). Nevertheless, recent studies, which use updated methods and include a robust program of absolute dating, largely confirm the observations made by Soviet scholars. In general, pollen spectra from Georgia show an open landscape indicating that the climatic conditions during the Younger Dryas (ca. 13,000-11,500 cal. BP) were cold and dry. There is evidence that glaciers in the Lesser Caucasus persisted into the Early Holocene with a general retreat starting during 12,000 – 8500 cal. BP (Messager, et al. 2013; Ollivier, et al. 2010). In contrast, pollen records from Lake Van, located around 150 km south-west of Masis Blur, depict a spread of herbaceous vegetation and a decrease in arboreal vegetation, indicating an increased climate aridity (Wick, et al. 2003). The presence of various oak pollen in cores from lowland regions of Armenia, Southern Georgia, and Southeastern Turkey indicate that a rapid transition to a warmer and more humid climate ca. 8200 cal. BP. According to geomorphological evidence and radiocarbon dating from Armenia and Azerbaijan, a more humid phase is recorded around 9500-9000 cal. BP and again between 8200-7500 cal. BP, with a drier phase at around 6400 cal. BP, 5300-4900 cal.

BP and 3000 cal. BP (Joannin, et al. 2014; Ollivier and Fontugne 2012; Ollivier, et al. 2016; Ollivier, et al. 2011).

The Lake Paravani pollen record indicates that during the Early Holocene steppe vegetation continued to predominate with more forested environments appearing only sometime after 8000 cal. BP (Messager, et al. 2013), suggesting a micro-regional variation in climate and environment, which is not surprising given the highly diverse topography of the Southern Caucasus. The pollen record from Lake Urmia (Iran) shows a similar pattern indicating an expansion of oak forests during the transitional phase from the Early to Middle Holocene (Djamali, et al. 2008). In the Zarishat basin of northwestern Armenia pollen and microcharcoal records show a shift ca. 8200 cal. BP from cold and arid to a more humid and warmer climate, accompanied by the appearance of water-dependent plants such as *Cyperaceae* (sedge) and increased tree cover (Joannin, et al. 2014). Thus, it is during the course of the 7th millennium BC that systemic climatic amelioration can be detected and agricultural groups begin to settle on the rich silty alluvial plains, on the banks of tributaries and away from rapidly flowing main flows (Ollivier, et al. 2016). The dense vegetation existing along the watercourses contributed to the presence of deer and beaver in the faunal assemblages of Aratashen, Aknashen, and Masis Blur. The paleobotanical assemblages from these Neolithic sites indicate the exploitation of two ecological zones: species such as *Quercus* (oak), *Amygdalus* (various flowering stone fruit trees), *and Acer* (maple) are found in plains and hills, while species such as *Salix sp.*(willow) and *Tamarix sp.* (evergreen) are common to more humid environments (Hovsepyan 2009).

4.5 Summary

Some 150 agro-pastoral settlements have been identified in the Caucasus since the late 19th century (Abibulayev 1959), only a few dozen have been excavated and only a handful of these using modern techniques. The chronology of these sites is poorly known, and the lack of faunal and botanical analysis further limits our understanding of the development, evolution, and regional variability in their cultural expression and economic adaptations. As a result, some scholars have argued for a wide variety of cultural and economic manifestations of farming communities in the Southern Caucasus starting around the 8th millennium BC. Different Neolithization processes have been proposed by scholars, but no definitive consensus has been reached. Nevertheless, the existing data show a rich and varied cultural remains associated with Neolithic and Chalcolithic food producing communities.

Three main regions of Neolithization have been identified in the Southern Caucasus: Western Georgia largely known from Colchis; the Aratashen-Shulaveri-Shomu group; and sites in the Mil'-Karabakh steppe. Data from Western Georgia is sparse and fragmentary, making it difficult to evaluate it in the larger framework of development of the Neolithic in the Southern Caucasus. The Aratashen-Shulaveri-Shomu group is the best research group. These settlements, clustered in the mid-Kura, mid-Araxes and the Kvemo-Kartli regions, are characterized by round dwellings units made from sun-dried mud-brick or pisé with small storage units attached to dwelling units. The subsistence economy is based on fully domesticated crops, along with sheep/goat and cattle herding. Limited number of wild species, including mammals, fish, birds, and reptiles, suggest that the Neolithic inhabitants were supplementing their diet with wild species hunted, or more likely captured, opportunistically. The bone/antler tool assemblage is extensive and varied. The flaked-stone industry is dominated by obsidian and is characterized by long blades struck from unidirectional pyramidal cores. While these sites have parallels with one another, local variations both in lithic technology, site structure, and subsistence patterns still exist. Contemporaneous settlements discovered in the Mil' steppe show certain differences from the Aratashen-Shulaveri-Shomu group and suggest a different set of processes of Neolithization.

Several hypotheses have been proposed for the processes that led to the origin of food producing societies in the Southern Caucasus. In general, these hypotheses rely on identifying changes in subsistence patterns and lithic technologies, as well as contact between groups. Many early Soviet scholars of Caucasian archaeology, such Munchaev and Kushnareva, suggested an independent change towards domestication and food production at some point between the 9th to the 7th millennium BC, during which Mesolithic communities of the region slowly transformed into Neolithic societies. Recent research has shown that there is a gap of nearly 2000 years between the Mesolithic groups in the Southern Caucasus and the Neolithic Aratashen-Shulaveri-Shomu group, which seem to appear overnight with a full suite of domesticated plants and animals. Furthermore, no evidence of early signs of domestication have been discovered at the Mesolithic sites of the Caucasus. In contrast, Masson saw Levant and the Zagros as the origin of agriculture in the Southern Caucasus (Masson and Merpert 1982). However, parallels between the Zagros/Levant and the Aratashen-Shulaveri-Shomu group are mostly seen in very specific and few elements of material culture. One such element is the Kmlo tool, which has morphological similarities to the Çayönü tools and Paluri "hooked" tools. Arimura et al. (2010) conducted use-wear and technological analysis concluding that while visually these tools look similar, they do not share the same function or *chaîne opératoire*. Similarly, Chabot and Pelegrine (2012) examined the production of long blades by pressure in the Ararat Plain and northern Mesopotamia and showed technical parallels between the long blades produced at Aratashen in the 6th millennium BC and the production of "Canannean blades" of Khabur dating to the 4th millennium BC. Thus, while technological similarities can be identified, the 2000-year gap does not allow for the identification of direct correlation between these areas. In fact, long blade production in the Ararat Plain in the 6th millennium BC has no contemporaneous parallels.

Another aspect of the material culture which shows connections between the Southern Caucasus and the Near East is ceramic production. The early layers of Aratashen-Shulaveri-Shomu sites are largely devoid of pottery, with the exception of fragments of high quality decorated sherds which resemble to the pottery of Halaf and Hassuna cultures of Mesopotamia (Badalyan, et al. 2010; Badalyan, et al. 2007; Lyonnet, et al. 2012; Munchaev 1975; Munchaev 1982; Palumbi 2007; Palumbi, et al. 2014). Several anthropomorphic figurines found at Khramis Didi Gora are akin to figurines found in Hassuna, Halaf, and Samarra culture (Hamon 2008:88). Moreover, Lyonnet's work in the Mil' steppe of Nakhichevan shows the relations between architectural and pottery elements discovered in the earlier layers of Neolithic sites in this area and of those discovered in the Iranian plateau (Lyonnet, et al. 2012). Although rectangular shapes are more common in Halaf architecture, circular and sub-circular structures are still an important part of their building tradition (Hansen, et al. 2007). The construction technique with mud-brick also has parallels in Ceramic Neolithic sites of Iran, such as Choga Mami and Choga Banut (Hamon 2008).

The available human genetic data has also revealed a link between modern Armenian and Near Eastern populations that originated during the Neolithic expansion in the Southern Caucasus. Herrera et al.'s study of Y-chromosomal diversity in four geographically distinct Armenian populations (Sasun, Ararat Plain, Gardman, Lake Van) shows the prevalence of paternal chromosomes associated with Neolithic populations of the Near East found in four distinct Armenian modern populations. Along with the haplotype distribution, these data suggest that these lineages were likely introduced into Armenia from the Levant (Herrera, et al. 2012).

More complex and contradictory findings are reported from the study of mtDNA and Y-chromosome variation for Caucasian and Iranian populations. Nasizde et al. report that while the Y chromosome indicates a predominantly West Asian influence in Caucasian populations, the mtDNA variation suggests a more complex interactions of European and West Asian influence (2004). The genetic evidence presented is compelling but, much like the limited material culture evidence, it does not provide a conclusive evidence of a Near Eastern demic diffusion in the 7^{th} – 6^{th} millennium BC in the Southern Caucasus.

The current research examines the role of obsidian, more specifically the acquisition and distribution of the raw material by the Neolithic inhabitants of Masis Blur, as a medium for cultural contact and exchange between the inhabitants of the Ararat Plain and Mesopotamia.

CHAPTER 5: RESEARCH METHODS AND DATA COLLECTION

5.1 Introduction

The study of obsidian movement is a useful tool in the investigation of the prehistoric record. The unique nature of obsidian and its study opens a range of possibilities for the reconstruction of past human mobility, and interaction. Contextual information of obsidian artifacts has been used to study its use as an object of utility, personal adornment, magic and ritual. As one of the most resilient materials found in archaeological contexts obsidian has been found in the earliest prehistoric contexts, among the tools fashioned by the *Homo habilis* at Olduvai Gorge in Tanzania (Leakey 1971:89), and it continues to be used in modern times. Obsidian scrapers continue to be manufactured and used for processing animal hide by the indigenous tribes of the Kamchatka Peninsula (Takase 2010). In its widespread use, both geographically and temporally, and ability to be sourced to a specific place of origin, obsidian is unparalleled, so it can offer unique information about exchange, contact, and interaction.

Due to its use in a variety of contexts, obsidian has been a focus of much anthropological research. It was used on every continent for making utilitarian tools, especially flaked stone tools, blades, and points (e.g., Hirth and Andrews 2002; Lewenstein 1981; Mortensen 1973; Nishiaki 1990). Obsidian has also been used to manufacture pendants and beads (Campbell and Healey 2011; Healey and Campbell 2014; Schechter, et al. 2013), mirrors (Vedder 2005), vessels (Bevan 2007; Schechter, et al. 2013) cylinder seals (Gorelick and Gwinnett 1990), ceremonial bloodletting knifes (Tate 1992), and similar objects. The value of obsidian beyond its utilitarian use has been demonstrated by historical accounts and ethnographic research in the New World on the symbolic meaning ascribe to various obsidian artifacts (Dillian 2007; Hayden 1998). In the Old World, non-utilitarian uses of obsidian have been considered by Cauvin (1998) and Coqueugniot (1998). Coqueugniot, in particular, has discussed its uses for rituals and magic.

In this chapter, I discuss the fundamental principles of obsidian research, briefly cover various analytical techniques used for obsidian sourcing, including pXRF, and justify my choice in the use of the latter technique over others. Then, I detail my analytical goals for this research and the choice of sampling strategy derived from the research goals. Here I develop the necessary framework to help understand how various adaptations and changes of material acquisition, production, and use can be proxy evidence for overarching social and cultural changes.

5.2 Fundamentals of Sourcing Studies

It is useful to determine the origin of an artifact or the source of its raw material and for complex societies, tracing the source of an artifact or a group of artifacts has been used to make inferences about exchange systems, economic, and political organizations, and social structures of the people involved. However, sourcing has its own theoretical bases and postulates, which has been a topic of much discussion and debate.

5.2.1 The Theory and Postulates of Sourcing

The "Provenance Postulate," coined by Weigand, Harbottle, and Sayre, states that the raw material source of an artifact can be determined, as long as "there exist differences in chemical composition between different natural sources that exceed, in some recognizable way, the differences observed within a given source" (1977:24). Since their publication, theoretical postulates of sourcing studies have undergone many reformulations by various researchers. Rapp and Hill have an important clause that there must be a "demonstrable set of physical, chemical, or mineral characteristics in raw-material source deposits *that is retained in the final artifact*"

(1998:134). Neff's definition of the "Provenance Postulate" is a refined reiteration of Weigand and his colleagues, stating that "sourcing is possible as long as long as there exists some qualitative or quantitative chemical or mineralogical difference between natural sources that exceeds the qualitative or quantitative variation within each source" (2000:107).

Rapp and Hill identify three main components in sourcing studies: 1) identification and sampling of all possible raw material sources, 2) selecting an analytical technique that can measure the compositional fingerprint with sufficient accuracy (i.e., how closely the results obtain by a given study are to accepted or actual values) and precision (i.e., obtaining the same results in successive measurements), and 3) using a statistical technique to assign artifacts to the most likely raw material sources (1998:135). Rapp and Hill also highlight two problems in sourcing studies: 1) adequate representation of all potential sources in the database, and 2) establishing that the artifact has not undergone any anthropogenic or post-depositional alteration that can negate comparison to raw materials (135).

Similarly, Pollard and his colleagues identify five conditions that must be met for artifact sourcing, these are: 1) *characterizability* – an artifact must have a compositional fingerprint that is specific to its source, 2) *uniqueness* – the source must be geographically unique, 3) *predictability* – the chemical fingerprint should be either unaltered by anthropogenic forces or, if altered, then the change must be predictable, 4) *measurability* – the techniques used to analyze the artifacts and raw materials need sufficient accuracy and precision for differentiating the sources, 5) *stability* – any physical and chemical changes of the artifacts must be either insignificant or predictable (2007:15).

Obsidian is one of the rare material types, that meets the conditions outlines by Rapp and Hill and Pollard and colleagues. Each obsidian source has its own unique fingerprint, which makes characterization possible. Obsidian sources are geographically limited and finite in number and out of these not all are suitable for knapping, further limiting the number of potential sources used by prehistoric communities. Although obsidian is a product of volcanic activity, the necessary conditions for obsidian formation are present only in some volcanoes. Many obsidian sources contain a high density of inclusions making it an unsuitable material for knapping, further restricting the number of potential sources. Unlike metals and clay, obsidian cannot be processed, mixed, or recycled, thus maintains its original compositional structure during manufacture and use, and even heat treatment. While obsidian can be fire-treated and it does hydrate, these changes are negligible and predictable. Obsidian hydrates, but this alteration is limited to the outer layer (Ericson 1975), thus elemental analysis of the material is not affected by hydration.

While obsidian sourcing is not without challenges, these issues are not discouraging sourcing studies, but calling for diligence and complete understanding of the limitations of sourcing studies. Many of the outstanding issues, both theoretical and practical, discussed in *Archaeological Obsidian Studies: Method and Theory*, edited by M. Steven Shackley (1998), are still relevant. What is the minimum number of required specimens for source characterization? How variable is the chemistry within a single obsidian source? And perhaps most importantly, how certain can we be that an artifact assigned by the analyst actually belongs to that source? In the same volume, Shackley also notes that “few archaeologists realize that elements useful in discriminating sources in one region may not be useful in another” (1998a:5). In a more recent article Speakman and Shackley (2013) have warned of the dangers of “internally consistent” results ignoring issues of validity and reliability (2013:1435). These issues are discussed in more detail in the subsequent sections of this dissertation.

5.2.2 The Goals of Obsidian Sourcing

Glascock states that the identification of "actual goods in the archaeological record that were exchanged between different areas…are the most tangible evidence that an archaeologist can hope for when looking to establish contact between prehistoric peoples" (2002b:1). Sourcing studies have been used to establish whether obsidian artifacts (or jade, copper, tin, ceramic, etc.) were moved at a local or regional level. Exchange implies social contact, thus transformation of ideas between groups. Recent archaeological research has shown that social and cultural interactions between distant regions can play a crucial role in explaining the transition into the Neolithic (e.g., Bar-Yosef and Belfer-Cohen 1989; Watkins 2008). Such networks can act as conduits for exchange of technology, values, and belief systems, for gaining access to exogenous marriage partners, and for acquiring resources not available locally. For non-sedentary groups, the movement of obsidian has been used to address questions of seasonal mobility or foraging radius (e.g., Andrefsky 1998; Shackley 2005). For sedentary communities, sourcing is used to investigate exchange models and economic systems by which material changed hands (e.g., Braswell and Glascock 2002; Cann, et al. 1968; Shackley 1994). Ammerman and his colleagues have addressed questions related to the value of obsidian by examining differences in the exchange of everyday objects and prestige goods (1990).

A through discussion of applications and aims of obsidian sourcing, as well as its role in studying exchange systems, can be found in Earle and Ericson (1977), Ericson (1982), and Dillian and White (2010). The more nuanced goals for obsidian sourcing in the present dissertation are 1) to delineate the diachronic patterns of obsidian procurement strategies at Masis Blur and 2) to investigate correlation between source and archaeological context. On a larger anthropological scale, my goals of obsidian sourcing elucidate patterns of exchange, cultural contact and interactions among the inhabitants of Masis Blur and their neighbors. As Clark argues, raw materials from geological sources diffuse continuously from a single point to the region, presumably following exchange networks, until the materials are found deposited at consumption sites (Clark 2003). Thus, the attribution of artifacts to specific raw material sources can help us establish whether obsidian was moved locally or over long distances, and various models of exchange can be used to explain the nature of this movement. These ideas have been covered more thoroughly in Chapter 3.

5.2.3 Analytical Techniques for Obsidian Sourcing

There has been ample discussion in archaeological literature surrounding instrumentation for obsidian sourcing, particularly which analytical technic is “best” for analyzing a given artifact type (e.g., Greene 1998; Shackley 2005). While an extensive and all-inclusive review of these techniques is beyond the scope of this dissertation, a brief overview of the most frequently employed techniques for sourcing is given below. Greene states that four techniques stand out from others: neutron activation analysis (NAA), inductive coupled plasma-mass spectrometry (ICP-MS), proton-induced x-ray emission/gamma-ray emission (PIXE/PIGME), and x-ray fluorescence (XRF) (1998:228). In the same volume, Shackley (1998a) and Glascock, et al. (1998:19) emphasize the same techniques, the latter noting that “XRF and NAA have proven to be highly cost effective and, therefore, are the methods most frequently used to source artifacts.”

In neutron activation (NAA) analysis, the sample is exposed to a neutron source inside a reactor irradiating the atomic nuclei of elements, which makes some of the elements in the specimen radioactive. By using the characteristic gamma rays emitted during the radioactive decay the elements are identified and their concentrations measured. NAA is always a destructive process, it requires a 50-100 mg sample of the artifact to be removed for analysis and this is eventually discarded as radioactive waste. As access to nuclear reactors is restricted, this technique requires archaeologists to send their samples for analysis by trained technicians. This combined with sample preparation requirements significantly increases the cost of analysis per sample. The advantage of NAA is that NAA is more sensitive, able to detect a wider range of major, minor, and trace elements, making discrimination between sub-source variation or slight variation between different sources possible.

In (LA-)ICP-MS the sample is hit with a pulsed laser beam in an ablation chamber and purged with argon. The resultant aerosol is carried into the plasma torch where it is atomized and ionized. The resulting emission spectrum of individual ions is then transported into a mass spectrometer and for analysis. (LA-)ICP-MS is semi-destructive in that the laser beam leaves 20-200 μm size crater pits in the sample (Gratuze 1999:870). While these pits are not visible to the naked eye, (LA-)ICP-MS nonetheless changes the physical morphology of the sample making the technique a semi-destructive one. The technique also has some limitations on specimen size; these should not exceed 1.5 cm in thickness and 5 cm in length (Gratuze 1999:870), thus only the smallest obsidian artefacts can be analyzed leaving out the vast majority of obsidian artifacts.

In PIXE-PIGME the sample is exposed to an ion beam which causes inner shell ionization of atoms in the sample. The energy emitted by characteristic x-rays of an element are recorded and measured using an energy dispersive detector. While PIXE detects trace elements, PIGME is used to detect certain light elements in a sample. While PIXE-PIGME is a non-destructive technique, its limitations lie in its sensitivity to surface weathering and residue, and maximum sample size restrictions. The beam penetrates only about 50 μm into the sample with the majority of x-ray and gamma-ray emission taking place within 10-20 μm, thus surface weathering and residue will influence the results (Summerhayes, et al. 1998:135). Summerhayes et al. state that if the sample should be washed with ethanol to eliminate any residue and if it is weathered the sample "should be polished or broken to expose a fresh surface" (Summerhayes et al.1998:135). Additionally, the sample mount cannot accommodate a specimen larger than 14 x 40 mm in size (Summerhayes et al.1998:135), greatly restricting the types of artefacts that can be analyzed with this method.

In x-ray fluorescence (XRF) a specimen is illuminated by an x-ray beam with a specific energy and wavelength displacing electrons from the inner orbital shells of the atom. The sample is excited and energy is lost, in the process emitting wavelengths unique to each element. These wavelengths are registered by the detector in the instrument and identified through software. XRF is an entirely non-destructive technique, which requires very minimal sample preparation, though as with PIXE-PIGME the sample should be cleaned of heavy residue. However, the x-ray beam of an XRF instrument penetrates farther into the specimen, thus making surface reside effects negligible. The main limitations of XRF analysis is minimum sample size and restricted elemental acquisition (largely restricted to mid-Z elements). This technique it requires that a sample be at least 10mm in dimeter and 2mm thick. The restricted sample size means that many obsidian microliths or small flakes important for the reconstruction of the lithic technology cannot be analyzed using XRF. However, unlike all other techniques XRF does not have restriction for maximum dimensions of a sample. This means obsidian artifact such as handaxes, cores, large preparation flakes, and blades can be analyzed using XRF. Despite the limitations, Shackley contends that "it [XRF] is simply the best non-destructive analytical tool at our disposal at this time" (2011:10).

5.2.4 Introduction to pXRF and its Application for Obsidian Sourcing

Each of the methods discussed above has been used extensively to investigate archaeological analytical problems, and the individual techniques have advantages and disadvantages for given archaeometric applications that must be understood before undertaking any analysis. Several aspects of analysis for archaeometric studies need to be taken into account. These include: sensitivity, accuracy, precision, effect on the sample (i.e., destructive or damaging), bulk versus surface analysis, laboratory vs. *in situ* and appropriateness for the type of sample. For any analytical study, there should be a balance between the information acquired from the data, time required to complete the analysis the cost, as well as the accuracy and precision required, all while achieving good quality control of the data.

X-ray has been recently adapted to portable instrumentation. Technological advances have allowed portable XRF (pXRF) to contribute in both fieldwork and museum settings. In addition, recent projects have been developed centering on the application of these portable techniques to not only accomplish the archaeometric study but also to characterize and define the uses and limitations of the instrumentation in the field. Developments in the portable analytical methodology have led to subsequent innovations in the technology used to support the methods. In the case of pXRF, such advances include compact X-ray tubes and data acquisition and manipulation based on portable computers. Shackley outlines 5 advantages of XRF over other techniques (2011:8-9):

1. Non-destructive – the analysed samples are not destroyed or altered in any way,
2. Minimal preparation – most samples can be analysed with little or no preparation, Because the x-rays penetrate far enough beyond the surface of the artefact, “contamination on the surface is generally not an issue,”

3. Time efficient – chemical composition is determined in seconds (generally between 150-300 seconds),
4. Easy to use – instrument operation does not require special training or high level of expertise,
5. Cost-effective – the cost is significantly lower, as it does not require extensive sample preparation or long-term storage of radioactive specimens (one of the major cons of NAA).

Portable XRF techniques have several advantages for archaeometric analysis: good accuracy and precision, fast and relatively inexpensive qualitative and quantitative analysis, extensive elemental coverage of elements of interest for archaeometry, and the capability to bulk or surface (10-40 μm) analysis (Papp 1994). Although pXRF is less sensitive than instrumental NAA (INAA), Liritzis and Zacharias contend that "the non-destructive advantages of the PXRF should be emphasized parallelly with their portability ... The portability coupled with the non-invasive capability makes the PXRF systems more favoured by archaeometrists and, especially, archaeological scientists" (2011:110). XRF provides data in the parts per million (ppm) for most trace elements, it is more cost effective and more accessible. Portable XRF methodology has been applied to a wide range of archaeometric applications. The most common are obsidian (e.g., Darabi and Glascock 2013; Nazaroff, et al. 2010; Vázquez, et al. 2011), ceramics (e.g., Speakman, et al. 2011), and metals, but it has also been used to analyse glass, pigments, minerals, soil (e.g., Zacharias, et al. 2009), paintings, and other multi-layer artefacts.

Following the increased interest and demand for non-destructive XRF analysis, there has been a steady rise in the number of instrument options for XRF analysis. A brief but comprehensive discussion of the most commonly used instruments cab be found in Liritzis and

Zacharias 2011. Here I will only discuss the pXRF instruments created by Bruker used for quantitative multi-elemental analysis of obsidian in this research.

The *handheld Tracer series* include the following models: Tracer III-V+, Tracer III-SD, Tracer IV-SD, and the most recent Tracer 5i. All models give the user a complete control of the excitation conditions (current, voltage, and 4 different filters), thus measurement conditions can be selected and optimized based on the material type being analysed. The older model, Tracer III-V+ operates with a SiPIN detector, while the newer models, Tracer III-SD and IV-SD, incorporate a silicon drift detector (SDD), providing better resolution and light element sensitivity than the SiPIN detector. Tracer III-SD comes with an optional integrated camera, which can be very useful for spot-specific analysis. Tracer 5i is the only one that comes with an embedded analytical and operational software.

5.2.5 Summary of Analytical Techniques

Each of the methods described (INAA, LA-ICP-MS, PIXE-PIGME, and XRF) have distinct advantages for the investigation of obsidian. For elemental studies of the materials, data on the characteristic elements important to each material are important for answering questions concerning sourcing and ancient exchange. Determining the most effective method for any type of archaeometric study is an important component of study design.

Portable XRF, a variation on XRF for fieldwork, offers a different set of capabilities. It is based on the instrumentation and software of lab-based XRF and is becoming more accessible to researchers in all fields. A pXRF instrument can be transported to the archaeological site or museum rather than exporting fragile or important artifacts. Due to the nature of the instrumentation (less powerful X-ray tubes, lack of secondary filters, analyses performed in atmosphere), the precision, accuracy, and limits of detection are inferior to lab based XRF.

Despite these limitations, for this study pXRF was successfully demonstrated to be effective in chemically characterizing obsidian, as described in Chapter 6.

5.3 Geological Reference Collection

Glascock and his colleagues list a number of principal factors that lead to flawed sourcing studies (1998:20); these include 1) failure to locate all possible sources, 2) collection and analysis of too few samples from each source, 3) poor description of source areas 4) analysis of too few elements, and 5) the failure to identify the most critical elements useful for discriminating between particular regions or individual sources (*ibid)*. The authors recommend that at least a dozen samples from each source be analyzed and more for "larger and complex sources more than a 100 specimens may be desirable" (1998:23). While they do not clarify what makes a given source "more complex" one can assume that sources with extensive geographic spread, multiple eruption events of obsidian producing lava flows, and discontinuous extrusive obsidian areas fit under the "complex" source umbrella. Shackley echoes a similar sentiment and argues for systematic collection of geological samples for sourcing studies (1998a).

While the presence of the shortcomings outlined by Glascock et al. are to be expected in early studies, a review of literature on obsidian sourcing studies from the past decade reveals that, with rare exceptions, the number of geological obsidian specimens analyzed in individual studies have not improved, particularly in Old World archaeology. For example, Badalian, et al. (2001) analyzed only 33 geological samples from 18 areas in Armenia; Chataigner, et al. (2003), analyzed 48 samples from 9 areas in Southern Caucasus, Bressy, et al. (2005) analyzed 18 samples from 4 areas in Turkey, Niknami, et al. (2010) analyzed 1 sample each from 3 sources in Iran, and Darabi and Glascock (2013) analyzed 38 samples from 8 sources (2 source groups) from Anatolia.

Guided by some of the most common criticisms of sourcing studies, namely the insufficient number of geological samples per source and the lack of systematically collected reference samples, I undertook over a dozen geological obsidian sample collection trips between 2013 and 2015. Shackley argues that, for each obsidian source, a sufficient number of samples "to analyze may only be discernible experimentally" (2002:60). In 2013 I visited 12 of the 13 known obsidian source groups in Armenia and collected hundreds of georeferenced geological samples. The Aghvorik, Sizavet, and Khorapor sources were already under snow by the end of our fieldwork, thus fieldwork at these sources was postponed until 2014 and 2015. Guided by the extensive study and publications of Sergey Karapetyan (1965, 1972) on volcanic mountain ranges in Armenia, at each source, I located and documented obsidian deposits occurring either as extrusive outcrops or continuous flows. Obsidian samples were collected directly from the outcrops or the flows to avoid potential mixing of samples from sub-flows as a result of erosion downhill movement. Each collection locus was documented using a Garmin 62 handheld GPS and a unique identifying number (UID) was assigned to each bag. During the second phase of the documentation, which took place in the laboratory after each field visit, sub-UID was assigned to each geological sample in each bag. Figure 5.1 below shows how each UID found in Appendix 1 can be decoded.

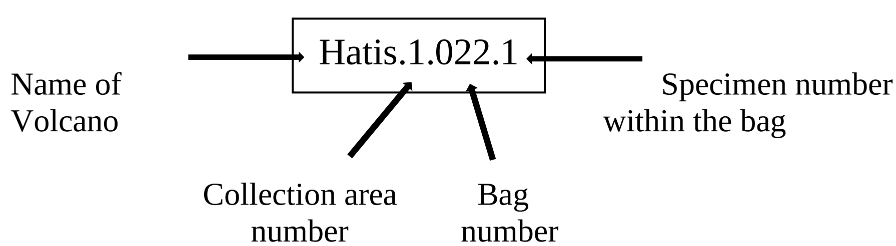


Figure 5.1 – Codifying geological obsidian samples collected from Armenia. Each sample analyzed was given a unique identifying information (UDI), which can be decoded using the formula above.

From the first season’s collection I chose 80 samples to export to the US for elemental analysis. The samples were chosen based on collection loci and visual differentiation. In 2014 and 2015, informed by the results of the first 80 samples, I revisited several sources to collect additional samples and visited the sources that were left out in 2013 due to weather conditions. In Armenia, most of the samples were cut into 5 x 5 x 2 cm standardized blocks and polished on one side, whereas others were not modified to show their natural surfaces. I made sure that all uncut samples have at least one flat surface, which could be used during analysis. All fragments from the cutting process were persevered along with their georeferenced information for future use.

An attempt was made to classify the geological obsidian specimens from Armenia based on color and use this as bases for visual classification of archaeological specimens. This proved to be difficult and perhaps even futile. While there are obsidian types that are very distinct and do not occur anywhere outside of a restricted area within a source, such as the blue-gray mottled obsidian of Gutanasar found only within the obsidian flows near the village of Nurnus (Figure 5.2), these types are in the minority. When placed next to one another the geological specimens seem to form a spectrum rather than distinct groups of colors, translucency, and opacity rather. The geological obsidian samples from Armenia are represented in Figure 5.3 – 5.13 and clearly illustrate this point.


Figure 5.2 – Blue-gray mottled obsidian from Gutanasar flows near the village of Nurnus (Armenia). Photo by Joseph “Seppi” Lehner.

5.3.1. Relevant Obsidian Sources in the Southern Caucasus and Neighboring Regions

In the section below, I detail the known obsidian sources in the Southern Caucasus and relevant neighboring regions (Figure 5.4) and discuss the reasons behind the exclusion (either intentional or circumstantial) of some sources from the reference collection. My current geological obsidian reference collection consists of 133 obsidian samples from Armenia, 7 from Georgia, and 23 from Eastern Turkey.

5.3.1.1 Georgia

Georgia has a single major obsidian source: the Chikiani volcano, also known as the Paravani Lake sources, is located in southern Georgia bordering north-western Armenia. A pilot sourcing study of 207 Masis Blur obsidian artifacts indicated that none of the north Armenian sources were represented in the study sample, making it unlikely that the Chikiani source, located 160 km north of Masis Blur, would be present in the site's assemblage. Nevertheless, I collected specimens (Figure 5.5) from five different loci on the southern slopes of the volcano to include in this study.

5.3.1.2 Armenia

Armenia poses a challenge for assembling a complete geological reference collection. Karapetyan (alternatively spelled Karapetian) has identified 6 volcanic regions in Armenia (Figure 5.3) with over 450 individual volcanoes (1972). Five out of the 6 volcanic regions have between 2 and 6 obsidian bearing mountains, each containing an even greater number of outcrops and flows, with majority having obsidian well suited for knapping. Yet, in comparison to Turkish and Aegean sources, many of these sources have not been systematically studied. However, this is beginning to change. Several scholars have undertaken obsidian characterization research on various obsidian sources in Armenia (Chataigner and Gratuze 2014a; Cherry, et al. 2007; Cherry, et al. 2010; Frahm, et al. 2014; Keller, et al. 1996; Oddone, et al. 2000).

My reference collection includes between 2 and over 20 specimens (Figures 5.6 – 5.13) from all known obsidian bearing mountains in Armenia. These include: Aghvorik, Sizavet, Mets and Pokr Arteni, Hatis, Gutanasar, Spitakasar, Geghasar, Mets Satanakar, Sevkar, and Bazenk.

5.3.1.3 Artsakh

The Republic of Artsakh (formerly known as Nagorno-Karabakh), located between Armenia and Azerbaijan, has a single obsidian source, Merkasar. In archaeological literature it is commonly referred to by its older Turkish name Kechel Dağ or Kelbajar/Kel'bedjar/Kel'badzhar. The Republic of Artsakh is a *de facto* independent state, having declared its independence after the collapse of the Soviet Union in 1991. However, Azerbaijan does not recognize this independence and since the end of the war fought between 1991-1994 the two republics have had closed borders and hostilities continue to this day. As the Merkasar obsidian source is located at a high altitude visible to Azeri border patrol, access was restricted as a result of increased violence along the borders. Thus, I was not able to obtain samples from Artsakh and this source is also not included in my reference collection. Instead I use published data in order to ascertain the role of Merkasar in the Neolithic obsidian procurement strategy at Masis Blur.

5.3.1.4 Azerbaijan

Before 1991, Azerbaijan, had a single obsidian source, the Kel'bedjar volcano, also known as Kechel Dağ or Merkasar in literature. Today the source is located in the Republic of Artsakh and is discussed below. The modern-day territory of the Republic of Azerbaijan does not have any other known obsidian sources.

5.3.1.5 Iran

Our understanding of geological obsidian sources in Iran are scant and incomplete at best. The very few studies of Iranian obsidian (Nadooshan et al. 2007 and Niknami et al. 2010) claiming to have analyzed Iranian obsidian samples neither describe their sample collection locations nor published their data. Unable to assign a number of obsidian artifacts from the site Chogabon to any published data on obsidian sources from Armenia and Turkey, Nadooshan et al. conclude that the "obsidian was brought to the site from locally available sources. However, these sources are currently unknown…" (2010:11). Similarly, a more recent publication Nadooshan and colleagues still refer to "unknown [obsidian] sources located in Iran (perhaps Sahand and Sabalan Mountains)" (2013:1956) but again do not offer any more information on this elusive obsidian sources. Many claims for local origin of obsidian in Iranian archaeological sites seems to be based on the authors' inability to assign these samples to a source in Armenia or Turkey either analyzed by the researcher or more often published by others.

Until the sources of Iranian geological obsidian have been identified and published or samples can be obtained directly from the field, Iran will be excluded from obsidian reference collection.

5.3.1.6 Turkey

Similar to Armenia, the modern-day territory of Turkey, the eastern part of which forms the western boundary of the Armenian Highland, has tens of obsidian sources located in its central and eastern plains. In contrast to Armenian obsidian sources, geochemical characterization of Turkish sources, particularly those of central Turkey, has a longer history and a more complete published record. Since, all researchers must at some point decide on geographical boundary out of practicality (both in terms of cost in time and money), based on the available literature and cultural comparisons of Neolithic populations in the Near East, I decided to draw the western boundary of my collection area after the accepted boundary of what is presently Eastern Turkey. Several major obsidian sources are known from this area: Yağlıca Dağ, Sarikamiş (Armenian: Սարիղամիշ [Sarighamish]), Pasinler (Armenian: Բասեն [Basen]), Erzurum (Armenian: Կարնո [Karno]), Tendürek (Armenian: Թոնդրակ [Tondrak]), Meydan Dağ, Suphan Dağ (Armenian: Սիփան [Sipan]), Bingöl (Armenian: Ճապաղջուր [Chapaghjur]), and Nemrut Dağ (Armenian: Նեմրութ [Nemrut]). I was able to obtain only 21 specimens from four obsidian sources (Figure 5.14). Thirteen geo-referenced geological samples from Sarikamiş were collected and given to me by Gregory Areshian. Christine Chataigner and Bernard Gratuze kindly provided 11 additional samples from 5 sources in Eastern Turkey: 2 from Yağlıca Dağ, 2 from Pasinler, 2 form Erzurum, and 5 from Sarikamiş. I also made use of published data for sourced mentioned above for which I do not have specimens.

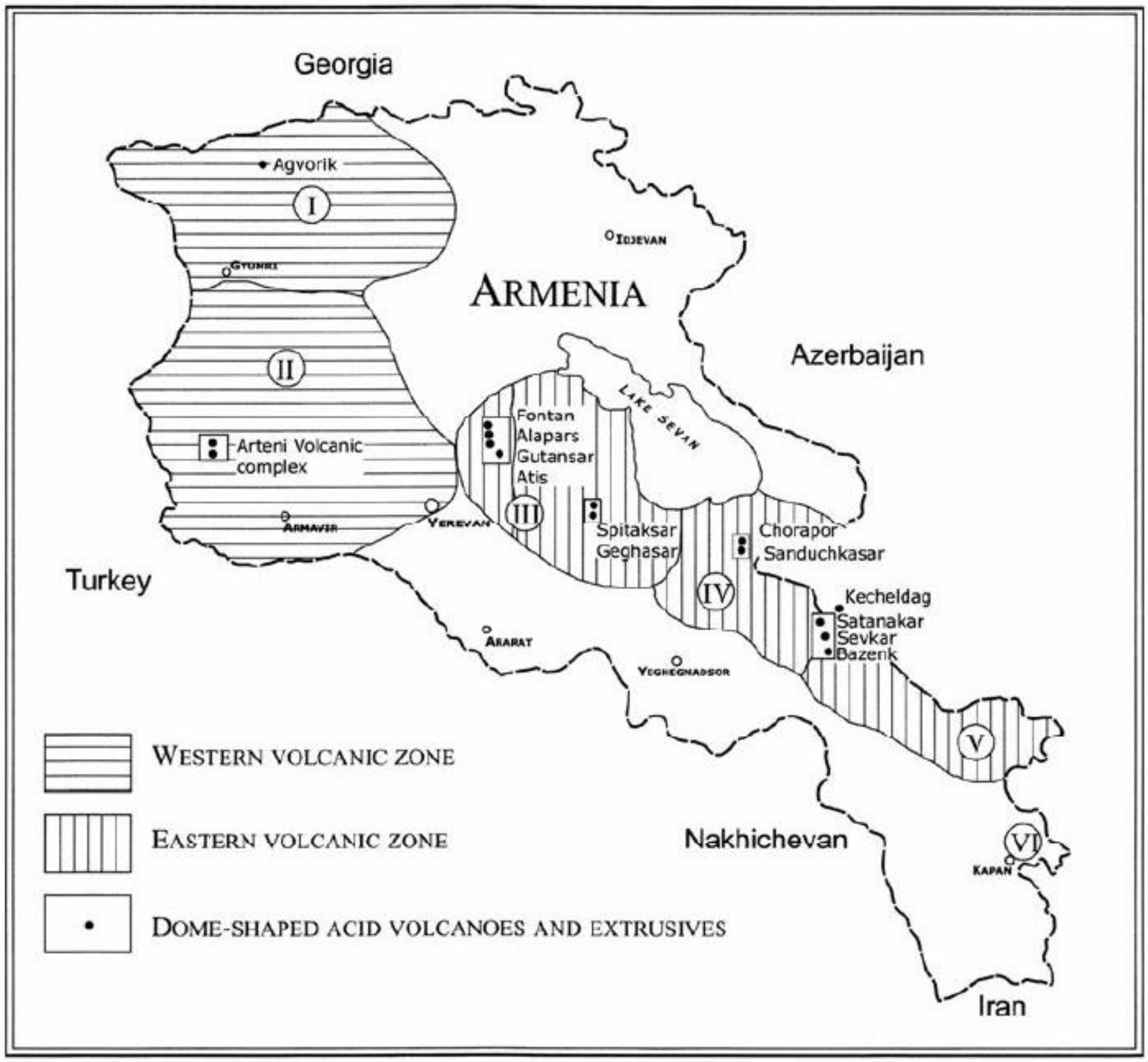


Figure 5.3 – Map of the volcanic zones of Armenia as delineated by S. Karapetyan. (redrawn from Karapetyan et al. 2001).

Figure 5.4 – Known obsidian sources in Georgia, Armenia, and Eastern Turkey and key sites mentioned in the text.

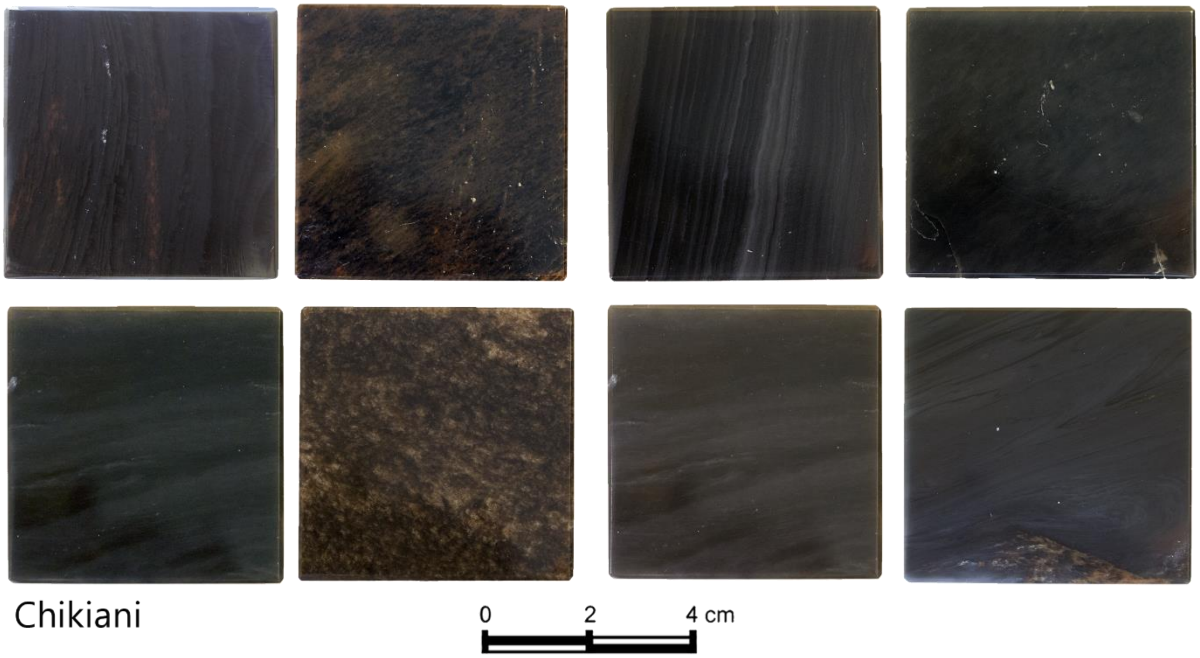


Figure 5.5 – Obsidian specimens from Chikiani, Georgia.

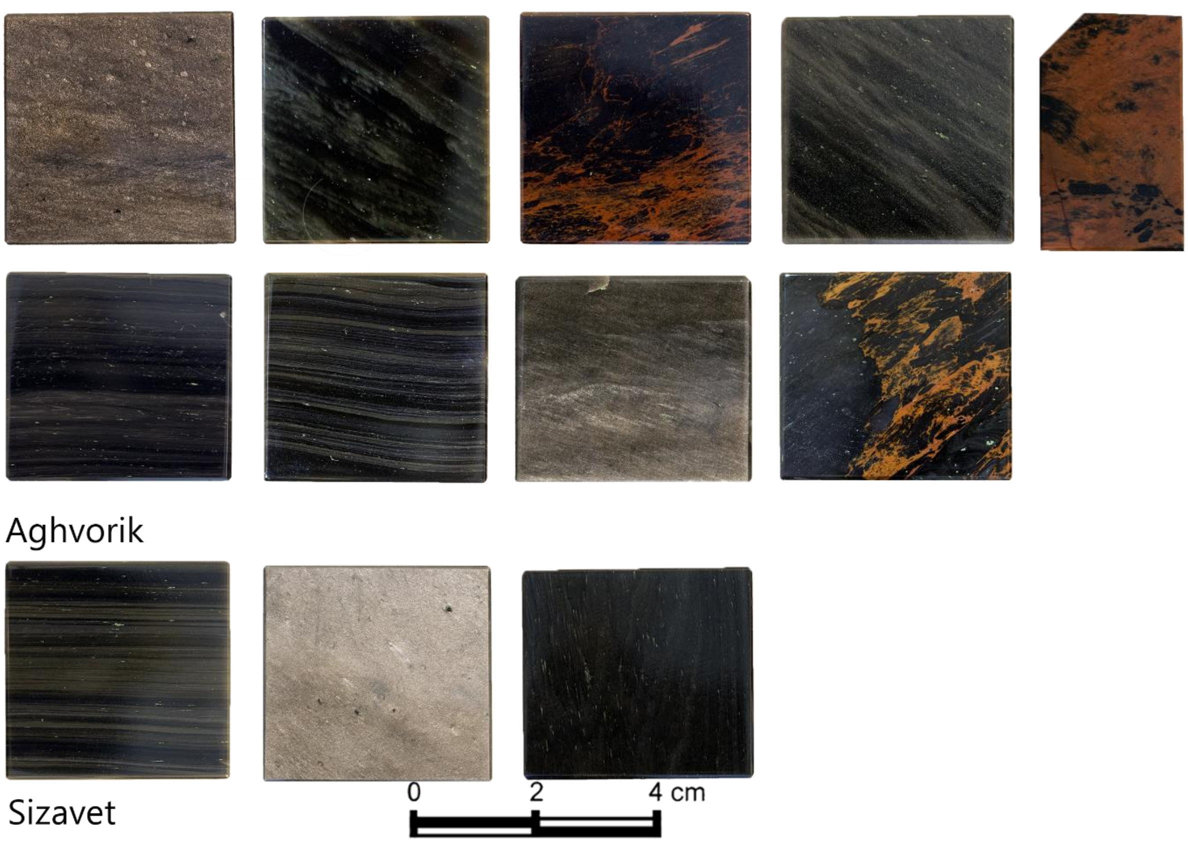


Figure 5.6 – Obsidian specimens from Aghvorik and Sizavet, Armenia.

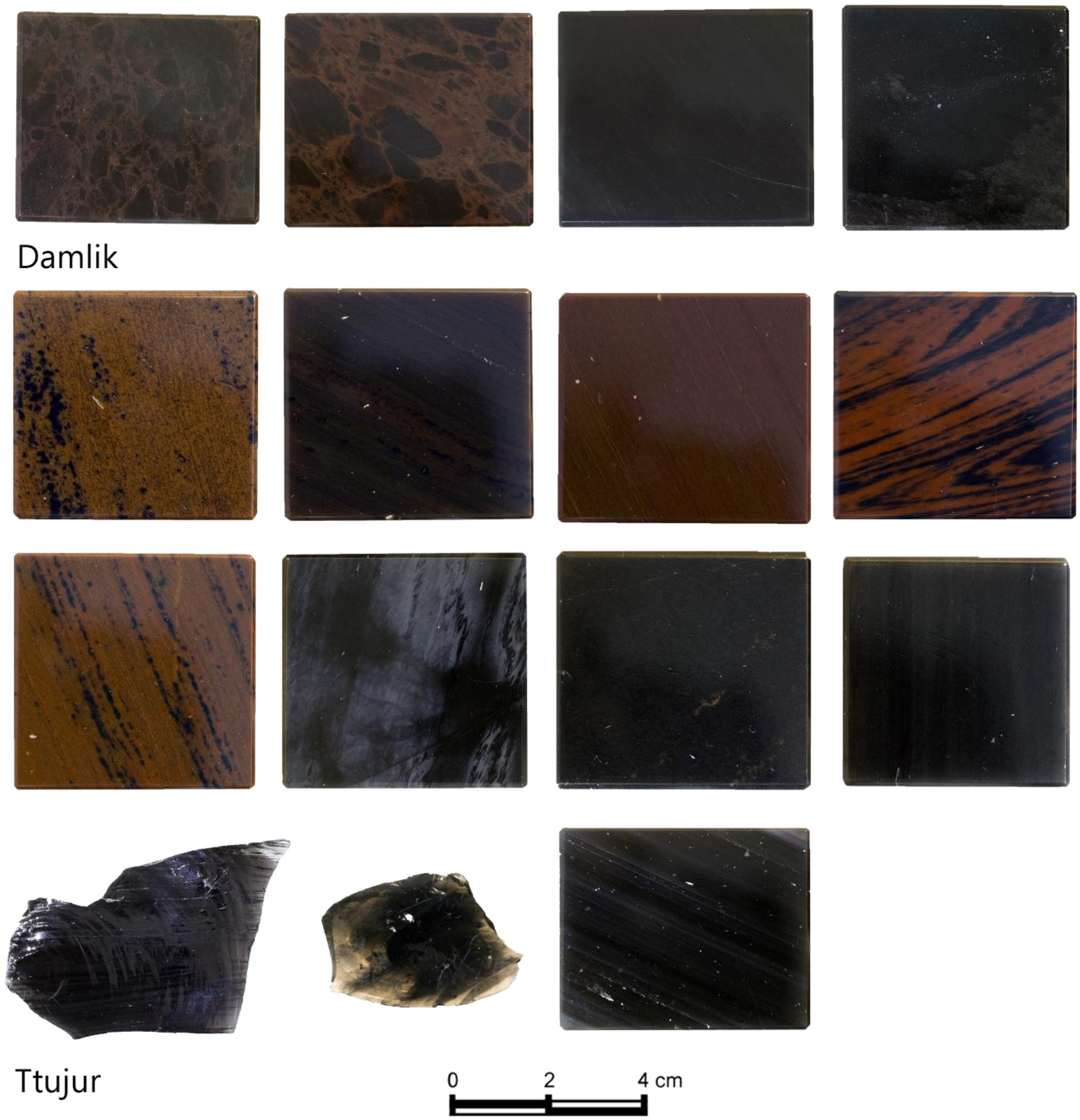


Figure 5.7 – Obsidian specimens from Damlik and Ttujur, Tsaghkunyats Range, Armenia.

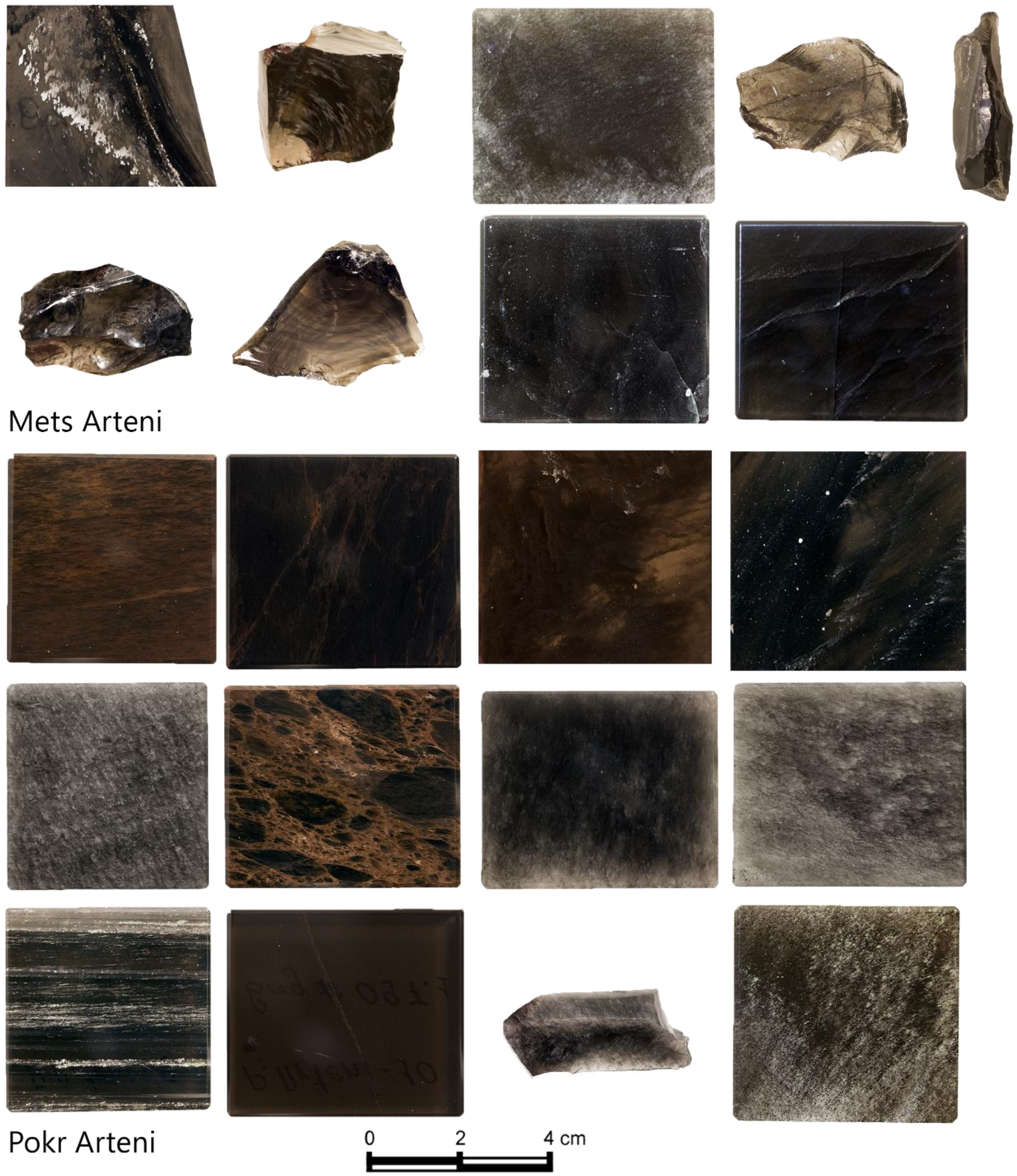


Figure 5.8 – Obsidian specimens from Mets Arteni, including the Aragats flow, and Pokr Arteni, Armenia.

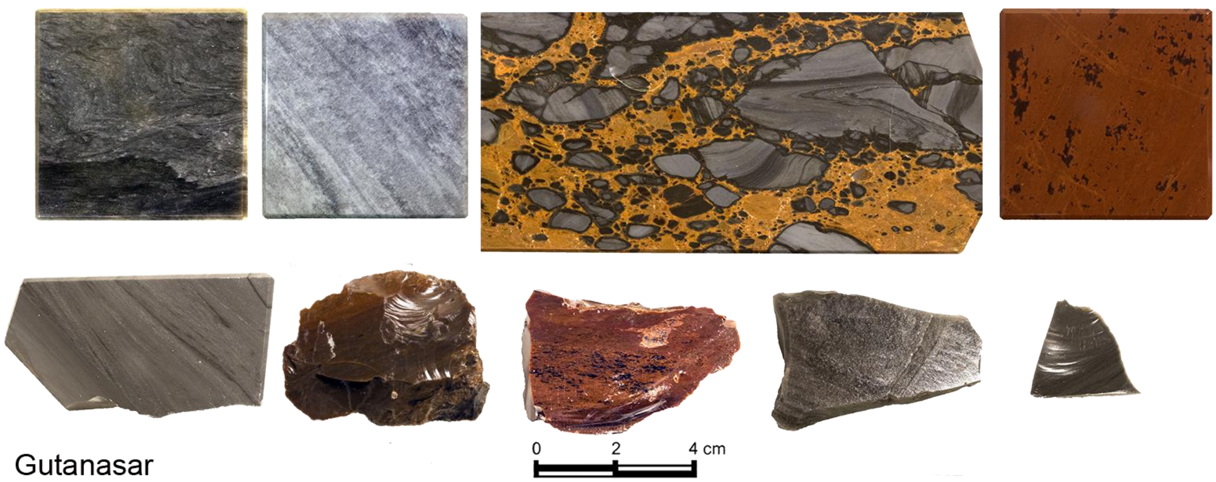


Figure 5.9 – Obsidian specimens from Gutanasar, Armenia.


0
2
4 cm

Figure 5.10 – Obsidian specimens from Hatis, Armenia.

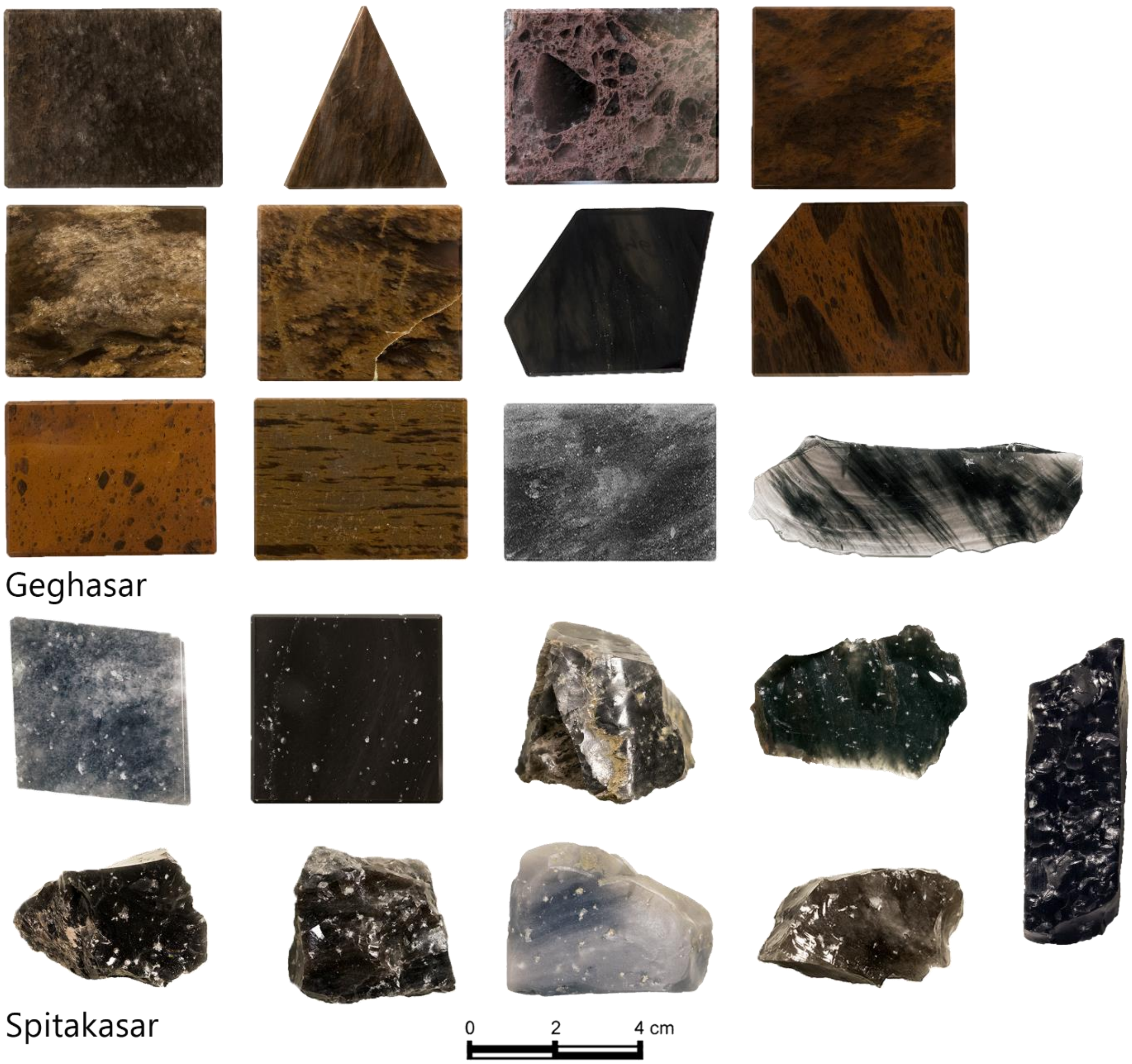


Figure 5.11 – Obsidian specimens from Geghasar and Spitakasar, northern Geghama Range, Armenia.

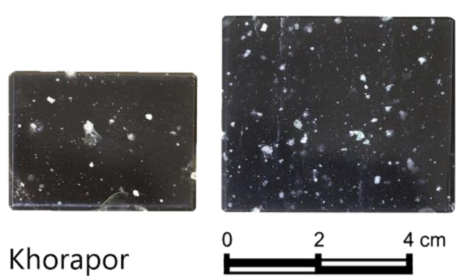


Figure 5.12 – Obsidian specimens from Khorapor, Armenia.

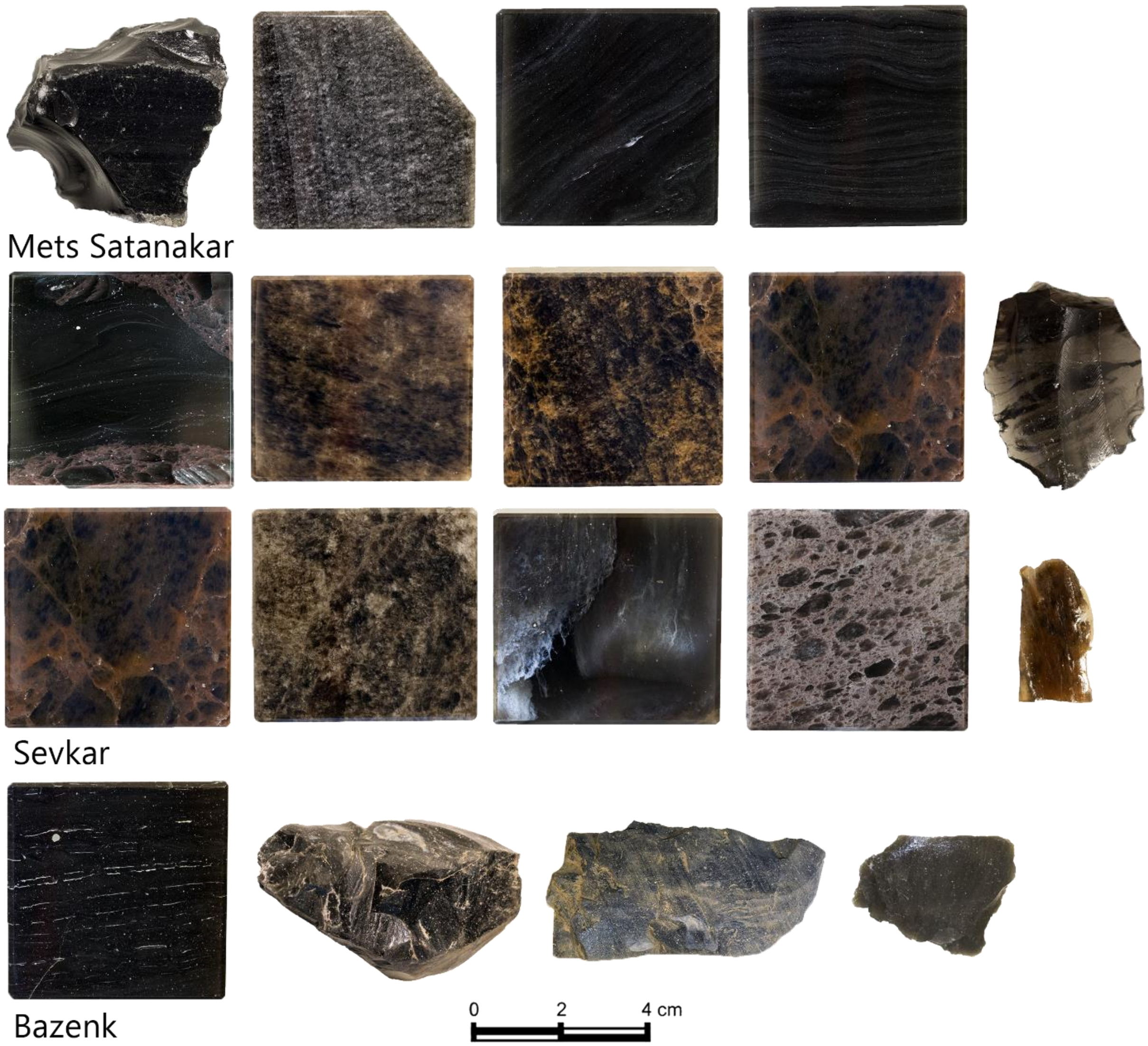


Figure 5.13 – Obsidian specimens from Mets Satanakar, Sevkar, and Bazenk sources of Syunik, Armenia.

Figure 5.14 – Obsidian specimens from Sarikamiş, Yağlıca Dağ, Pasinler, and Erzurum sources of Eastern Turkey.

5.4 Masis Blur Obsidian Artifacts Selection Strategy

Obsidian artifacts were selected from the field seasons of 2012 through 2014 with the main purpose of bulk compositional analysis. A total of 11,881 lithic artifacts were uncovered during 3 seasons of excavations, 97% of these (n=11,538) are made of obsidian. As a result of instrument availability, the elemental analyses of the obsidian artifacts were undertaken in several phases and with three different Tracer pXRF instruments. In 2013, I chose a sample of 207 artifacts based on visual variations and exported these to UCLA for analysis. In 2014, I was permitted to export an additional 750 artifacts, the total number of artifacts excavated from secure contexts, for non-distractive analysis. Upon closer examination a number of these had either a patina or residue visible to the naked eye, so I excluded them from analyses. At the end, I analyzed 854 artifacts, out of which 754 come from secure contexts. While the samples analyzed in 2013 meant to establish a general trend with respect to the potential number of sources represented in the assemblage and were chosen independent of context and tool type, obsidian artifacts analyzed in 2014 were chosen specifically for their contextual information. This group comes from household, burial, and domestic activity areas that have been securely dated using radiocarbon dating. The final phase of analyses took place in Armenia. In 2015, using an instrument on loan from Bruker, I analyzed all the cores and core fragments (n=114), plus a 7% random sample (n= 831) from the topsoil and disturbed or intrusive contexts. Since the artifacts analyzed between 2013 and 2014 were selected specifically because of their appearance (color, texture, etc.) or their context (e.g. burial), they cannot be assumed to depict an accurate representation of source preferences at Masis Blur. A random sample guarantees an unbiased selection from the sample population that meets the criteria of the pXRF analytical method (i.e. all the obsidian artifacts excavated between 2012 and 2014).

In order to select random samples from the assemblage, I assigned a Unique Identifying Number (UID) to all obsidian artifacts and entered these into a Microsoft Excel database. Next, I identified all those obsidian artifacts, which meet the minimum requirements (detailed below) for pXRF analysis. In turn, a separate database was created for all samples meeting these requirements and digitally numbered from 1 to 5070. I used an online random number generator to obtain non-repeating numbers between 1 and 5070. All those artifacts that had been analyzed as part of the "context-based" or "color-based" analysis were not re-analyzed. The selection criteria for the artifacts follow the minimum requirements for pXRF analysis are as follows: the selected sample must 1) have a smooth surface, 2) be at least 2 mm thick and 10 mm wide, and 3) be free of heavy residue. The artifacts required minimal preparation and a quick rinse under running water cleaned all adhering soil. In total, over the course of three lab season, I analyzed 1799 artifacts from Masis Blur. Regrettably, I was unable to find a sound method that would allow me to directly compare artifacts and specimens analyzed on different instruments. Thus, in this dissertation I present only the dataset analyzed in the US (i.e., 854 artifacts). The second dataset analyzed in Armenia will be incorporated into future publications.

5.4.1 Analytical Parameters and Instrumentation

All artifacts and geological specimens were analyzed using a Bruker Tracer III-SD portable XRF. The x-ray tube was operated at a 40 kV, 14 µA, using a Cu-Ti primary beam filter. The obsidian artifacts were scanned for 200 seconds live-time to generate x-ray intensity data for the following elements: manganese (Mn), iron (Fe), zirconium (Zn), gallium (Ga), thorium (Th), rubidium (Rb), strontium (Sr), yttrium (Y), and zirconium (Zr), and niobium (Nb). The instrument was operated on a stand as previous experiments have shown that the stability, largely a result of practical "know how" concerning hand held operations of the instrument can affect the results (Frahm 2014; Goodale, et al. 2012). In addition, the analyses were performed in laboratory-like conditions, over many days making the use of a stand more practical.

In order to facilitate inter-laboratory comparisons and determine the analytical precision and accuracy of the instrument, three standards: AGV-1 (andesite, Gunao Valley, Oregon), SCo-1 (cody shale, Teapot Dome, Wyoming), and QLO-1a (quartz latite, Lake County, Oregon) were included in the analysis. In order to determine *accuracy* established values of the standards are compared against the values measured by this study. Accuracy is commonly expressed as the percent relative error (%RSD) of a measurement. P*recision*, also known as reproducibility, is defined as the degree to which a series of measurements with the same conditions give the same results. The results of precision and accuracy tests are summarized in Table 5.1. The only significant difference is observed in the unusually high levels of strontium in the andesite standard (AGV-1). This is explained by the fact that the calibration file used to convert the spectra of the pXRF into part per million (ppm) concentration measurements is based on obsidian; a material that does not have high concentrations of Sr. Thus, the calibration file is not perfect for using with samples containing high Sr concentrations. However, when Sr concentrations are lower and closer to that of obsidian, such as in the cody shale (SC0-1) standard, the instrument shows remarkably similar concentration levels.

Element (ppm)	AGV-1		SCo-1	
	USGS reported	%RSD	USGS reported	%RSD
Mn	710	11	-	23
Fe	-	1	410	1
Zn	88	11	100	8
Ga	20	6	15	8
Th	7	21	9.7	19
Rb	67	3	110	4
Sr	660	2	170	3
Y	20	9	26	8
Zr	227	2	160	2
Nb	15	9	11	7

Table 5.1 – Results of precision and accuracy tests of the Bruker Tracer III-V^+ pXRF using AGV-1 (Andesite), QLO-1 (Quartz Latite), and SCo-1 (Cody Shale) USGA standards. Each sample was analyzed 10 consecutive times to measure instrument precision and once at the beginning and at the end of each measurement session.

5.5 Statistical Methods for Source Discrimination and Artifact Assignment

In obsidian sourcing, the two main approaches used to differentiate sources from one another (generally called source discrimination) and artifact assignment to a specific source are graphics-based approached using scatter plots and multivariate analysis techniques. Graphics-based approaches are simple yet effective ways to present visually elemental concentrations and groupings, which can be done in Microsoft Excel and do not require much (if any) expertise. Multivariate data analysis employs statistical techniques and there is an abundance of models to choose from, each with its own assumptions and requirements. In the following section I discuss the most commonly used multivariate techniques used in obsidian sourcing studies and the techniques adopted for this dissertation.

5.5.1 Graphics-Based Discrimination and Sourcing

Graphical representation of elemental concentrations, often two or three elements, using scatter plots are the most common approach to data analysis. Shackley states that "in many cases the bivariate plots may be a more accurate reflection of source heterogeneity, as well as a better media for source assignment" (1998a:13). He further maintains that "simple bivariate plots and central tendency statistics comparing the artifact and geological data is often sufficient to assign artifacts to sources (2008:198).

5.5.2 Multivariate Discrimination and Sourcing

Multivariate statistical techniques are another approach to source differentiation and artifact assignment. Although Shackley cautions that source “assignment based on multivariate statistical measurements do not necessarily represent groupings based on what is occurring in the field” (2002:60) and warns against the exclusive reliance on multivariate analyses (2005:94). Principal components analysis (PCA) (e.g., Ericson and Glascock 2004), discriminant function analysis (e.g., Eerkens, et al. 2008; Keller and Seifried 1990), cluster analysis (e.g., Blackman 1984; Oddone, et al. 2000) are the most commonly used statistical techniques. There has been some criticism in recent archaeometric literature regarding the use of these techniques for sourcing studies, largely because these techniques make a number of assumptions about that dataset, which often cannot be met. For example, discriminant function analysis requires the identification of *a priori* groupings in the dataset. Since we cannot assume that collection locals or even visually distinct sub-sources of obsidian flows correspond to distinct chemical groups, there is no valid way to define such groups in advance. Clustering analysis requires a choice regarding the number of groups present in a dataset, which forces an arbitrary and artificial structure onto a dataset. This approach is most problematic for sources which have more than one chemical group. In cluster analysis groups are formed based on “likeness” of variables, but it is left up to individual researchers to determine whether these groups are meaningful to the archaeological question at hand (Harbottle 1982). Principal components analysis (PCA) is used to reduce the overall dimensionality of the dataset to those variables that account for the grates amount of variation in the dataset. In obsidian sourcing studies, these variables, or principal components, are those elements that clearly demonstrate clustering patterns, i.e. source groups. It assumes there is an existing structure in the data and this structure can be modeled. The first few principal components (or PCs) often explain most of the variance in a dataset, which allows to identify patterns that correspond to clusters. In terms of obsidian sourcing, these clusters correspond to distinct chemical groups either representing different sources and sub-sources within a group. One key requirement of PCA is that the number of observations (i.e., obsidian specimens or artifacts) used must be equal to or greater than the number of variables. While generally two PCs can be used to describe the difference in the dataset, in order to adequately describe the entire datasets multiple PCs may be needed. The results of PCA are often illustrated using bivariate or tri-variate scatterplots, which help to identify the elements responsible for the variance and how these elements differ between individual samples.

5.5.3 Analytical Techniques Employed in the Dissertation

In the present research, I made use of a number of methods for identification of obsidian source groups, including graphic-based discrimination based on bivariate plots and statistical methods, such as PCA and group membership probabilities using Mahalanobis distances. Bivariate elemental plots are used to identify and refine groups within the dataset suggested from the PC analysis. Confidence ellipses are drawn around the groups to show the probability surfaces (in two dimensions) for group membership. Typically, the ellipses are drawn at the 90 percent confidence level. For this study, PCA was used to determine the elements which describe the greatest variance in the dataset, to determine the archaeological data structure and possible groupings within the data. Bivariate scatter plots were used to compare the results of simple bivariate plots and multivariate analyses and to illustrate groupings in a more elegant and accessible manner.

5.6 Discussion

The utility of portable XRF for sourcing geological and archaeological obsidian has been well established in archaeometric research. Good accuracy and precision, fast and relatively inexpensive non-destructive analysis, extensive elemental coverage of elements of interest for archaeometry, the capability to bulk or analysis, and portability have made pXRF a preferred tool for archaeological research. In my analyses I used a Bruker Tracer pXRF to collect elemental composition data on the geological and archaeological samples and the obsidian calibration file developed by University of Missouri Research Reactor Centre to convert the instrument's spectral output into parts per million (ppm) counts for quantitative analysis. I used scatterplots and Principal Components Analysis (PCA) to identify elements which exhibit most variability among different sources, and bivariate scatterplots and Mahalanobis distances probabilities to determine the archaeological data structure, and to assign archaeological obsidian artefacts to geological sources based on elemental composition data.

In total, I have analyzed 167 geological obsidian specimens from 13 source groups in Armenia, 7 from the Chikiani source in Georgia, and received 22 specimens from 5 sources in eastern Turkey. These were used as a reference collection for the 854 obsidian artifacts analyzed from Masis Blur. Chemical composition data for ten different elements were collected using a Tracer III-SD portable XRF. The results of the analyses are presented in Chapters 6, while raw elemental data for both geological and archaeological samples are presented in Appendices 1 and 2 of this dissertation.

CHAPTER 6: RESULTS OF COMPOSITIONAL ANALYSIS OF MASIS BLUR ARTIFACTS

This chapter presents the results of geological source characterization and source assignment for obsidian artifacts analyzed from Masis Blur Neolithic settlement. It discusses, in some detail, the results of obsidian characterization from the sources considered in this study, which are important for obsidian sourcing studies in the region as well as allowing us to present a more complex sub-source variation within each source. To put these results within a larger context, the chapter begins with some statistics about the prevalence of obsidian, as well as offers initial assessment of the tool types and observations about the likelihood of obsidian production at the site. The implications of the obsidian sourcing results from Masis Blur are discussed in Chapter 7.

The results of the geological source characterization and artifact attributions are illustrated using bivariate plots of key elements, Principal Component plots, and tables illustrating the probability of an artifact belonging to a specific source group based on their Mahalanobis distances. Appendix 1 provides the element concentration information on the geochemical source studies, mean values, and the standard deviation for the source. Appendix 2 provides the elemental concentration information on the archaeological artifacts analyzed in this study. Artifacts that could not be attributed to a source are indicated with an asterisc. Appendix 3 provides individual element scatterplots for all the sources. Appendix 4 provides bivariate plots of geological sources and overlap of artifacts and specimens. Appendix 5 gives the results of source attribution based on MD probabilities for the 167 geological specimens and 854 archaeological artifacts. Maps with GPS points indicating specimen collection loci are provided in Appendix 6. Images of Armenian and Georgian obsidian sources analyzed in this study can be found in Appendix 7. And Appendix 8 provides images of select Masis Blur obsidian artifacts attributed to Eastern Turkish sources.

6.1 Observations on the Obsidian Industry at Masis Blur

The chipped stone industry at Masis Blur is dominated by high quality obsidian with 97% of 11,881 artifacts made of obsidian. Basalt, andesite, dacite, flint, quartzite, and marble make up the remaining 3 percent. All these are either flakes or rough tools. The total mass of excavated obsidian is over 60 kg. This mass excludes cores and core fragments, which have a total mass of about 15 kg. Blades and blade fragments dominate the assemblage. Microblades, with a large number of retouched tools, such as backed blades, geometric microliths, especially trapezes and triangles, and various perforators and scrapers are also present in the assemblage. The near absence of cortical flakes (less than 1%) and sparsity of debitage indicates that initial core preparation was done outside of the settlement, likely at the raw material source, and only well-formed cores were brought to the site. However, the large number of cores in various stages of use, secondary flakes, and crested blades, indicated that blade knapping and final tool production was done at the site. The general distribution of obsidian blanks and tools suggests house-hold level production activities of chipped stone. While obsidian pebbles and cobbles have been found in every building horizon at Masis Blur, none of them seem to have been used for tool production, as their size was not sufficient for knapping the large obsidian blades preferred by the Neolithic inhabitants of the Ararat plain. Their function within cultural layers is yet to be identified.

The vast majority of obsidian at Masis Blur is of high quality, many of these are translucent, and some are so clear that one can read text through them. Few pieces have mineral inclusions, likely feldspar, visible to the naked eye (Figure 6.1). The wide variety of visually distinct obsidian types present at Masis Blur may lead one to suggest that the Neolithic inhabitants utilized multiple sources for obtaining the raw material. While sourcing studies demonstrate this to be accurate, volcanological studies undertaken in the 1960-1970s revealed that a single source with the same geochemical composition (e.g., Pokr Arteni and Geghasar) can have as many as a dozen color and pattern variations. Source attribution based on visual parameters can be not only more time consuming and challenging, but also highly inaccurate for Armenian obsidian, hence, requiring more advanced techniques and instrumentation for sourcing studies.

Figure 6.1 – Worked cobble flake from Masis Blur showing white inclusions (likely feldspar) visible to the naked eye.

6.2 Findings from the Geochemical Characterization of Geological Obsidian

From prior studies using a number of different analytical methods, it has been determined that the elements Mn, Fe, Rb, Sr, Zr, and Nb, could be used to differentiate obsidian from various sources in the region. I used scatterplots (Figure 6.2) and PCA (Figure 6.3) in this study for the initial exploration of the dataset and to identify key elements that are contributing the most to the variability within the dataset. PCA is a method known to be highly influenced by large differences in scale (Baxter 1995), thus a log-transformation of concentration data was performed to produce statistically comparable values and to enhance the PCA in the identification of source groups. Once the initial clusters were identified using PCA, I used Mahalanobis distances (van der Knaap, et al. 2010) probabilities to calculate the probability that a particular specimen belongs to a group. The eigenvectors of the PCA indicate that Fe, Sr, Zr, Nb, and Y (to a lesser degree) contribute the greatest to variability within the dataset and that PC1 and PC 2 (the first two components) summarize 86.87% of the variability. The elemental scatterplots of geological specimens analyzed in this study indicate that, while Mn can be helpful for distinguishing sub-sources of Pasinler and Sarikamiş, it does not exhibit a strong variability across many of the sources. Elements Zn, Ga, and Th exhibit even less or nearly no variation, thus were entirely omitted from subsequent analysis. Using scatter plots, five main elements – Fe, Sr, Zr, Nb, Y – can be used to distinguish among the various sources analyzed in this study. These results are well corroborated by the PCA. While not all elements and element combinations are equally well suited to differentiate between different sources, different combinations of the five key elements can be used to distinguish between overlapping sources. For example, while the Syunik sources – Mets Satanakar, Sevkar, and Bazenk – overlap with Arteni, Khorapor, Geghasar, Spitakasar, and Sarikamiş when plotting the concentrations of Fe, Nb, and Sr, the biplot of Rb versus Y separates this group quite well from all other sources analyzed in this study. Similar observations were made for many of the sources analyzed. I discuss these in some detail below. I also used an iterative process to help refine source differentiation and artifact attribution.

The elemental composition analysis revealed sub-source variation within several of the volcanic complexes confirming observations reported elsewhere that portable XRF is a reliable method for obsidian sourcing studies in the Southern Caucasus and eastern Turkey. Through the examination of the Fe, Sr, and Zr scatter plots, I was able to identify sub-source variation using Fe and Zr concentrations at Chikiani in Georgia, Hatis, Arteni, and Bazenk in Armenia, and Sarikamiş, Pasinler, and Yağlıca Dağ in eastern Turkey. The results of geochemical characterization of geological obsidian specimens are presented below. The Southern Caucasus sources are discussed in a north to south order starting with Chikiani in Georgia. Specimens from eastern Turkey are discussed in an east to west order starting with Yağlıca Dağ.

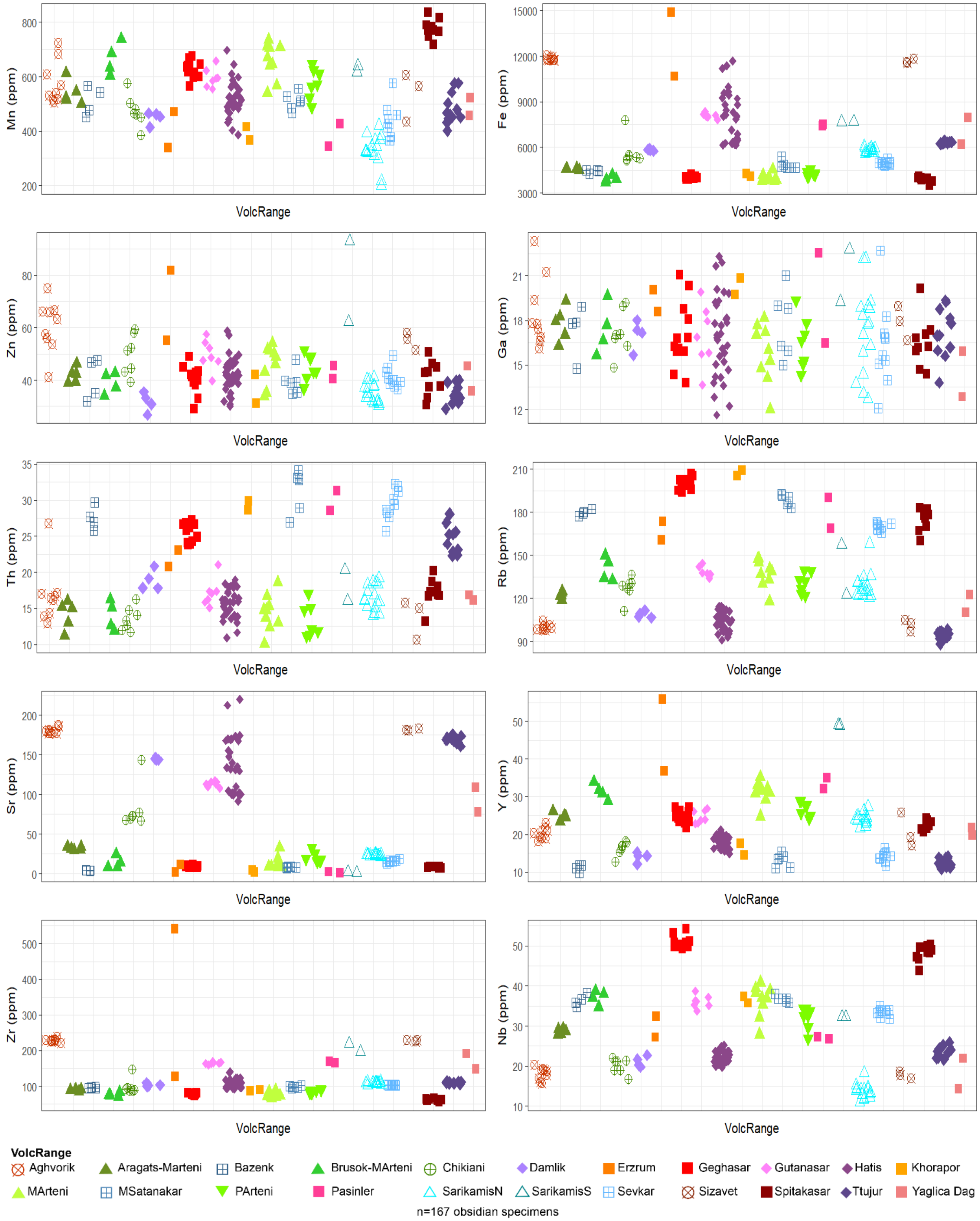


Figure 6.2 – Elemental scatter plots for 167 geological specimens demonstrating discrimination between sources based on the 2 major, Mn and Fe, and 8 trace elements, Zn, Ga, Th, Rb, Sr, Y, Zr, and Nb, measured by the portable XRF.

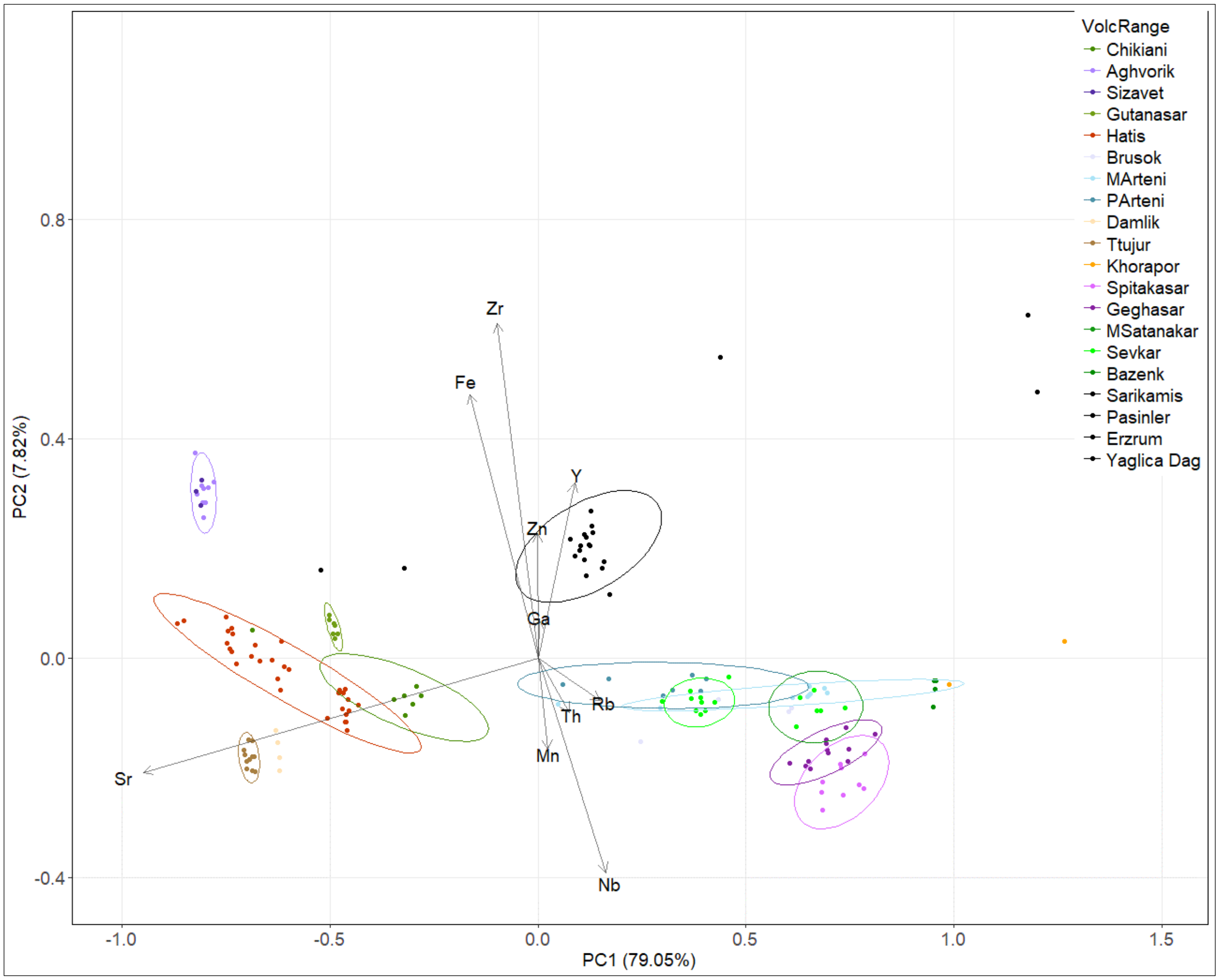


Figure 6.3 – PCA bivariate plot of first two components (summarizing 86.87% of the total variation) of 167 geological obsidian specimens from Georgia, Armenia, and eastern Turkey showing the elements responsible for greatest variance within the dataset. The confidence ellipses are drawn at 95%. Confidence ellipses can be calculated only for sources with more than 4 specimens. Log-transfer was performed to reduce the scale difference of variables.

Importance of components	PC1	PC2	PC3	PC4	PC5
Standard Deviation	1.931	1.4701	1.1910	1.0250	0.62635
Proportion of Variance	0.373	0.2161	0.1418	0.1051	0.08407
Cumulative Proportion	0.373	0.5891	0.7309	0.8360	0.92005
Rotation:					
Mn	0. 0244522452	-0. 16733228	0.41756050	0. 38081423	0. 13527920
Fe	-0.1645430657	0.48026047	-0.05389860	0.27807328	0.05887623
Zn	-0.0006865452	0.22688256	0.20905140	0.25807739	0.56118654
Ga	0.0023213147	0.06992110	-0.03249569	0.05599554	-0.04716359
Th	0.0754396866	-0.09910204	-0.56563600	0.39483868	-0.44268278
Rb	0.1507230877	-0.07814220	-0.05803564	0.14108357	-0.04767339
Sr	-0.9485857129	-0.20884293	0.08110409	0.06945453	-0.12553805
Y	0.0881161002	0.31818962	0.59885292	-0.15002313	-0.64801558
Zr	-0.0982191737	0.60900216	-0.12752842	0.36082850 -	0.08594140
Nb	0.1633612684	-0.39155341	0.27055739	0.61203440 -	0.14059761

Table 6.1 – Standard deviation and their contribution to correlations for the first five principle components describing geological obsidian source differentiation.

6.2.1 Compositional Groups of Chikiani (Georgia)

Most obsidian characterization and sourcing studies that included source specimens from Chikiani focused on discrimination of the source based on its barium (Ba) concentrations, with some authors reporting a single group with a low concentration of Ba (400-700 ppm), while others report very high concentration (900-1200 ppm). A more extensive characterization of Chikiani obsidian by Biagi and Gratuze using LA-IC-PMs and based on 69 specimens from 20 different collection areas identified 3 distinct chemical groups based on Ba and Zr concentrations (2016). While portable XRF is not able to measure Ba, with only 5 geological specimens, I identified two distinct chemical groups based on Fe and Zr concentrations (Figure 6.4). Chikiani-1 is represented by only one sample (Chikiani.3.112) and has a high Fe (~ 7800s ppm) and Zr concentration (~140s ppm). Chikiani-2 is represented by 4 specimens with lower Fe (~5000s ppm) and Zr (~90s ppm) concentrations. The third group identified by Biagi and Gratuze was not identified in the present study. This is most likely a sampling issue, as I collected only 5 specimens from a relatively restricted area of Chikiani. Chikiani-1 identified in this study corresponds to Group 3 identified by the authors, and Chikiani-2 corresponds with Group 2. The specimens from Chikiani overlap with those from Hatis, Damlik, Ttujur, and Yağlıca Dağ; however, the bivariate plot of Sr and Zr can separate the Chikiani source from all others analyzed in the study. While Chikiani contains high quality obsidian, prior studies show that none of it seems to have been exploited by the Neolithic and Chalcolithic inhabitants of the Ararat plain and sites located further south and west.

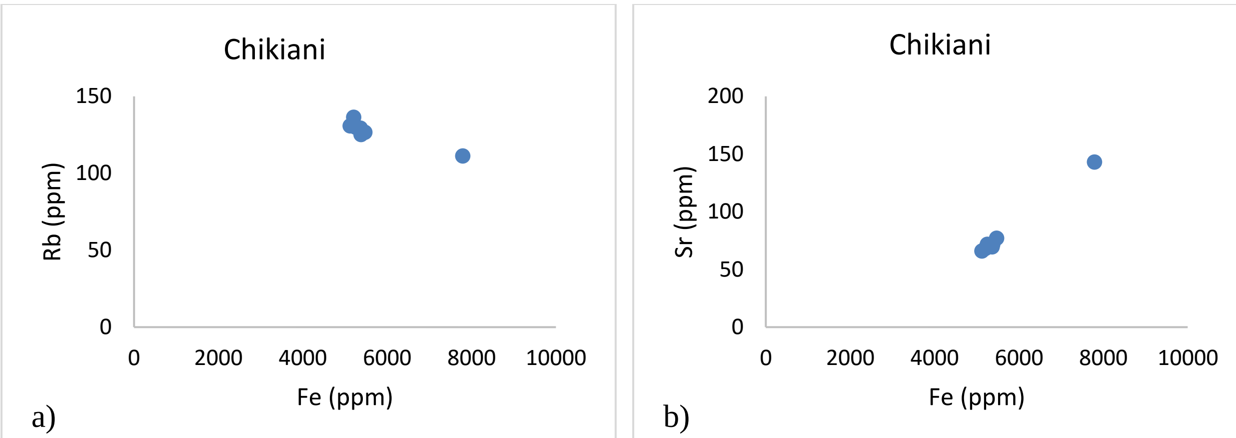
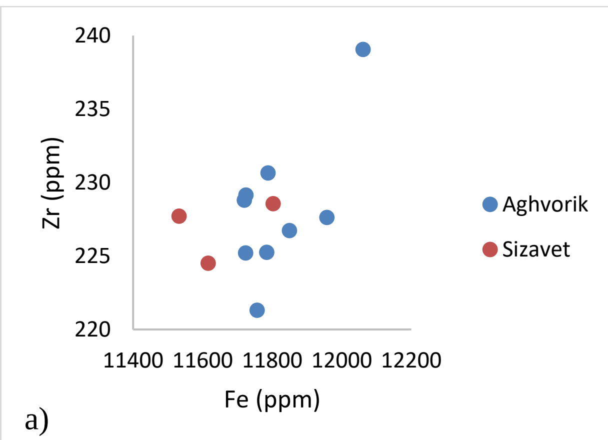


Figure 6.4 – Bivariate scatter plots for 7 obsidian specimens from Chikiani, Georgia, illustrating sub-source differentiation based on (a) Fe versus Rb and (b) Fe versus Sr concentrations.

6.2.2 Compositional Groups of Aghvorik and Sizavet (Armenia)

Located on the south-western foothills of the Djavakheti (Javakhk in Armenian), Aghvorik and Sizavet are the northernmost obsidian deposits of Armenia. Their outcrops are rare and not clearly visible on the surface due to heavy Holocene period deposits and vegetation coverage. While the obsidian is of high quality, their small size, between 10-15 cm, does not make them ideal for knapping the long blades preferred by Neolithic inhabitants of the Southern Caucasus. Blackman et al. (1998) analyzed 6 specimens from Aghvorik and 6 from Sizavet reporting a single chemical composition. Similarly, Chataigner and Gratuze analyzed 3 specimens from Aghvorik and identified a single homogeneous group. This is supported by my findings as well. I analyzed 3 specimens from Sizavet and 9 from Aghvorik and identified a single chemical composition. The obsidian from Aghvorik and Sizavet is differentiated from other Southern Caucasus sources by its considerably higher Fe (11,532-12,061 ppm) and Zr (225-239) concentrations. From all the geological specimens analyzed in this study, only a single specimen from Erzurum West has a higher Fe and Zr concentration measured at 16,728 ppm and 516 ppm respectively. As iron and zirconium concentrations from Erzurum West are considerably higher than those for Aghvorik and Sizavet, these sources can also be easily distinguished from one another. Furthermore, Fe versus Nb and Fe versus Sr biplots can be used to separate Aghvorik and Sizavet from all other sources analyzed in this study (Figure 6.5).



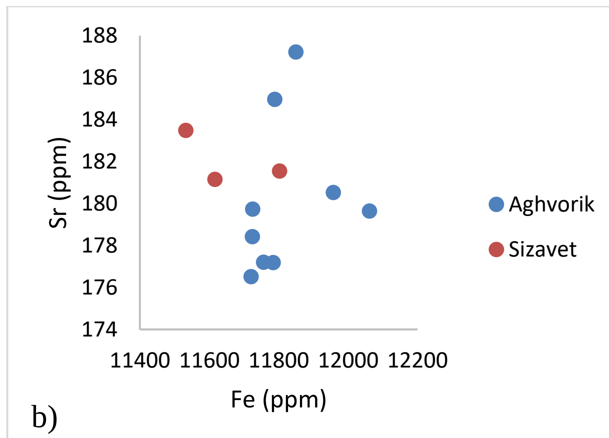


Figure 6.5 – Bivariate scatter plots for obsidian specimens from Aghvorik (n=9) and Sizavet (n=3), Armenia, showing specimen groupings based on (a) Fe versus Zr and (b) Fe versus Sr.

6.2.3 Compositional Groups of Tsaghkunyats Volcanic Range (Armenia)

The Tsaghkunyats volcanic range stretches for 43 km and has several obsidian-bearing volcanos: Damlik, Ttujur, Kamakar, Arkayasar, Haykasar, and Dalar. In earlier literature “Hankavan” (Blackman, et al. 1998), named after the village where obsidian boulders were found, was identified as one of the Tsaghkunyats obsidian sources. However, these are only secondary deposits of the number of sources mentioned above, which were transported downstream the Marmarik River. Two distinct chemical groups were reported by Blackman et al.

(1998) based on 8 specimens from “Hankavan/Damlik” and 2 from Kamakar. Chataigner and Gratuze (2014) also reported two compositional groups: Tsaghkunyats 1 comprised of specimens from Damlik and Ttvakar (another name for Ttujur) and Tsaghkunyats 2 formed by specimens from Kamakar and Haykasar. Chataigner and Gratuze were not able to distinguish between specimens collected from Damlik and Ttujur, which contrasts to the findings of the present study. In this study, I analyzed 4 specimens from Damlik and 12 specimens from Ttujur, which form two distinct chemical groups (Figure 6.6). The two sources can be differentiated based on their Fe, Rb, Sr, and Zr contents. Damlik specimens containing lower Fe (5755-5902 ppm), Sr (144-146 ppm), Zr (100-104), and higher Rb (107-111 ppm), whereas Ttujur contains higher Fe (6461-6239 ppm), Sr (161-176 ppm), Zr (105-114 ppm), and lower Rb (88-98 ppm). The results reported by Chataigner and Gratuze are surprising, as LA-IC-PMS is able to identify more elements including many measured by a pXRF and key REE elements used to differentiate between obsidian sources. Since they do not specify their sample collection loci, it is reasonable to suggest that this may be a result of sampling strategies. Specimens from Damlik and Ttujur overlap with those from Hatis and Chikiani-2; however, Fe and Sr concentrations can be used to separate these sources from all the other sources analyzed in this study and from one another.

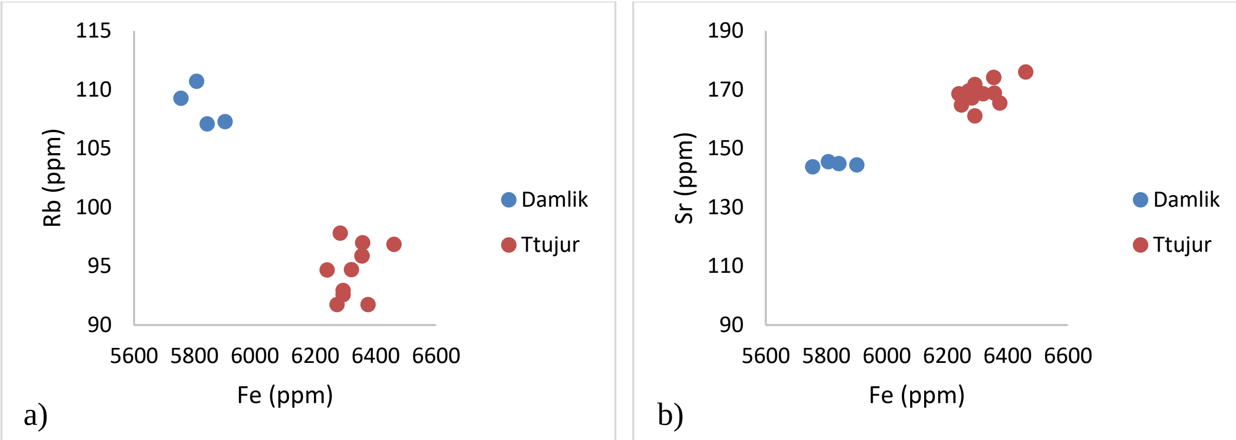


Figure 6.6 – Bivariate scatter plots for obsidian specimens from Damlik (n=4) and Ttujur (n=12), Armenia, illustrating differentiation between the two sources of the Tsaghkunyats volcanic range based on (a) Fe versus Rb and (b) Fe versus Sr concentrations.

6.2.4 Compositional Groups of the Arteni Volcanic Complex (Armenia)

The Arteni volcanic complex has two centers, Mets and Pokr Arteni, both of which produced high quality obsidian. The Aragats flow of Mets Arteni and Pokr Arteni flows extend to the base of the Ararat plain. Obsidian blocks also occur in the pumice deposits associated with the volcanic complex, such as Brusok and Satani Dar (also known as Tapak Blur). Many of the small tributaries of the Hrazdan and Akhuryan rivers, both of which are major tributaries of Araks River, flow through these obsidian deposits and were likely used as highways by the prehistoric inhabitants of the Ararat plain. Prior obsidian sourcing studies, particularly those by Badalyan and colleagues (2004a; Badalyan 2010), indicate that Arteni, specifically Pokr Arteni, was one of the most used obsidian sources in Armenia, contributing at least half of the assemblages at sites as far as 70 km away. Based on sourcing research of 29 artifacts from Masis Blur, Badalyan, et al. (2004a) have argued that over 70% of the obsidian at Masis Blur comes from Arteni. With Arteni obsidian found in the obsidian assemblages of all analyzed sites in the Ararat plain, and as far south as Nakhichevan and Iran, Arteni seems to have been a dominant choice for raw material acquisition by the prehistoric inhabitants of the region.

Three main chemical groups have been reported for the Arteni volcanic complex. Keller and Seifried (1990) analyzed three specimens form Mets and Poqr Arteni obsidian specimens and report that these constitute a coherent chemical group (Arteni 1A). Blackman et al. (1998) analyzed 5 specimens form the eastern flanks of Pokr Arteni and reported a notable compositional variability with 3 artifacts forming one group and the remaining two artifacts forming two more groups showing a considerable variance from the first group and from each other. Chataigner and Gratuze (2014) analyzed three specimens from Mets and Poqr Arteni and identified three groups: Arteni 1, 2, and 3. Their Arteni 1, based on obsidian specimens from Mets Arteni and Satani Dar, corresponds to Keller and Seifried's Arteni 1A sample, characterized by low Ba and Zr content. Arteni 2, characterized by high Ba concentration corresponds to Keller and Seifried's Arteni 1B sample. Finally, Arteni 3, characterized by the highest Ba concentration corresponds to Keller and Seifried's Arteni 1C sample. The obsidian specimens for the latter two groups come from the Pokr Arteni and Aragats flows. More recently, Frahm analyzed 55 specimens from Pokr Arteni collected from four loci concluding that "two similar obsidian compositions exist on one continuum, likely due to geochemical evolution of the magma" (2014:119). He further maintains that the gap observed in the two groups is either a sampling issue or that the intermediate group cannot be sampled due to a number of geological events, such as flow folding during emplacement.

I identified five potential chemical groups within the Arteni volcanic complex based on 25 specimens from Mets Arteni, the associated Aragats flow, Pokr Arteni, and Brusok. Samples were not obtained from the Satani Dar outcrop. These groups are best differentiated by their Sr and Zr contents, however, as noted by Frahm, the groups associated with Pokr Arteni seem to be more continuous in their elemental concentrations than those of Mets Arteni (Figure 6.7).

Additionally, obsidian specimens from the Aragats flow exhibit a closer elemental composition to groups of Pokr Arteni than to compositional groups of Mets Arteni. In order to create tighter groupings, I plotted the ratios of Zr to Rb and Sr to Nb were against each other (Figure 6.8). While this improved the clusters slightly, Pokr Arteni still exhibits a wider spread. The Brusok outcrop is not well defined, two of the specimens fit with the chemical composition of Mets Arteni and two with that of Pokr Arteni containing the lowest Fe concentrations. Following existing nomenclature, the chemical group of Mets Arteni, containing the lowest Sr and Zr values, between 8-9 ppm and 67-75 ppm respectively, is identified in this study as Arteni-1. Two specimens from Brusok (Brusok.1.090.2 and Brusok.2.091) fit best with Aretni-1. Arteni-2 is defined by the specimens from the Aragats flow, which contain higher concentrations of Fe and Sr, between 4590-4607 ppm and 30-34 ppm respectively, high concentrations of Zr, between 87-92 ppm, and the lowest concentrations of Rb. One specimen from Mets Arteni (MetsArteni.7.092) and one from Pokr Arteni (PokrArteni.0.095) also fit with Arteni-2. Arteni-3, Arteni-4, and Arteni-5 are associated with the flows of Pokr Arteni.

Arteni-3 has the lowest concentration of Fe, ~ 4100-4280s ppm, with Arteni-4 containing 4386 ppm of Fe and Arteni-5 containing the highest concentration at 4546 ppm. Arteni-4 and Arteni-5 also contain higher levels of Sr, 25 ppm and 32 ppm respectively, whereas the Sr content of Arteni-3 ranges between 16-19 ppm. Arteni-3 identified in this study matches Group 1 and Arteni-4 matches Group 2 identified by Frahm (2014). Portable XRF values reported by Frahm were plotted against the values obtained in this study to see how they compare. Figure 6.9 shows that the compositional data for the key elements obtained by the two studies compare quite well. Groups Arteni-4 and Arteni-5 are both represented by one artifact, which does not allow for statistical comparisons between and within the groups. However, as is demonstrated by the scatter plots in Figure 6.9, these specimens exhibit a strong variation from other Poker Arteni specimens, identified here as Arteni-3, and from one another. While it is possible that Arteni-4 and Arteni-5 represent outliers, when these specimens are plotted with specimens analyzed by Frahm, Arteni-4 falls within Frahm's Group 2, which is represented by 5 specimens, suggesting that the single specimen identified in this study as Arteni-4 is more likely to represent an individual sub-group rather than an outlier. It seems plausible that Pokr Arteni has several chemical groups; however, the associated flows are not easily identifiable, making a representative sample collection difficult. Due to certain requirements of the statistical methods utilized in this study, which require a greater sample size, I treated the specimens identified above as belonging to distinct chemical groups as a single "Mets Arteni" or "Pokr Arteni" group in the analysis. While, various specimens from the Arteni sub-groups overlap with specimens from the Syunik sources, Khorapor, Spitakasar, Geghasar, and Sarikamiş, differentiation between these sources is possible using Nb and Y concentrations normalized to Zr.

I must note here, that in Appendix 1 and 2 the specimens collected from the Aragats flow of Mets Arteni were identified ("Sample IDs") as coming from Pokr Arteni. These flows are very difficult to distinguish in the field and the error was realized only in the laboratory, when GPS points where imported into Google Earth. To avoid further potential errors that could be made during relabeling the artifacts, which would require also the relabeling of specimens from the same collection loci left in Armenia, changing associated notes in the field notebook, and the metadata of the GPS unit, it was decided to leave the original specimen IDs.

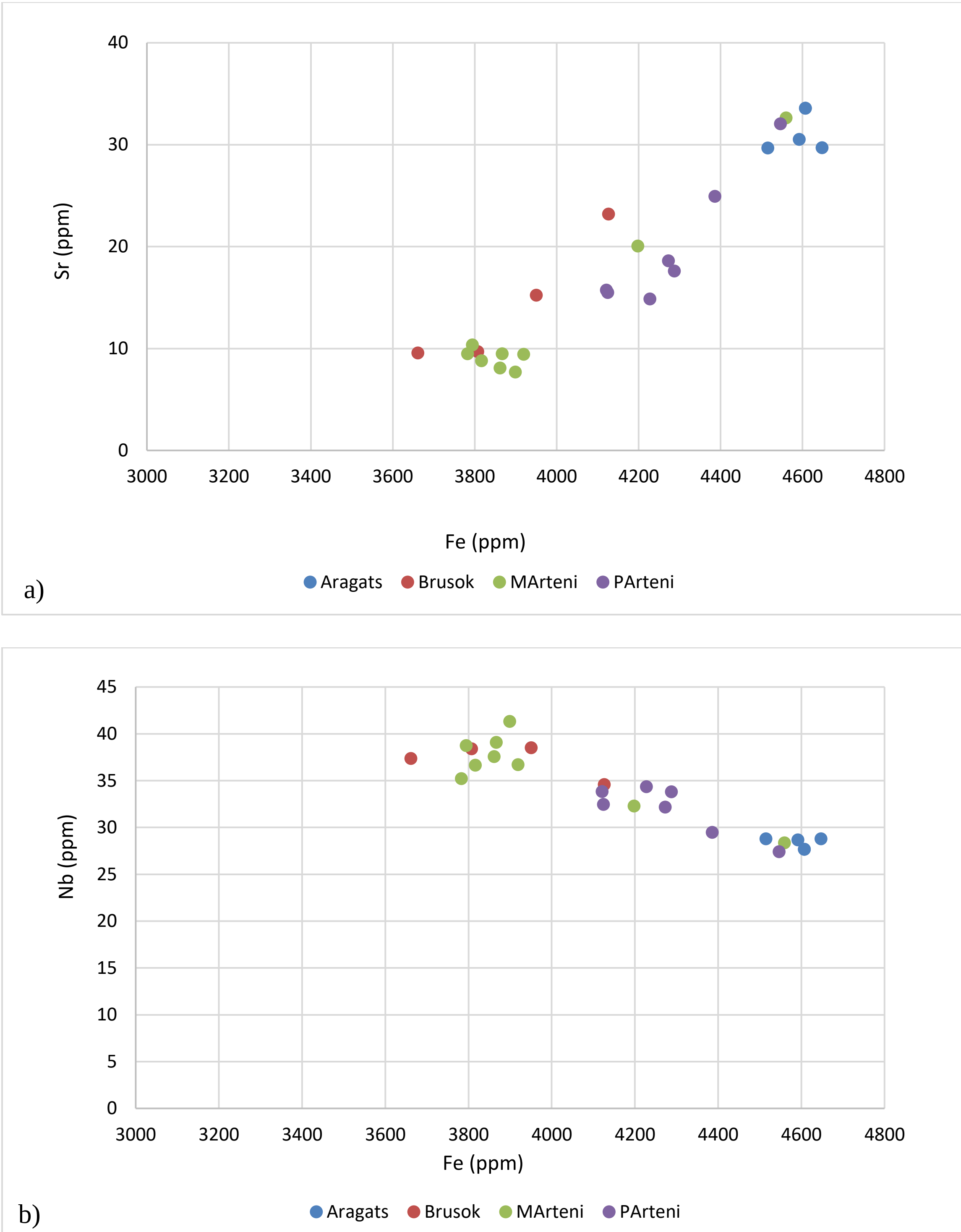


Figure 6.7 – Bivariate scatter plots of 25 obsidian specimens from the Arteni volcanic complex, Armenia, illustrating differentiation between Mets (Big) and Pokr (Speakman, et al.) Arteni, the Aragats flow of Mets Arteni, and the Brusok outcrop based on (a) Fe versus Sr and (b) Fe versus Nb concentrations.

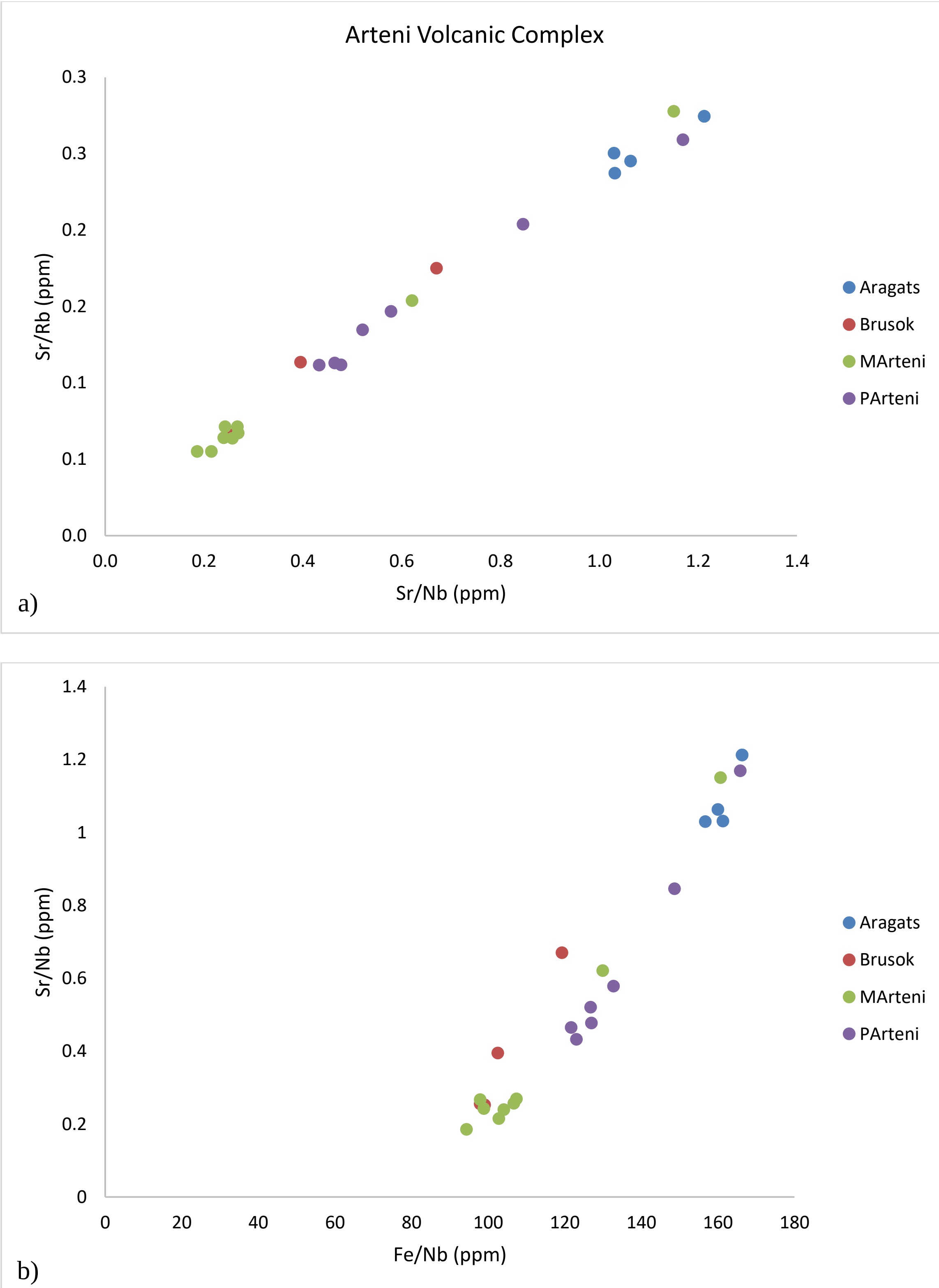


Figure 6.8 – Plots of (a) Sr/Nb versus Sr/Rb and (b) Fe and Sr normalized to Nb demonstrating a better separation of obsidian specimens from the Arteni Volcanic Complex (Armenia).

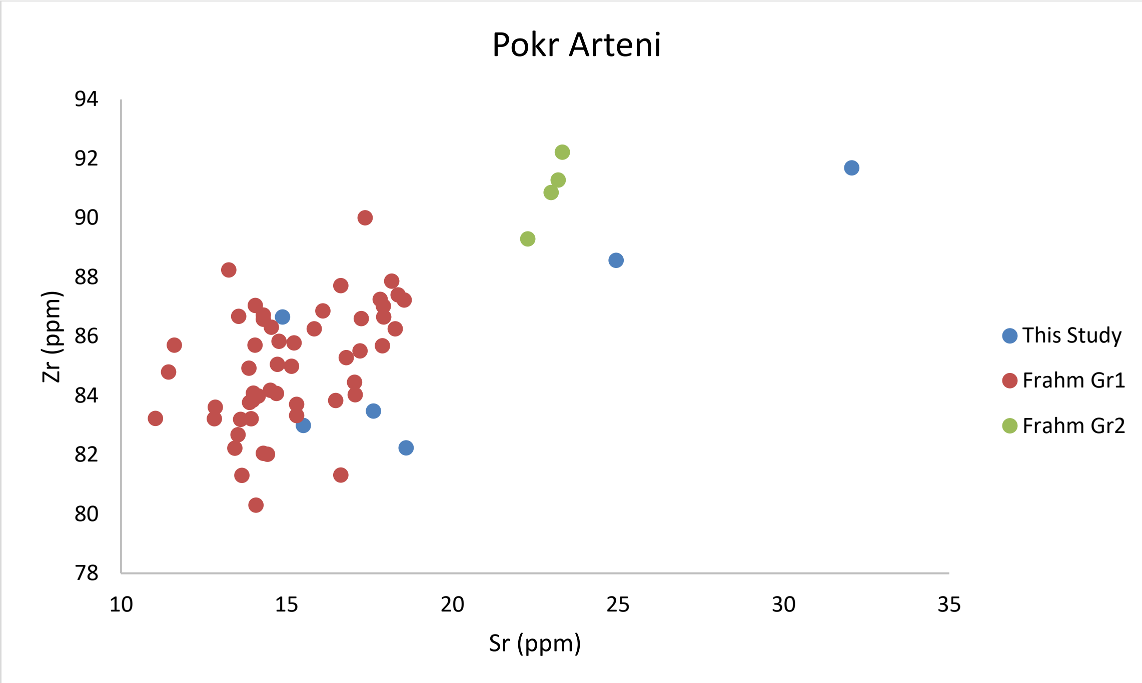


Figure 6.9 – Plot illustrating pXRF measurements for Pokr Arteni specimens from this study plotted with data obtained by Frahm. Note the identification of two sub-sources reported by studies.

6.2.5 Compositional Group of Gutanasar (Geghama Range, Armenia)

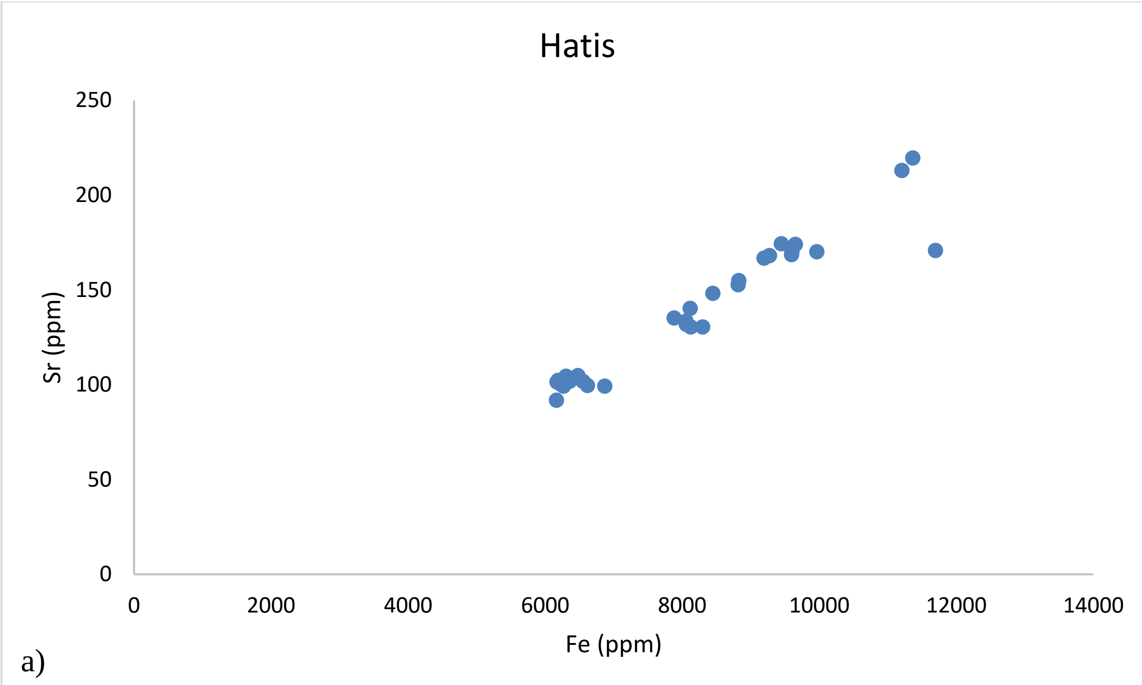
The Gutanasar volcanic complex and Hatis volcano (discussed below) form the northern (Hrazdan-Abovyan) group of obsidian-bearing volcanos of the Geghama Mountain Range, a 70 km-long chain, which stretches between Lake Sevan and the Ararat plain. The high plateaus with steppe vegetation are home to hundreds of transhumant herders in the summer months. The Gutanasar volcanic complex has three main obsidian outcrops: the Gutanasar flow, which is one of the largest obsidian flows in the region, and the Alapars, and Fontan lava domes located near the villages of the same name. For the present research, I collected obsidian from the Gutanasar flow and selected seven specimens for analysis. Various sourcing studies show that Gutanasar was one of the most important sources for prehistoric populations of the Southern Caucasus. In the earlier studies by Keller, Blackman, Bader, Gratuze, Francaviglia, and others, the Gutanasar source was identified either as “Erevan” or “Sevan.” Located between Yerevan and Lake Sevan, the highway cuts right through Gutanasar flow exposing its numerous obsidian flows to the travelers. Comparison of the geochemical signatures of “Erevan” and “Sevan” specimens make it clear that the specimens were collected from the Gutanasar volcanic complex, most likely, from the Gutanasar flow along the Yerevan-Sevan highway. All geochemical analysis undertaken thus far (Keller et al. 1996, Blackman et al. 1998, Chataigner and Gratuze 2014, Frahm et al. 2014, Frahm et al. 2016) reported that the various outcrops of the Gutanasar volcanic complex cannot be differentiated from one another. The homogeneity of Gutanasar specimens was confirmed by my research as well. Gutanasar obsidian overlaps with Sarikamiş North, Yağlıca Dağ, Hatis, Damlik, Ttujur, and Arteni; however, a combination of Rb, Nb, Zr versus Sr concentrations clearly differentiate between Gutanasar and all other specimens.

6.2.6 Compositional Groups of Hatis (Geghama Range, Armenia)

Blackman et al. (1998) identified a single homogeneous group at Hatis based on 5 specimens, whereas Chataigner and Gratuze (2014a) reported two chemical groups using 4 specimens. Two specimens collected from the south-western slops form their “Hatis 1” (Sr=81 ppm) group and 2 specimens from the south-eastern slopes the “Hatis 2” (Sr= 136 ppm) group (Chataigner and Gratuze 2014b:28, 38). I analyzed a total of 36 specimens collected from the south-wester, south-eastern, and north-eastern slopes. The four compositional groups identified seem to correspond to distinct obsidian flows, which are clearly visible on the slopes of the volcano. Poidevin (1998) distinguished three groups at Hatis: Hatis I, II, and III, with groups I and II belonging to the first phase of activity and group III, which contains feldspars mineral inclusions visible to the naked eye, belonging to the second phase of activity of the volcano. Badalyan et al. (2004a) also report three distinct groups, but do not provide any details with respect to elemental concentrations or geographical locations of these groups.

I identified four different chemical groups based on 33 specimens from Hatis (Figure 6.10) easily distinguishable through their Fe, Sr, and Zr concentrations. At Hatis-1, the Fe content ranges between 6100-6900 ppm, Sr is 100-102 ppm, and Zr is 92-100 ppm; Hatis-2 contains 7800-9600 ppm of Fe, 130-172 ppm Sr, and 107-124 ppm of Zr; Hatis-3 contains 11,200-11,300 ppm Fe and has the highest concentration of Sr and Zr at 213-220 ppm and 138-140 ppm respectively; and finally, Hatis-4 contains the highest concentration of Fe at 11,600 ppm, with Sr at 171 ppm and Zr at 119 ppm. Hatis has some overlap with Damlik, Ttujur, and Yağlıca Dağ 1; however, the bivariate plot of Fe versus Sr can be used to differentiate Hatis from all other sources, as well as among the Hatis sub-groups.

These studies make it clear that Hatis is a complex source, with multiple eruption events and a number of geo-chemically distinct obsidian flows, which require a more nuanced and systematic study of the volcano. Being one of the major raw material sources exploited by Neolithic through Iron Age communities of the Ararat plain, a more detail geochemical map of Hatis can have important implications for archaeological sourcing research. It is possible that some of the unsourced artifacts coming from the various sites which fall with the utilization zone dominated by the Hrazdan-Abovyan group (Gutanasar and Hatis) originate from the yet uncharacterized sub-sources of Hatis.



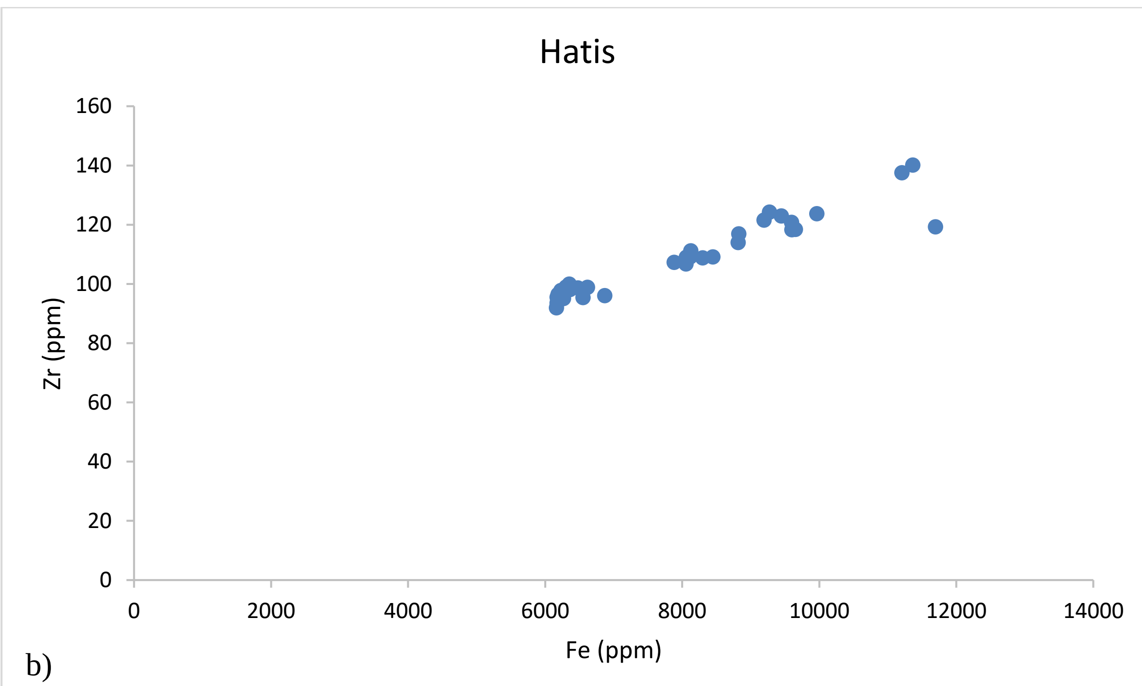


Figure 6.10 – Bivariate scatter plots of 32 obsidian specimens from the Hatis, Armenia, illustrating sub-source variation based on concentrations of (a) Fe versus Sr and (b) Fe versus Zr.

6.2.7 Compositional Groups of Spitakasar and Geghasar (Geghama Range, Armenia)

The Spitakasar and Geghasar volcanos form the southern group (Martuni group) of obsidian-bearing volcanos of the Geghama Mountain Range. The southern high plateaus (~3000-3500 m) with steppe vegetation are home to hundreds of transhumant herders in the summer months. Visually the obsidian from Spitakasar and Geghasar are quite different from one another; while Geghasar obsidian is of high quality and comes in a number of colors (translucent, gray, red, brown, black, and banded), the obsidian of Spitakasar contains small crystals visible to the naked eye, which makes it not ideal for knapping. Prior analysis of obsidian specimens from Spitakasar and Geghasar (Blackman et al. 1996, Chataigner and Gratuze 2014) were not able to distinguishes between the two sources, thus a single chemical composition is suggested.

I analyzed 12 specimens from Geghasar and 9 from Spitakasar. In contrast to prior studies, my findings suggest that while the elemental compositions of the two sources seem to be on a continuum, when the concentrations are plotted as bivariant elemental scatter plots the two groups, albeit close to one another, still plot in two different regions. The separation of the two groups is possible based on Rb, Sr, Zr, and Y concentrations (Figure 6.11). Normalizing the ratios of Nb and Y to Zr, which were used by Chataigner and Gratuze in their source differentiation studies were also tested here (Figure 6.12). The ratio of these elements only improves source separation. These results suggest that Spitakasar and Geghasar form two distinct chemical groups. Geghasar and Spitakasar overlap with Arteni, Khorapor, the Syunik sources, and Sarikamiş; however, concentrations of Rb versus Y, as well as Nb/Zr versus Y/Zr separate the sources from all others and from one another.

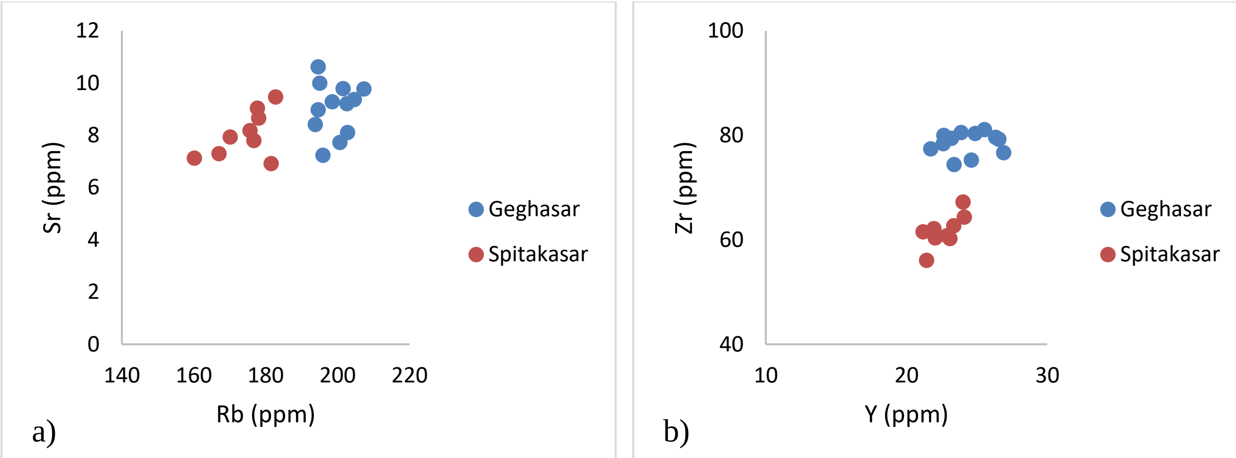


Figure 6.11 – Bivariate scatter plots of obsidian specimens from Geghasar (n=12) and Spitakasar (n=9) sources of the Geghama Range, Armenia, illustrating source differentiation based on concentrations of (a) Rb versus Sr and (b) Y versus Zr.

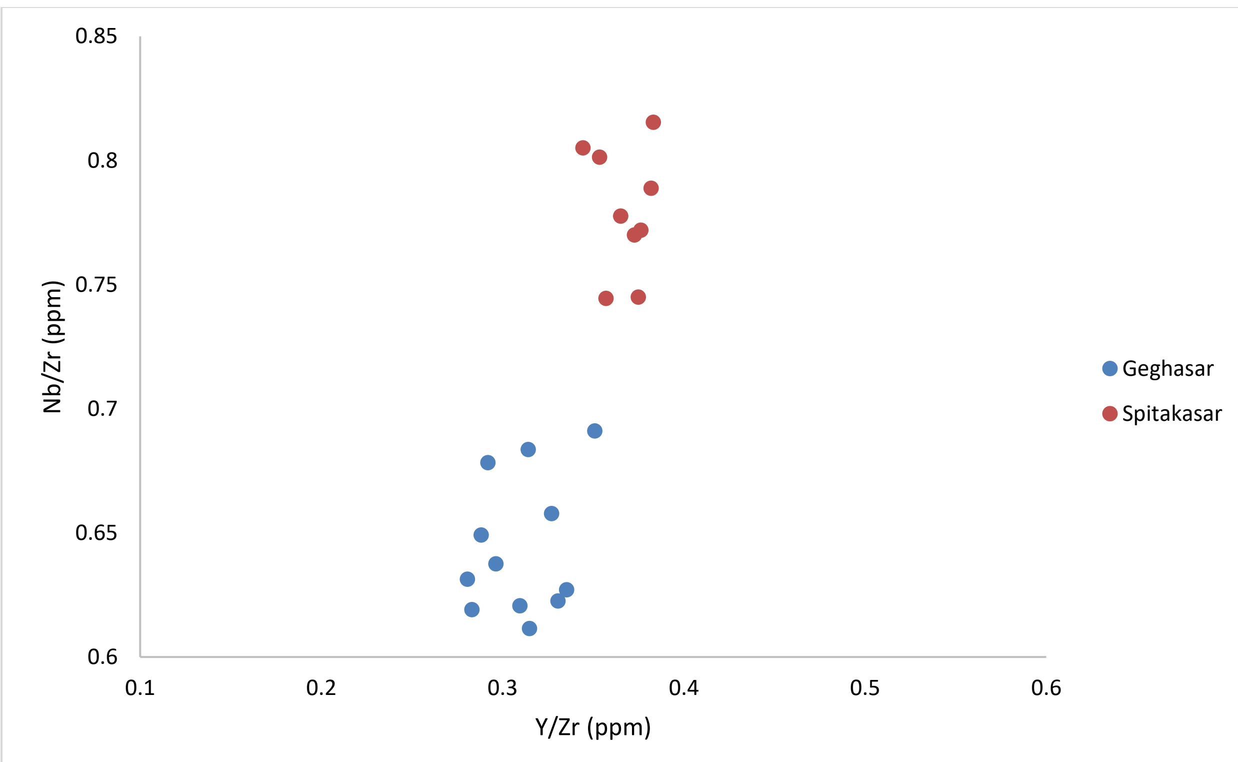


Figure 6.12 – Scatter plot of Geghasar and Spitakasar obsidian specimens with normalization of Nb and Y measurements to Zr, which reduces the overlap and enhances separation between the two sources.

6.2.8 Compositional Groups of Khorapor (Armenia)

The Khorapor volcanic dome contains poor quality obsidian, it appears mostly as small nodules containing crystalline inclusions visible to the naked eye. Prior characterization studies (Blackman et al. 1998, Chataigner and Gratuze 2014) of Khorapor reported only one compositional group. I analyzed only 2 specimens from this source and the results fall in line with other studies. Khorapor overlaps with Arteni, the Syunik sources, and Geghasar; however, the bivariate plot of Rb versus Y is used to separate these sources.

6.2.9 Compositional Groups of Bazenk, Mets Satanakar, and Sevkar (Syunik, Armenia)

Bazenk is one of the several obsidian-bearing volcanos of Syunik, the others being Mets Satanakar, Pokr Satanakar, Mets Sevkar, and Pokr Sevkar. Prior characterization research of these sources is quite limited in comparison to some other sources in Armenia. Keller and Seifried (1990) analyzed only one sample from Bazenk and Sevkar in their initial study. In a later study, Keller and colleagues (1996) analyzed 2 specimens from Bazenk, 5 from Satanakar, and two from Sevkar. The suggest that the Syunik sources can be distinguished based on their rear earth elements (REE) but differentiation between the sources is not discussed. Blackman and colleagues (1998) analyzed one same from Bazenk, one from Sevkar, and one from Satanakar. concluding that the three sources form two chemical groups: Sevkar/Satanakar and Bazenk. They further note that their analysis was not able to differentiate between Kelbajar 1, Kechaldag, and Bazenk sources. Chataigner and Gratuze (2014) analyzed 8 geological specimens from four sources in Syunik: 2 from Bazenk, 1 from Mets Satanakar, 2 from Mets Sevkar and 2 from Pokr Sevkar. They report that 3 closely related chemical groups can be differentiated in Syunik, corresponding to Bazenk, Mets Satanakar, and Mets and Pokr Sevkar. The most extensive source characterization in Syunik was conducted by Cherry et al. (2007; 2010). They analyzed 68 specimens from Bazenk, Satanakar, and Sevkar sources, which they assigned to 5 distinct chemical groups based on lanthanum (La) and cerium (Ce) contents. They identified 2 distinct groups from Bazenk (Bazenk-1 and Bazenk-2), 2 from Satanakar (Satanakar-1 and Satanakar-2), and the fifth group is comprised of specimens from Pokr and Mets Sevkar forming a single homogeneous group. Three specimens from Satanakar fall between the two identified groups, which could either be outliers or represent a third chemical group at Satanakar (Cherry, et al. 2010:156).

Based on 20 specimens from the three Syunik sources (Bazenk=4, Sevkar=6, Satanakar=10), I identified 2 chemical groups at Bazenk, 1 group at Sevkar, and 2 at Mets Satanakar (Figure 6.13). The groups can be differentiated by their Fe, Sr, and Zr concentrations. Bazenk-1, represented by only 1 artifact, has a higher Fe content (~ 4500 ppm) than Bazenk-2 (~4200-4480 ppm), represented by 3 specimens. While one sample might seem insufficient for delineation of a chemical group, this finding is supported by a more robust sample size analyzed by Cherry et al. mentioned above. Sevkar has the highest concentrations of Fe (~ 5240-4780 ppm), Zr (~ 102-105 ppm), and Sr (13-19 ppm) among all the Syunik sources analyzed in this study. Finally, the chemical groups present at Mets Satanakar are a little more difficult to differentiate within the source. Mets Satanakar-1 is represented by 4 specimens and Mets Satanakar-2 by 2 specimens. In general, the Fe, Zr, and Sr concentrations of Mets Satanakar fall between those measured for Bazenk and Sevkar, yet a single sample (Mets Satanakar.1.001) has a considerably higher concentration of Fe (5397 ppm) than any of the other specimens analyzed from the Syunik volcanic complex. This sample may be an outlier; however, it is also possible that it corresponds to what Cherry et al. identified as outliers in their dataset, thus forming a third, not well sampled, chemical group at Mets Satanakar. The Syunik sources overlap with Arteni, Khorapor, and

Geghasar, Spitakasar, and Sarikamiş; however, the bivariate plot of Y versus Rb and Y versus Nb normalized to Zr are used to separate the Syunik sources from others analyzed in this study, as well as from one another. This source being one of the largest obsidian sources in the Near East, so much so that the black obsidian covering its slopes is visible on satellite imagery, is quite poorly studied. It is not unlikely that Mets Satanakar has more than two obsidian sources with distinct chemical signatures, however, a more detailed study of the volcano is needed to elucidate its full potential.

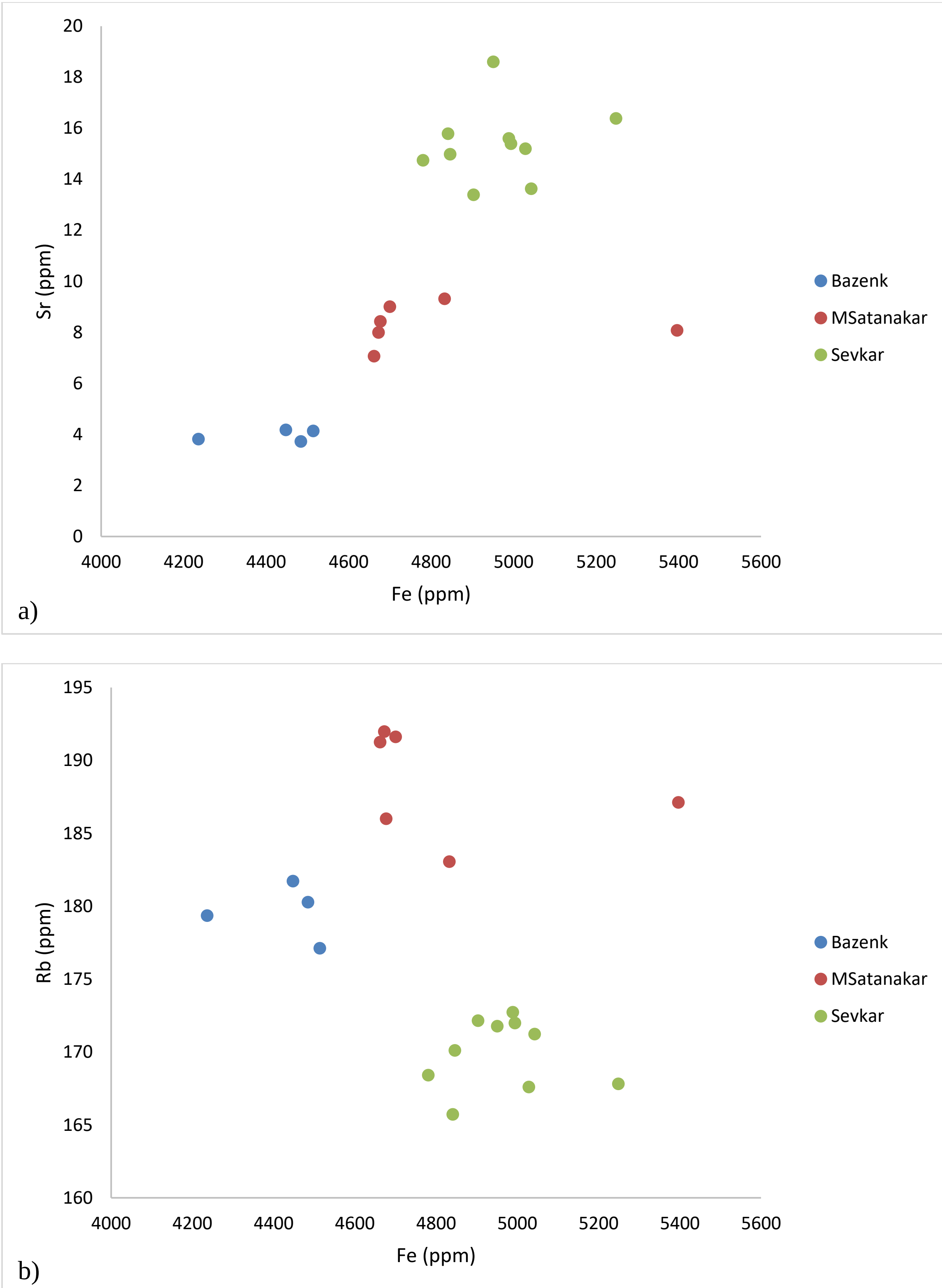


Figure 6.13 – Bivariate scatter plots of obsidian specimens from Syunik, Armenia: Bazenk (n=4), Mets Satanakar (n=6), and Sevkar (n=10) illustrating source differentiation based on (a) Fe versus Sr and (b) Fe versus Rb concentrations.

6.2.10 Chemical Groups of Yağlıca Dağ (E. Turkey)

The obsidian sources of eastern Turkey are not as well studied as those of central Turkey, thus the information presented below is limited. The obsidian outcrops of Yağlıca Dağ are also called Digor or Kars-Digor in literature, as they are located about 10 km south of the town Digor. A total of seven specimens from this source have been analyzed in prior studies (in Chataigner, et al. 2014; Oddone, et al. 1997). Obsidian outcrops are encountered from around Yağlıca Dağ and stretching southward for some 35-40 km. Chataigner et al. define two zones: the summit area where obsidian has many whitish inclusions and is of poor quality, and the southern zone with very high-quality obsidian (2014:17). The two specimens analyzed in this study were collected from near the villages Yağlıca and Kuruyayla, each forming a distinct chemical group (Figure 6.14). Yağlıca Dağ-1 has a considerably higher Fe content at 8329 ppm, as well as higher content of Sr (101 ppm) and Zr (181 ppm). Yağlıca Dağ-2 has an iron content of 6551 ppm, Sr content of 65 ppm, and Zr 138 ppm. Yağlıca Dağ has some overlap with Sarikamiş South, Hatis, and Gutanasar; however, Yağlıca Dağ specimens are separated from all others based on the biplot of Sr versus Zr.

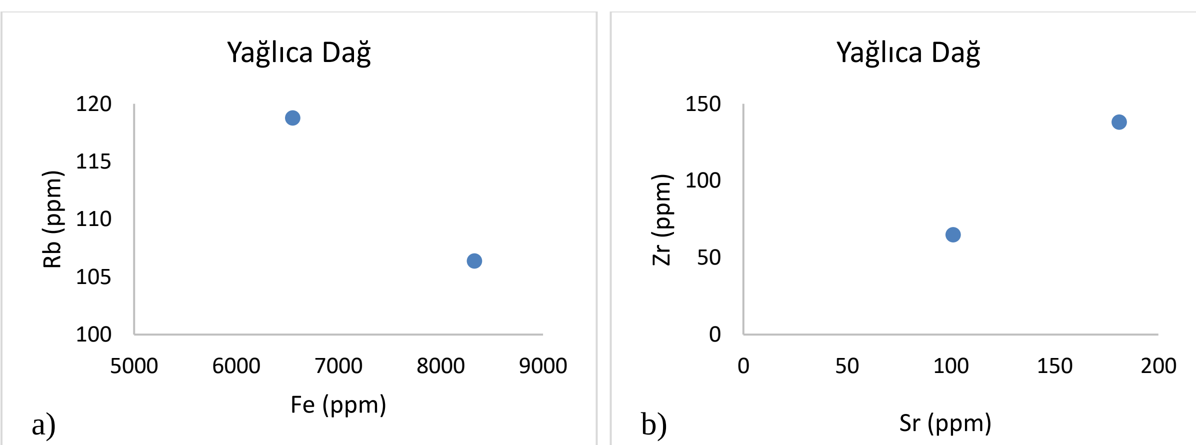


Figure 6.14 Bivariate scatter plots of 2 obsidian specimens from Yağlıca Dağ (eastern Turkey), illustrating sub-source differentiation based on (a) Fe versus Rb and (b) Sr versus Zr concentrations.

6.2.11 Chemical Groups of Sarikamiş (E. Turkey)

With the exception of specimens labeled SarikamişSouth.GA1-13, all other specimens from eastern Turkey were provided by C. Chataigner and thus sample ID numbers correspond to the specimens published in Chataigner et al. 2014. The eastern Turkish sources Sarikamiş North, Pasinler, Erzurum, and Yağlıca Dağ are each represented by two specimens. While two specimens may not allow for a more detailed characterization of each source, these proved to be sufficient for discerning intra-source variation using key major and trace elements. The bivariate elemental scatter plots below clearly demonstrate the chemical groups formed by Fe, Rb, Sr, Zr, and Y concentrations.

The obsidian identified as Sarikamiş is named after the district in which the two sources, Sarikamiş North and Sarikamiş South are located. Sarikamiş North comes from Çiplak Dağ near Mesçitli village, and Sarikamiş South is the Ala Dag near Şehitemin. Keller and Seifried (1990) analyzed 4 specimens collected from areas south and west of Sarikamiş (presumably, the town of the same name) and identified two chemical groups differentiated based on the barium content. Their group Sarikamiş 1 has a higher iron content and lower barium in comparison to Sarikamiş 2, which is richer in barium. Chataigner et al. conducted the first systematic survey of obsidian sources in north-east Turkey revealing the complex nature of obsidian occurrences in this region. In this study, they report on two geochemical sources for Sarikamiş: Sarikamiş North and Sarikamiş South. In a later publication, Chataigner and Gratuze (2014) analyzed specimens from Sarikamiş identifying two distinct groups, both coming from the Sarikamiş South outcrops. Their Sarikamiş South 1 and Sarikamiş South 2 groups match Keller's Sarikamiş 1 and 2, respectively. The differentiation between the subs-sources present at Sarikamiş 2 was possible on the bases of Ba/Zr and Ba/Sr concentration ratios.

I analyzed 15 specimens were from Sarikamiş South and 2 specimens from Sarikamiş North. Two distinct chemical groups are identified among the 15 specimens (Figure 6.15). The specimens from Sarikamiş North and South are easily distinguished based on their Fe, Sr, Y, Zr, and Nb concentrations. The Sarikamiş North group, here Sarikamiş-1, has higher concentrations of Fe (7690-7680 ppm), Y (49 ppm), Zr (197-222 ppm), and Nb (32) and a lower concentration of Sr (1-2 ppm). In fact, the strontium contents are so low that they close to the detection limits of the pXRF. In contrast, Sarikamiş South, here Sarikamiş-2, has a lower Fe (5600-6068 ppm), Y (22-27 ppm), Zr (103-11 ppm), and Nb (18-11) concentration and a higher Sr (21-25 ppm) concentration. Despite the greater number of specimens analyzed from Sarikamiş South than in prior studies, this study was not able to identify more than one chemical group at the source. This is likely a sampling issue, as all 15 specimens were collected alongside of the road between the Mesçitli and the town of Sarikamiş. Sarikamiş North specimens overlap with Gutanasar, Pasinler, and Erzurum, but can be separated using the Rb versus Sr biplot, whereas Sarikamiş South can be separated from Arteni, Gutanasar, Pasinler, Erzurum, and Yağlıca Dağ based on the biplot of Sr versus Nb concentrations.

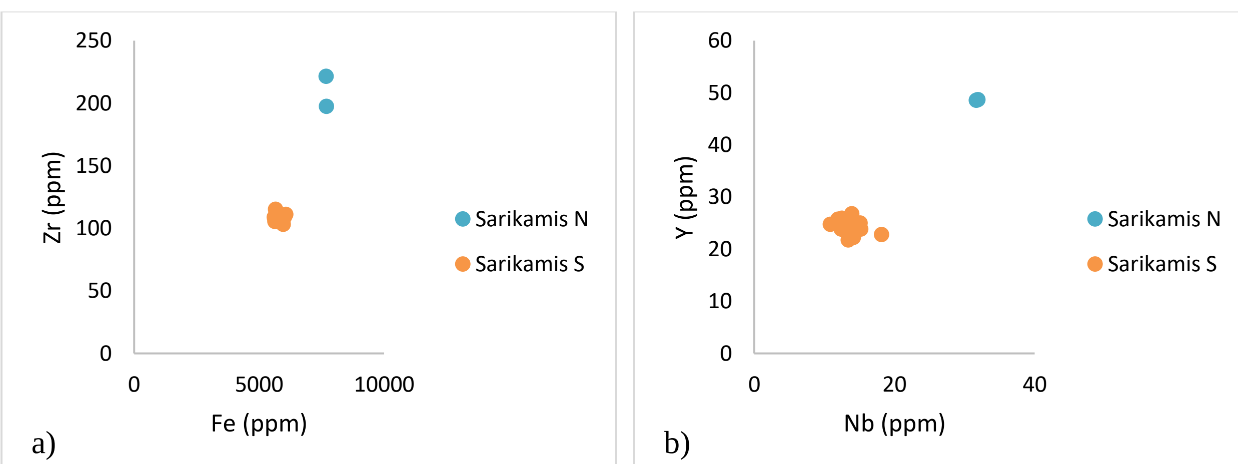


Figure 6.15 – Bivariate scatter plots of 18 obsidian specimens from Sarikamiş sources, eastern Turkey, illustrating differentiation between Sarikamiş North and Sarikamiş South sources based on (a) Fe versus Zr and (b) Nb versus Y concentrations.

6.2.12 Chemical Groups of Pasinler (E. Turkey)

There are obsidian outcrops throughout the Pasinler Basin with the most prominent being five flows exposed on the eastern flank of the gorge located north of Büyükdere (Chataigner, et al. 2014). In the literature these outcrops are mentioned with various names: “Tizgi” (Bigazzi, et al. 1998), “Pasinler” (Poidevin 1998). The two specimens analyzed in this study were collected about 10-15 km north of the town of Pasinler. While two specimens are not enough to make any definitive arguments, the scatterplots suggest the presence of two distinct chemical groups (Figure 6.16). Pasinler-1 has a higher concentration of Fe (7518 ppm), Rb (191 ppm), Zr (169 ppm), and a lower concentration of Y (33 ppm), whereas Pasinler-2 has a lower concentration of Fe (7362 ppm), Rb (174 ppm), Zr (166 ppm), and a higher concentration of Y (36 ppm). Pasinler overlaps with Sarikamiş, Erzurum, Arteni, and Syunik sources; however, it is differentiated from these sources based on the bivariate plot of Rb versus Y, as well as Zr/Rb versus Sr/Rb concentrations.

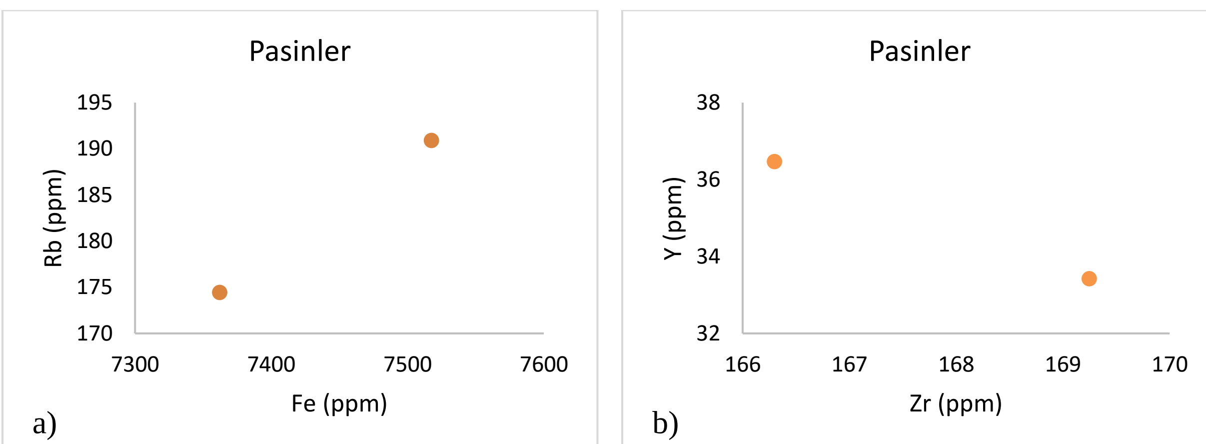
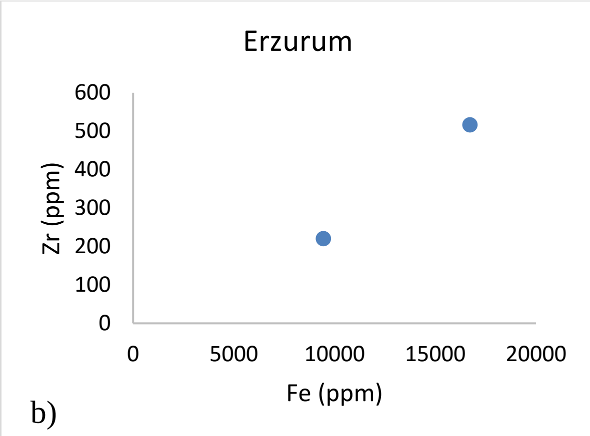


Figure 6.16 – Bivariate scatter plots of 2 obsidian specimens from Pasinler (eastern Turkey), illustrating sub-source differentiation based on (a) Fe versus Rb and (b) Zr versus Y concentrations.

6.2.13 Chemical Groups of Erzurum (E. Turkey)

The Erzurum Basin, much like Pasinler, has several sources of obsidian, both primary and secondary deposits. The primary deposits are: an unnamed volcano north-west of village Başköy; Güzelyurt (or Tambura), which has poor quality obsidian, and outcrops on the slopes and summit of Söğütlü. Four specimens of obsidian from Güney Dağ were analyzed by Poidevin (1998) and named Erzurum West. Chataigner et al. (2014) reported that the specimens collected near the village of Başköy form a new chemical group, which is different from previously identified Pasinler or Erzurum specimens. Two specimens from Erzurum were provided by Chataigner for analysis in this study. One specimen comes from Erzurum West, collected west of the village of Söğütlü, and one sample from Erzurum South, just west of Başköy village. Like the specimens from Pasinler, these too represent two distinct chemical groups. They are easily distinguishable by their Fe and Zr contents (Figure 6.17). Erzurum-1 contains over 16,700 ppm Fe and 516 ppm Zr, whereas Erzurum-2 contains 9450 ppm Fe and 221 Zr. In fact, Erzurum-1 has the highest concentration of Fe and Zr of any geological specimen analyzed in the study. These results correspond to prior characterization studies. Erzurum overlaps with Pasinler, Sarikamiş, Arteni, Hatis; however, it is differentiated from these sources using Fe versus Nb, Rb versus Y, or Sr versus Zr biplots.



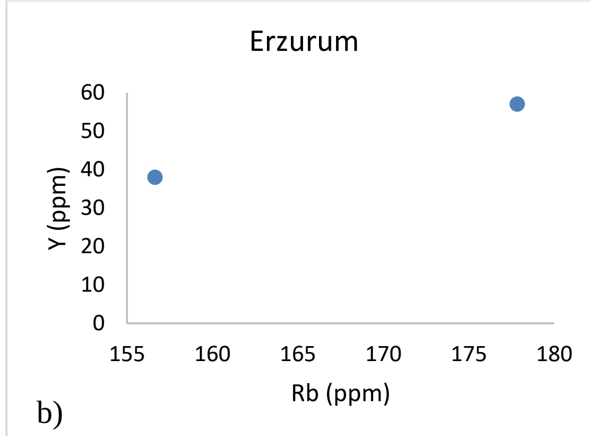


Figure 6.17 – Bivariate scatter plots of 2 obsidian specimens from Erzurum (eastern Turkey), illustrating sub-source differentiation based on (a) Fe versus (b) Zr and Rb versus Y concentrations.

6.3. Archaeological Obsidian Characterization and Source Attribution

Once initial source separation was achieved for geological specimens, I used PCA to verify that the same key elements which contribute the most to the variability of the geological dataset are still useful when artifacts are added. The PCA evaluation of geological specimens and artifacts shows that Sr and Zr still contribute the most and the first two principal components explain 83.14% of the variability in dataset (Figure 6.18). Fe and Y are also important elements for reducing the variability in the dataset. After the evaluation through PCA, the key elements are used to illustrate groupings using bivariate scatter plots.

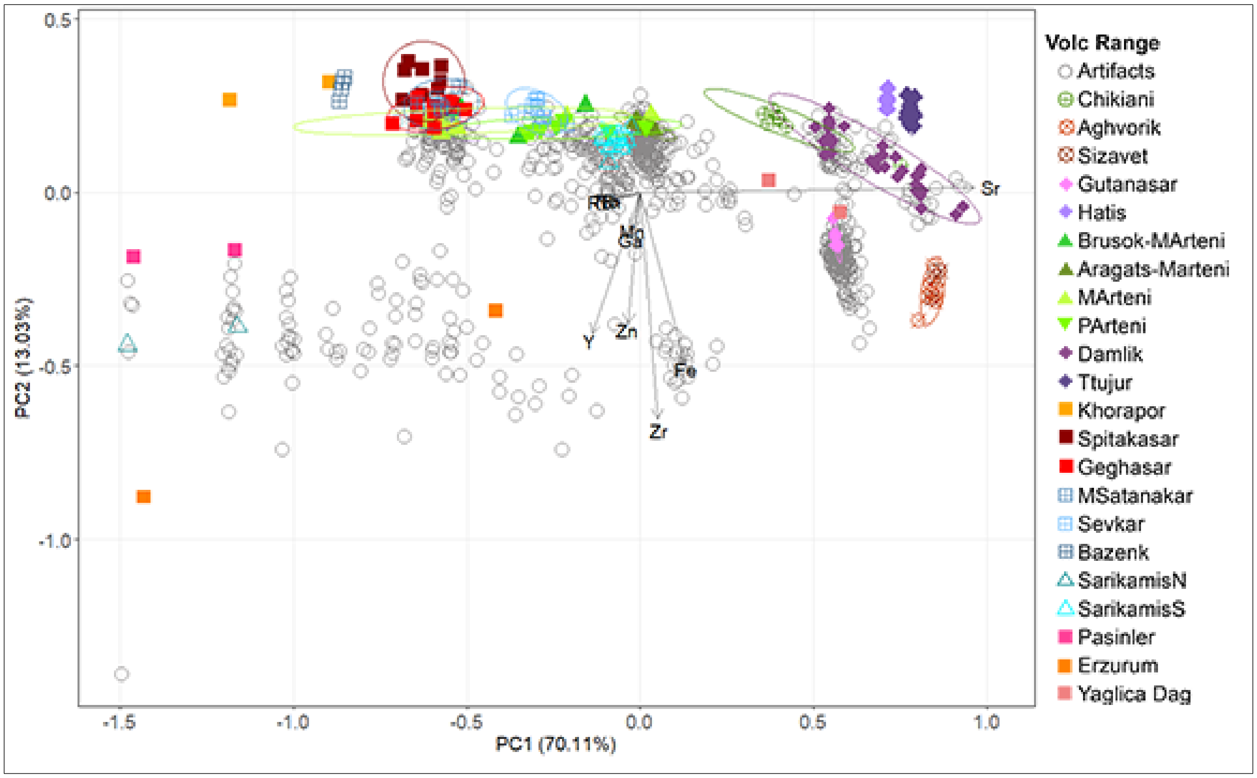
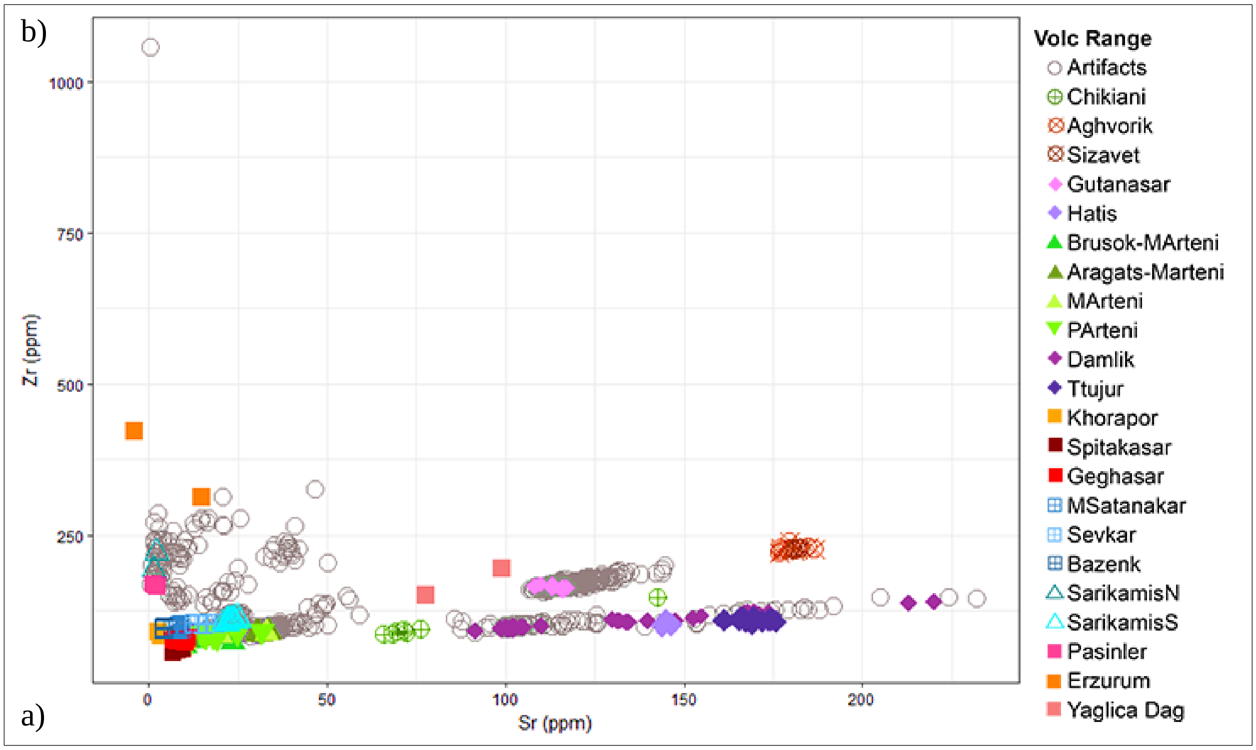


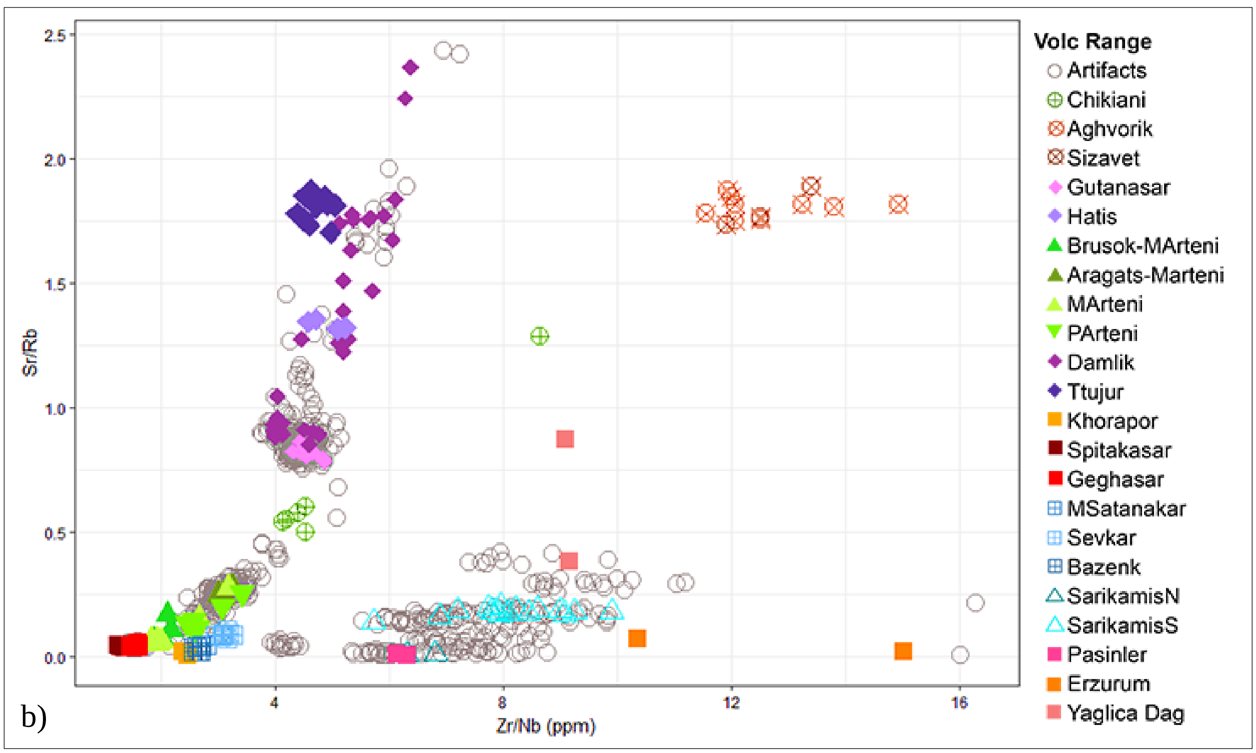
Figure 6.18 – Biplot of first two PCA components 167 geological specimens and 854 artifacts from Masis Blur with 90% confidence ellipses.

Numerous sourcing studies have demonstrated that simple bivariate plots are often sufficient for assignment of an artifact to a given source. Shackley has argued that “in many cases the bivariate plots may be a more accurate reflection of source heterogeneity, as well as a better media for source assignment” (Shackley 1998:13). In this study, for initial source assignment I compared the artifacts’ chemical signatures with those of source specimens run under the same analytical conditions using bivariate plots. Then, I mapped the elemental data obtained for artifacts are mapped onto source data and the results are illustrated using bivariate plots used for source differentiation. The bivariate plots, particularly ones with Fe or Zr concentrations (e.g., Figure 6.19a), reveal that a single artifact (Artifact ID: MB2013.M11/1.TP0310a.7) dominates the dataset with significantly higher concentration of Fe (19158 ppm) and Zr (1057 ppm), thus causing a skew in the scale of the plots. As a result, the geological specimens and artifacts are forced to plot on a much smaller scale and intermingle more than in reality. Normalizing the concentrations to a given element, in this case Zr (Figure 6.19b-c), reduces the overlap and enhances separation between groups.

The investigation of several bivariate scatter plots of artifacts and geological specimens show that none of the artifacts from Masis Blur analyzed in this study can be attributed to Chikiani (160 km NW), Aghvorik and Sizavet (120 km NW), and the Syunik sources (120 km SE). While not entirely unexpected, it is still interesting to see this observation reported in prior studies based on markedly smaller datasets, reaffirmed on a significantly larger sample size. The inhabitants of the Ararat plain did not utilize the obsidian sources located in to the far north and north-west, nor were artifacts fashioned from these obsidians brought into the Ararat plain via other means (e.g., trade, gift exchange, dowry, or secondary utilization of discarded artifacts). This bivariate plot of Nb/Zr versus Y/Zr (Figure 6.19.c), also separates Spitakasar from Geghasar specimens quite distinctly and illustrates that while a substantial number of artifacts are attributed to Geghasar, located around 50 km east of Masis Blur, its slightly northern counterpart, the Spitakasar source was not utilized at all. Both volcanos, located on the Geghama mountain range. This is not unexpected, as the Geghasar obsidian is of high quality, whereas the obsidian of Spitakasar has numerous large inclusions visible to the naked eye, making it problematic for knapping.

The elemental scatter plots indicate that the vast majority of artifacts from Masis Blur can be attributed to a handful of sources in Armenia and eastern Turkey, with the nearest sources (Hatis) located 30 km and the farthest (Sarikamiş) 160 km away. Obsidian flows of Arteni, Hatis, Gutanasar, Geghasar, and Sarikamiş are the main contributors of raw material.


b)
a)
Zr (ppm)
Sr (ppm)
1000
750
500
250
0
50
100
150
200
Volc Range
Artifacts
Chikiani
Aghvorik
Sizavet
Gutanasar
Hatis
Brusok-MArteni
Aragats-Marteni
MArteni
PArteni
Damlik
Ttujur
Khorapor
Spitakasar
Geghasar
MSatanakar
Sevkar
Bazenk
SarikamisN
SarikamisS
Pasinler
Erzurum
Yaglica Dag


Sr/Rb
Zr/Nb (ppm)
2.5
2.0
1.5
1.0
0.5
0.0
4
8
12
16
b)
Volc Range
Artifacts
Chikiani
Aghvorik
Sizavet
Gutanasar
Hatis
Brusok-MArteni
Aragats-Marteni
MArteni
PArteni
Damlik
Ttujur
Khorapor
Spitakasar
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MSatanakar
Sevkar
Bazenk
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SarikamisS
Pasinler
Erzurum
Yaglica Dag

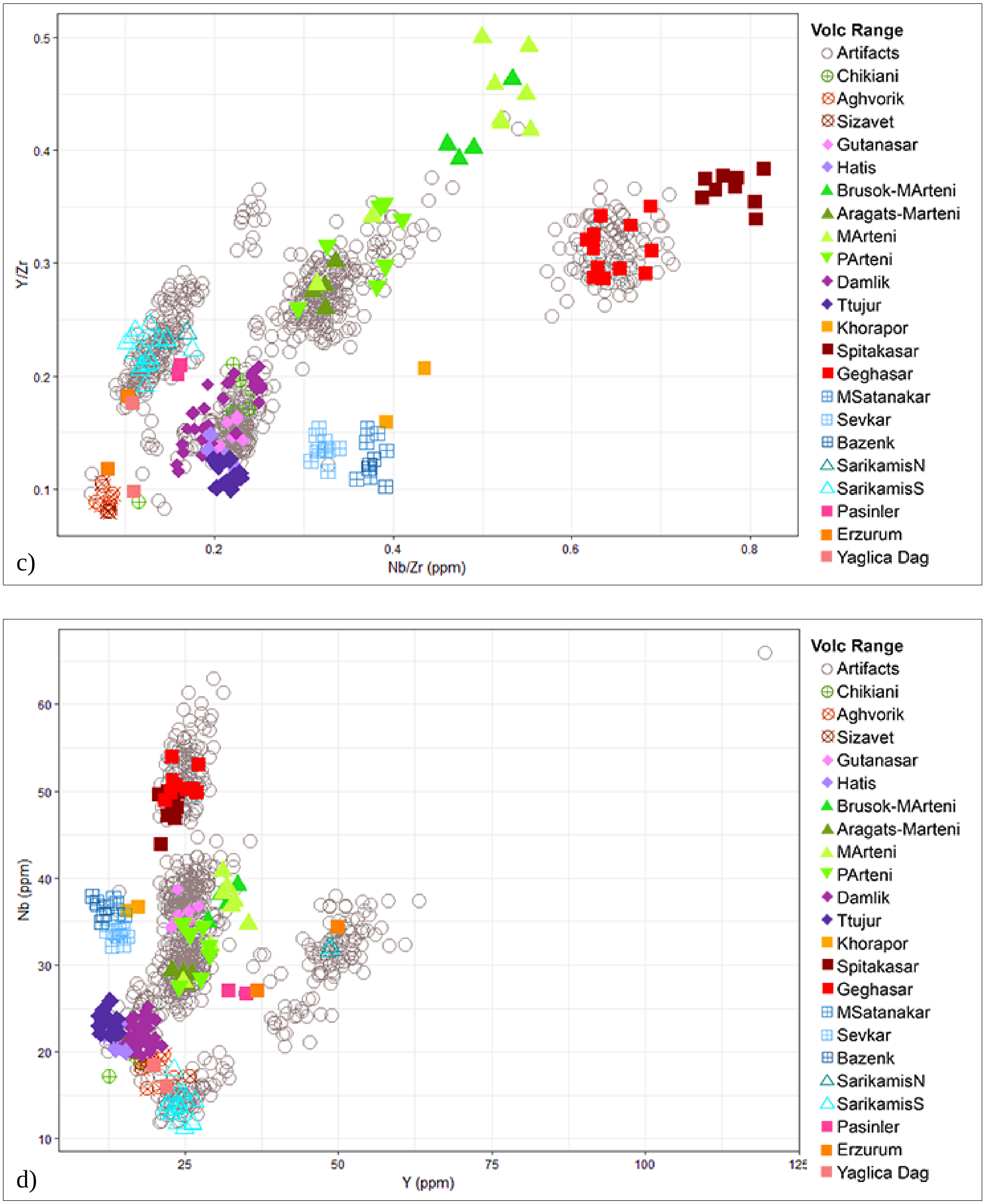

Figure 6.19 – Bivariate plots of 167 geological sources and 854 artifacts from Masis Blur. The plots show that none of the artifacts analyzed in this study can be attributed to (a, b) Chikiani (Georgia), Aghvorik and Sizavet (Armenia), and (c, d) the Syunik sources (Armenia).

Bivariate and PCA plots can only show relative abundance of artifacts assigned to a source. In order to determine how many artifacts are matched to a given source and which ones specifically, I used Mahalanobis distances to calculate the probability that a particular artifact belongs to a group based upon both its proximity to the centroid of the group. A major limitation of MD is that the number of group members (i.e., geological specimens) must exceed the number of elements under consideration (Glascock, et al. 2004). In fact, for every element included in MD probabilities at least three times as many specimens are required per group. Thus, for the 10 elements measured by the pXRF, at least 30 specimens from each group (i.e., geological source) are needed. Unfortunately, this sample size requirement is not met for all the sources analyzed in this study. In order to maximize the number of group members, I combined specimens representing distinct chemical groups from a single source; thus, specimens from the Aragats flow of Mets Arteni were combined with specimens collected from the dome of Mets Arteni, even though compositionally the Aragats flow is closer to Pokr Arteni. Additionally, I excluded from final MD probabilities calculations sources (e.g., Chikiani and Syunik obsidian sources) determined to be not represented in the artifact dataset through bivariate scatter plots and confirmed with MD probabilities calculations using a training artifact dataset, as well as sources with less than 6 specimens (e.g., Pasinler, Erzurum, etc.). After MD calculations, I plotted those artifacts still unassigned to a source using MD probabilities against sources with fewer than 6 specimens using bivariate plots. Thus, I used an iterative process and combined analysis to maximize artifact attribution.

To test which combination of elements would result in the correct attribution of source samples to the source itself I calculated MD probabilities for all 167 geological specimens using different combinations of 6 elements - Fe, Sr, Zr, Rb, Nb, Y – resulting in 21 different combinations. The examination of the results showed that the four elements – Fe, Sr Zr, and Y – identified through PCA give the most accurate attribution of geological specimens to their own groups. I must note, that regardless of the elemental combinations used, none of the specimens are attributed to their own group with 100% certainty. Moreover, membership probability for some specimens to their own group is as low as 2 or 3 percent. For example, while specimen Gutanasar.1.074.2 was assigned to the Gutanasar source with nearly 84% probability, specimen Gutanasar.7.069 received only a 3.53% probability of belonging to the source. But at the same time, the probability of either specimen belonging to another source analyzed in this study is zero, this is important to keep in mind when examining group membership probability of a given artifact (Table 6.2).

All statistical analyses presented in this research were performed using MURRAP statistical routines v8.8 with the GAUSS v8.0 runtime environment (available freely from the Archaeometry Laboratory at the University of Missouri Research Reactor) and RStudio, an open-source integrated development environment for R (availably freely at https://www.rstudio.com).

Membership probabilities (%) for samples in group: **Gutanasar**									
Results are based on the following variables: Fe, Sr, Y, Zr									
Probabilities calculated after removing each sample from group.									
Specimen ID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Best Group
Gutanasar.1.059	0.0000	66.6513	0.0000	0.0000	0.0000	0.0214	0.0000	0.0000	Gutanasar
Gutanasar.10.074.1	0.0000	81.9298	0.0000	0.0000	0.0000	0.0219	0.0000	0.0000	Gutanasar
Gutanasar.10.074.2	0.0000	83.4292	0.0000	0.0000	0.0000	0.0235	0.0000	0.0000	Gutanasar
Gutanasar.2.061.1	0.0000	59.6565	0.0000	0.0000	0.0000	0.0244	0.0000	0.0000	Gutanasar
Gutanasar.2.061.2	0.0000	33.6328	0.0000	0.0000	0.0000	0.0221	0.0000	0.0000	Gutanasar
Gutanasar.4.064	0.0000	31.9399	0.0000	0.0000	0.0000	0.0205	0.0000	0.0000	Gutanasar
Gutanasar.7.069	0.0000	3.5269	0.0000	0.0000	0.0000	0.0269	0.0000	0.0000	Gutanasar

Membership probabilities (%) for samples in group: **Mets Arteni** (including Aragats flow and Brusok)									
Probabilities calculated after removing each sample from group.									
Results are based on the following variables: Fe, Sr, Y, Zr									
ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Best Group
Brusok.1.090.1	0.0294	0.0018	0.0000	0.0000	2.681	9.6699	0.0000	0.0000	P.Arteni
Brusok.1.090.2	0.0757	0.0007	0.0000	0.0000	10.4711	2.9962	0.0000	0.0000	M.Arteni
Brusok.1.090.3	1.0163	0.0008	0.0000	0.0000	50.2402	34.9132	0.0000	0.0000	M.Arteni
Brusok.2.091	0.0051	0.0028	0.0000	0.0000	3.9152	2.2284	0.0000	0.0000	P.Arteni
MArteni.1.029	0.0503	0.0006	0.0000	0.0000	37.3986	4.3979	0.0000	0.0000	M.Arteni
MArteni.2.030	0.0402	0.0007	0.0000	0.0000	59.9898	9.1318	0.0000	0.0000	P.Arteni
MArteni.3.031	0.2314	0.0007	0.0000	0.0000	91.3564	12.054	0.0000	0.0000	M.Arteni
MArteni.4.032.1	6.2792	0.0006	0.0000	0.0000	24.364	20.4793	0.0000	0.0000	M.Arteni
MArteni.4.032.2	0.1648	0.0007	0.0000	0.0000	44.6812	24.5337	0.0000	0.0000	M.Arteni
MArteni.4.032.3	2.4604	0.0006	0.0000	0.0000	54.6983	17.9004	0.0000	0.0000	M.Arteni
MArteni.5.033	0.2707	0.0009	0.0000	0.0000	73.0721	20.3338	0.0000	0.0000	M.Arteni
MArteni.7.092	0.0073	0.0066	0.0000	0.0000	83.2716	54.19	0.0000	0.0000	M.Arteni
MArteni.8.093	0.0348	0.0028	0.0000	0.0000	88.2892	68.6914	0.0000	0.0000	M.Arteni
PArteni.10.097.1	0.0053	0.0074	0.0000	0.0000	75.8452	73.0638	0.0000	0.0000	M.Arteni
PArteni.10.097.2	0.0188	0.0057	0.0000	0.0000	14.4472	16.6868	0.0000	0.0000	M.Arteni
PArteni.11.098	0.0053	0.0074	0.0000	0.0000	75.8452	73.0638	0.0000	0.0000	M.Arteni
PArteni.9.095	0.0055	0.0057	0.0000	0.0000	49.7866	65.459	0.0000	0.0000	M.Arteni
PArteni.9.096	0.0116	0.0058	0.0000	0.0000	82.322	76.6476	0.0000	0.0000	M.Arteni

Table 6.2 – Example of Mahalanobis Distance measures and best fit group attribution of geological specimens from Gutanasar and Mets Arteni sources.

6.4 Using Mahalanobis Distances to Assign Artifacts to Sources

In order to test the consistency of source attribution, I considered 14 different elemental combinations: 1) Fe Sr; 2) Fe Zr; 3) Fe Y; 4) Sr Zr; 5) Fe Sr Y; 6) Fe Zr Y; 7) Fe Sr Y Zr; 8) Fe

Sr Zr Nb; 9) Rb Sr Zr Nb; 10) Sr Zr Y Nb; 10) Fe Zn Sr Y Zr; 11) Fe Rb Sr Y Zr; 12) Fe Rb Sr Zr Nb; 13) Fe Sr Y Zr Nb; 14) Rb Sr Y Zr Nb. The first four combinations are the equivalents of bivariate plots and the fifth is the equivalent of a trivariate plot. Much like bivariate and trivariate plots, MD probability calculations show that there is considerable overlap between certain sources (e.g., between Geghasar and Arteni); thus, the probability of an artifact attributed to these sources can be quite similar. For example, artifact MB2012.M9/1.200.2003.7 was attributed to Geghasar with a 54.7% probability when using the elements Fe Y Zr and to Pokr Arteni with a 40.1% probability when using Fe Zr. In most cases, where an artifact was attributed to two different sources with similar probability, adding another element into the calculations resolved the issue. At the same time, nearly all other element combinations attribute this artifact to Geghasar, thus making Geghasar a "primary class" and Pokr Arteni a "secondary class" match. With 854 artifacts and 167 geological specimens, the final matrix contained over 128,000 MD values calculated using 14 different element combinations (or 510 pages of data). Due to space constraints only two element combinations are presented in here: 1) Fe, Sr, Y, Zr and 2) Rb Sr Y Zr Nb. Table 6.3 gives the MD probability values (in %) for artifact MB2012.L10/4.100.1003.2 and illustrates its assignment of the sources analyzed in the study. Note that all fourteen element combinations attribute the artifact to Geghasar with probabilities ranging between 59 to 99.8 percent. Thus, artifact MB2012.L10/4.100.1003.2 can be securely assigned to the Geghasar source, located 50 km NE of Masis Blur.

Membership probabilities (%) for samples in group: **MB Artifacts**									
Probabilities calculated after removing each sample from group.									
Sample ID: MB2012.L10/4.100.1003.2									
Aragats (Arteni)	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Best Group	Element Combinations
-	92.0996	0.0177	0.0000	0.0000	0.0018	4.9650	0.0000	Geghasar	Fe Rb Sr Y Zr
-	99.9864	0.0061	0.0000	0.0000	0.0003	3.7334	0.0000	Geghasar	Fe Rb Sr Zr Nb
0.0662	96.5954	0.0000	0.0000	0.0000	47.9894	5.6948	0.0000	Geghasar	Fe Sr
0.9986	74.9733	0.0000	0.0000	0.0000	3.2907	13.8332	0.0000	Geghasar	Fe Sr Y
-	84.4173	0.0008	0.0000	0.0000	5.3961	15.3508	0.0000	Geghasar	Fe Sr Y Zr
-	92.1899	0.0288	0.0000	0.0000	0.0621	14.2050	0.0000	Geghasar	Fe Sr Y Zr Nb
-	99.8833	0.0003	0.0000	0.0000	0.0595	5.6390	0.0000	Geghasar	Fe Sr Zr Nb
2.7350	91.8704	0.0007	0.0000	0.0000	2.9231	5.0214	0.0000	Geghasar	Fe Y Zr
-	59.6635	0.0029	0.0000	0.0000	4.2427	16.2778	0.0000	Geghasar	Fe Zn Sr Y Zr
0.3157	99.1546	0.0000	0.0001	0.0000	71.6621	19.2968	0.0000	Geghasar	Fe Zr
-	91.8857	0.0091	0.0000	0.0000	0.0007	4.2153	0.0000	Geghasar	Rb Sr Y Zr Nb
-	99.9697	0.0001	0.0000	0.0000	0.0019	0.5589	0.0000	Geghasar	Rb Sr Zr Nb
0.0413	97.3977	0.0000	0.0000	0.0000	27.6103	11.2440	0.0000	Geghasar	Sr Zr
-	82.7975	0.0003	0.0000	0.0000	0.0223	4.0499	0.0000	Geghasar	Sr Zr Y Nb

Table 6.3 – Example of Mahalanobis Distance measures and source attribution of an artifact from Masis Blur based on 14 different element combinations.

All 854 artifact assignments follow this procedure: 1) identify the "best group" assignment for a particular artifact for each of the 14 element combinations; 2) identify the most frequent sources listed among the 14 attributions and assign a "primary class" to the most frequent source and a "secondary class" to the second most frequent source. Artifacts which were attributed to multiple sources each with less than 10% probability are categorized as "not assigned to source" (NATS). Because sources (i.e., Damlik, Sarikamiş-1, Erzurum, Pasinler, Yağlıca Dağ) with fewer than 7 specimens could not be included in MD analysis, it was necessary to assess artifacts against these sources with another method. Using bivariate plots, as well as direct comparison of ppm concentrations, 77 artifacts are attributed to one of the eastern Turkish sources analyzed in this study. None are assigned to the Damlik source in Armenia. Within the group of unassigned artifacts several stand out with their very high Fe and Zr concentrations. For example, artifact MB2013.M11/1.TP.0310a.7 has an Fe content of 19,158 ppm and Zr content of 1057 ppm, nearly twice higher than any source analyzed. Artifact MB2013.L/8.500.5000.26 has an even higher Fe content at 27,312 ppm with Zr at 1020 ppm. The enriched Fe and Zr concentrations and correlated very low Sr concentrations are characteristic of peralkaline obsidian. The only known peralkaline obsidian sources in the Near East are Bingöl A and Nemrut Dağ sources of eastern Turkey. Regrettably, obsidian samples from a number of important eastern Turkish sources, including Bingöl, Nemrut Dağ, Tendürek Dağ, Meydan Dağ, and Süphan Dağ were not available for analysis in this study. Thus, while not ideal, it became necessary to compare these artifacts with published compositional data for these sources. This comparison shows that eight artifacts can be attributed to Meydan Dağ near Lake Van, located 140 km SW of Masis Blur, and two artifacts to Bingöl, one from Bingöl A and one from Bingöl B, located 375 km SW of Masis Blur (Table 6.4 and 6.5). However, it is possible that the artifact I matched with Bingöl A should be attributed to Nemrut Dağ instead. Most sourcing studies cannot discern obsidian from Bingöl A and Nemrut Dağ (Francaviglia and Palmieri 1998; Pernicka, et al. 1997, but see Frahm 2012a), so it is usually unclear if the peralkaline obsidians identified in archaeological assemblages come from one or two sources. My assignment to Bingöl A is based on the artifact’s closer compositional match to published Bingöl A data, though as I noted above direct comparison of results obtained with different instrumentation is problematic. In this case it might be more appropriate to assign artifact MB2013.M11/1.TP.0310a.7 to Bingöl A/Nemrut Dağ. A fourth artifact, MB2012.pebble.brown, (Figure 6.20), an obsidian pebble excavated from the topsoil at Masis Blur has an Fe concentration above 25,000 ppm, but an unusually low concentration of Zr, around 170 ppm. Its high Fe composition is akin to both Nemrut Dağ and Bingöl, however, both of these sources have a correlated high concentration of Zr. Among Southern Caucasus obsidian sources, Aghvorik and Sizavet have the highest Fe concentration, but even these contain only around 12000 ppm and have a correlated Zr concentration around 230 ppm. Thus, the origin of this artifact can only be traced to the peralkaline obsidian sources in eastern Turkey.

Following the above procedures, I was able to assign 671 artifacts (78.5%) to nine different sources and 183 (21.4%) could not be assigned to any of the sources included in the MD probabilities calculations. As the number of unassigned artifacts seemed to high, I assessed these once more. Nearly 100 of the 183 artifacts (or around 55%) are right at the limit of the minimum requirement of the Tracer pXRF. Thus, we cannot exclude the possibility that the inability to attribute these artifacts to a source is due to the inability of the instrument to measure the element concentrations accurately. Three sources located north of Masis Blur – Arteni, Gutanasar, and Geghasar – provided the majority of raw material to the inhabitants of Masis Blur; though, there is a clear preference for Arteni sources with 28.1% (240 artifacts) of the analyzed artifacts coming from either Mets or Pokr Arteni sources (Figure 6.21). Around 17% (143 artifacts) and 13% (114 artifacts) of the analyzed artifacts are attributed to Gutanasar and Geghasar respectively. Hatis, another high-quality source located 5 km closer to Masis Blur then Gutanasar, and just as easily accessibly contributes only 7% (62 artifacts) to the analyzed artifacts, while Sarikamiş, located 160 km west of Masis Blur, contributes 11% (96 artifacts) to the dataset. Five artifacts are definitively attributed to Pasinler (230 km W) and 1 to Erzurum (280 km SW).

The artifacts which cannot be attributed to any of the sources analyzed in this study form at least five or six different compositional groups (Figure 6.22), suggesting that they are coming either from multiple sources or from one or two sources with distinct sub-source variation.

Considering that both Meydan Dağ and Bingöl sources were exploded at Masis Blur, it is not unlikely that a number of the unassigned artifacts are coming from other eastern Turkish sources, such as Tendürek Dağ, located roughly half way between Masis Blur and Meydan Dağ, or Süphan Dağ and both located near the north-western shores of Lake Van. There are a number of smaller obsidian sources in northeastern Turkey, such as Erzinca near Pasinler, which are little studied and poorly understood. Thus, these represent a second possible point of origin for some of the unassigned artifacts from Masis Blur. The third possibility, is the Merkasar (Kelbajar or Kecheldag) source in Artsakh. Badalyan, et al. (2004a) attributed 1 artifact from Masis Blur to Kelbajar-2, located 135 km SE of Masis Blur. However, this high mountainous source is also poorly studied and current access is difficult. Exploitation of this source by the inhabitants of Masis Blur is less likely. It would require an arduous journey over difficult terrain with an elevation gain of over 1200 meters and would take more than 40 hours to reach the source on foot. There are no known Neolithic settlements in this area, which could have acted as loci of interaction for the inhabitants of Masis Blur, and other than obsidian raw material and summer pastures, the area would not have offered anything more to Neolithic communities. Both resources, obsidian and summer pastures, are available much closer to Masis Blur. Nevertheless, without a direct comparison of geological specimens from Merkasar to Masis Blur artifacts, this source cannot be ruled out. Until further work is done, Merkasar remains a possible source of origin for some of the unassigned artifacts from Masis Blur.

Artifact ID/Source	Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb	Publication	Analytical Technique
Bingöl A/Nemrut Dağ	731	29400	196	-	31	231	1	136	1205	54	Gratuze 1999	LA-ICP-MS
MB2013.M11/1.TP.0310a.7	504	19158	187	24	21	205	1	120	1057	66	This study	pXRF
Bingöl B	307	12665	55	-	27	241	33	32	355	23	Khalidi et al. 2009	XRF
MB2013.M11/1.TP(E).0330.4	346	13509	56	23	27	219	47	31	326	20	This study	pXRF
Meydan Dağ	477	9564	76	-	-	183	12	43	230	32	Chataigner and Gratuze 2014	LA-ICP-MS
MB2014.M9/6.804.8073.17	567	9404	92	27	23	198	15	55	272	34	This study	pXRF
MB2014.M9/6.804.8059.1	496	9276	91	18	22	196	21	49	267	33	This study	pXRF

Table 6.4 – Comparisons of Masis Blur artifacts to published specimens from Bingöl, E. Turkey.

Artifact ID/Source	Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb	Publication	Analytical Technique
Meydan Dağ	477	9564	76	-	-	183	12	43	230	32	Chataigner and Gratuze 2014	pXRF (N=10)
	31	726	13	-	-	18	3	11	48	4		SD
MB2012.L10/4.111.1075	504	9575	90	20	22	196	13	58	269	32	This study	pXRF
MB2013.M11/1.026.FT2.0362.3	553	9614	88	21	21	204	17	52	270	34	This study	pXRF
MB2013.M11/1.TP(E).0330.15	587	10629	102	24	26	211	26	55	276	36	This study	pXRF
MB2014.M9/6.804.8052.2	498	10140	101	20	22	205	21	55	264	34	This study	pXRF
MB2014.M9/6.804.8059.1	496	9276	91	18	22	196	21	49	267	33	This study	pXRF
MB2014.M9/6.804.8059.1	496	9276	91	18	22	196	21	49	267	33	This study	pXRF
MB2014.M9/6.804.8073.17	567	9404	92	27	23	198	15	55	272	34	This study	pXRF
MB2014.M9/6.804.8073.3	520	9921	105	22	24	215	17	54	277	36	This study	pXRF
MB2014.M9/6.804.8077.2	596	10090	101	24	25	214	15	61	277	32	This study	pXRF

Table 6.5 – Comparisons of Masis Blur artifacts to published specimens from Meydan Dağ, E. Turkey.

Figure 6.20 – Peralkaline obsidian pebble from Masis Blur.

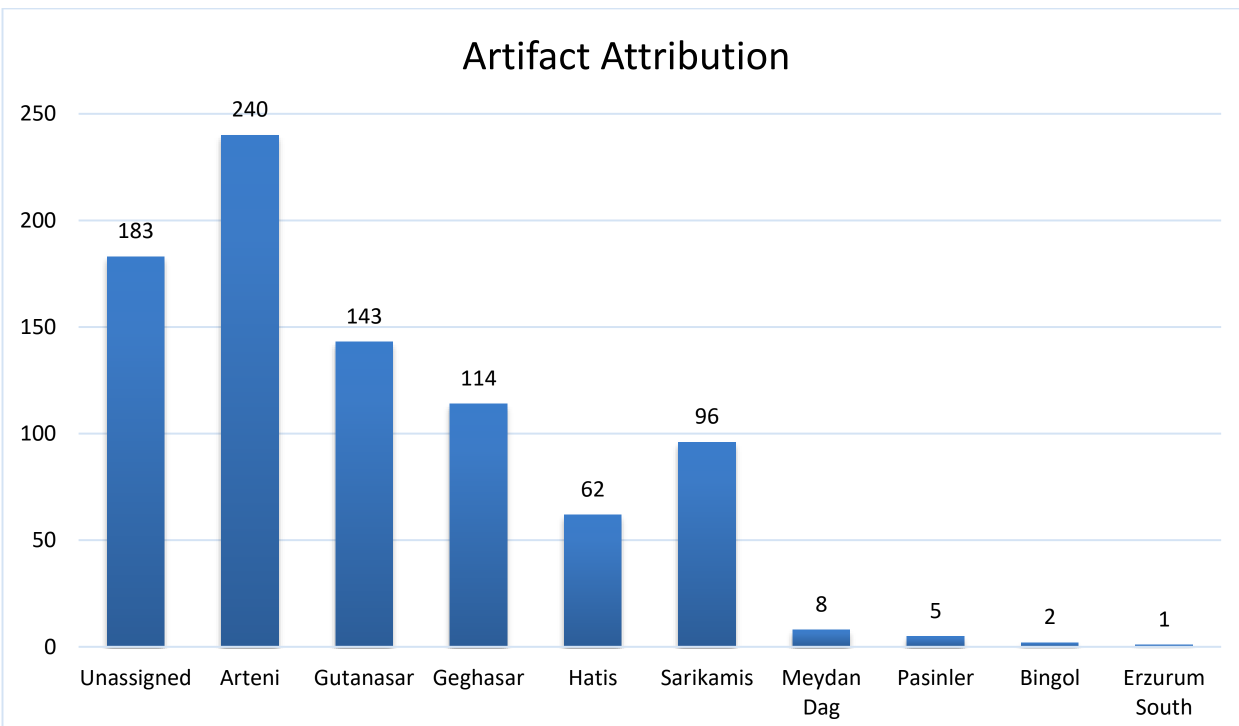

Figure 6.21 – The proportion of Masis Blur artifacts assigned to a source or unassigned to any source analyzed in this study.

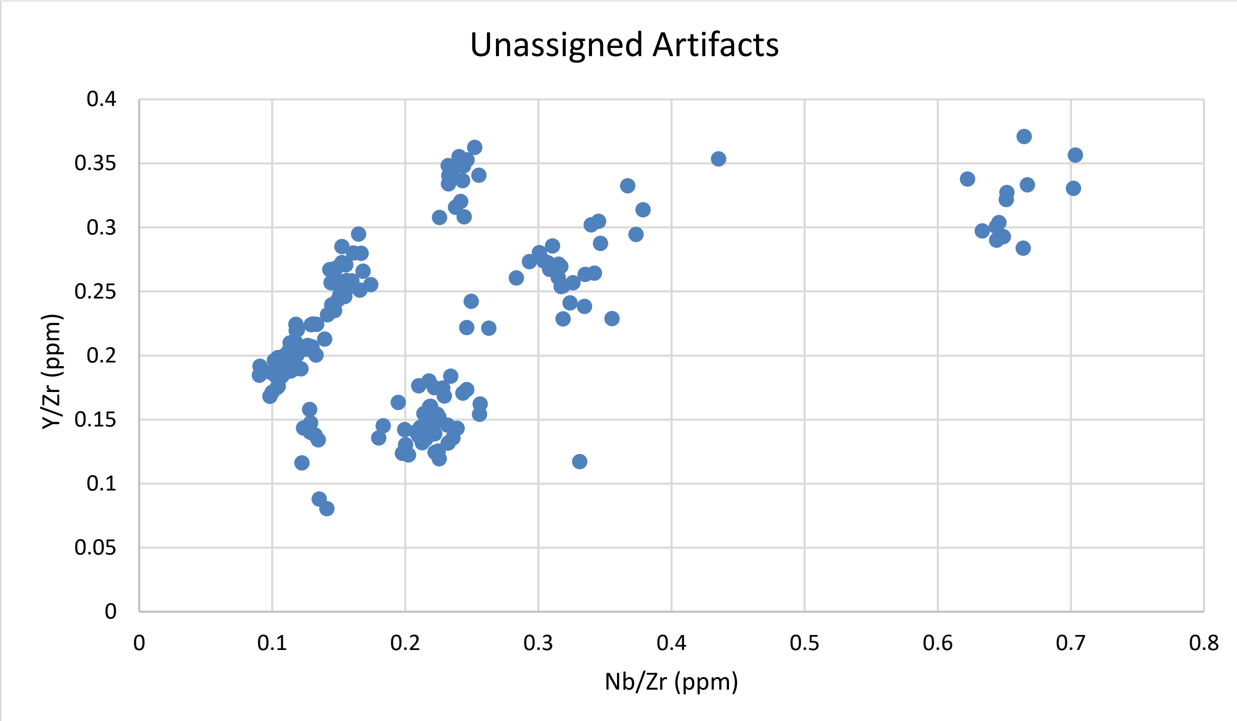

Figure 6.22 – The bivariate plot of Nb and Y measurements normalized to Zr illustrates the presence of a number of different compositional groups within the unassigned artifacts from Masis Blur.

6.5 Sourced Artifacts in Context

The following section discusses the available stratigraphic information for the sourced artifacts. As noted before, excavations at Masis Blur are ongoing, thus the division of cultural horizons presented in this dissertation are preliminary. Additionally, not all cultural horizons exposed so far have been excavated to the same extent, as a result, horizons with great exposure yielded greater number of obsidian artifacts, thus a greater number of these is included in this study. Five hundred seventy-four artifacts from the 854 analyzed come from five cultural horizons, the remaining 280 come either from the plough zone area (identified by the excavators as “Topsoil”) or from disturbed/intrusive contexts. Figure 6.23 illustrates the distribution of analyzed artifacts by context and Figure 6.24 illustrates the distribution of sources identified in the assemblage by context.

6.5.1 Sourced Artifacts from Horizon I

Horizon I is dated to 5475 – 5375 cal. BC and is represented by a single primary burial (Burial-1) with two accompanying features in Trenches O8/1 and O7/13. Only parts of these two 5x5 m trenches have been excavated. A total of 364 obsidian artifacts were excavated from this area with only 219 coming from secure contexts; of these 32 were analyzed in this study. All analyzed artifacts were either placed on the deceased or in the accompanying features containing burial offerings. The obsidian from the burial context comes from Arteni, Gutanasar, Geghasar, Hatis, Sarikamiş, and a single artifact was not attributed to a source.

6.5.2 Sourced Artifacts from Horizon II

Horizon II is represented by trench M10/3 and dates to 5615 – 5520 cal. BC. The trench has several features from the preceding occupation phase. A total of 48 artifacts were analyzed from the secure contexts of M10/3; 43 were attributed to obsidian flows of Arteni, Geghasar, Gutanasar, Hatis, and Sarikamiş. Five artifacts could not be attributed to any source.

6.5.3 Sourced Artifacts from Horizon III

Horizon III is represented in trenches M10/2, M10/3, and M11/1. In trenches M10/3 it is represented by a slopped floor with consecutive white and gray plastering with an associated cobble feature. The latter appears to be a working area of some sorts. The horizon is best represented in trench M10/3 where there is a relatively large dwelling unit with accompanying storage structures and various features. In M11/1 is represents several loci and a number of construction phases observed on the stratigraphy of the Test Pit placed in the south-western corner of Trench M11/1. However, it should be noted that the assignment of the strata in the Test Pit have not been finalized. This horizon dates between 5715 – 5630 and 5745 – 5665 cal. BC. A total of 105 artifacts were analyzed from Horizon III, 79 of which were attributed to seven different sources in Armenia and eastern Turkey, 24 could not be assigned to any source. The Armenian sources present are Arteni, Geghasar, Gutanasar, and Hatis. Eighteen out of the 20 artifacts attributed to the eastern Turkish sources are attributed to Sarikamiş and one artifacts from Meydan Dağ, Erzurum, and Bingöl B. The artifacts from Maydan Dağ and Bingöl B were excavated from the Test Pit, whereas the artifact attributed to Erzurum was excavated from locus 911 in Trench M10/2.

6.5.4 Sourced Artifacts from Horizon IV

Thus far, Horizon IV has been identified only in trench M11/1; it dates between 5765 – 5675 and 5780 – 5700 cal. BC. The horizon is represented by the construction phase of the collapsed wall and the associated burnt beam in the north-west corner of the trench and the period immediately succeeding this event. One hundred and five artifacts were analyzed from Horizon IV; 79 were attributed to sources in Armenia and eastern Turkey and 26 could not be assigned to any source. Artifacts were attributed to the Arteni, Geghasar, Gutanasar, and Hatis sources in Armenia and the Sarikamiş and Pasinler sources in eastern Turkey.

6.5.5 Sourced Artifacts from Horizon V

Horizon V has been identified in trenches L10/4, M10/1, and M11/1. The horizon has three sub-division and dates between 5835 – 535 to 5895 – 5785 cal. BC. Two hundred and forty-seven artifacts were analyzed from three trenches; 184 were attributed to sources in Armenia and eastern Turkey, 63 artifacts could not be attributed to a source. The sources present are Arteni, Gutanasar, Geghasar, Hatis, Sarikamiş, Pasinler, Meydan Dağ, and the peralkaline source Bingöl A.

6.5.6 Sourced Artifacts from Horizon VI

Horizon VI has been identified in trenches M9/1, M9/5, and M9/6. It dates to 5925 – 5835 cal. BC. A single radiocarbon date of 6245-6205 cal. BC was obtained from M9/5, however, this date should be taken with caution, as it was based on wood charcoal and can be reflective of the age of the tree more than the age of the occupational phase. However, if this date is collaborated by dates based on annual plants, the establishment of Masis Blur will predate all currently known Neolithic settlements in the Southern Caucasus. A total of 367 obsidian artifacts were excavated from Horizon VI and 176 were analyzed in this study. One hundred and twenty-nine artifacts were attributed to sources in Armenian and eastern Turkey and 47 could not be assigned to a source analyzed in this study. The raw material of the attributed artifacts originated from Arteni, Gutanasar, Geghasar, Hatis, Sarikamiş, Pasinler, and Meydan Dağ.

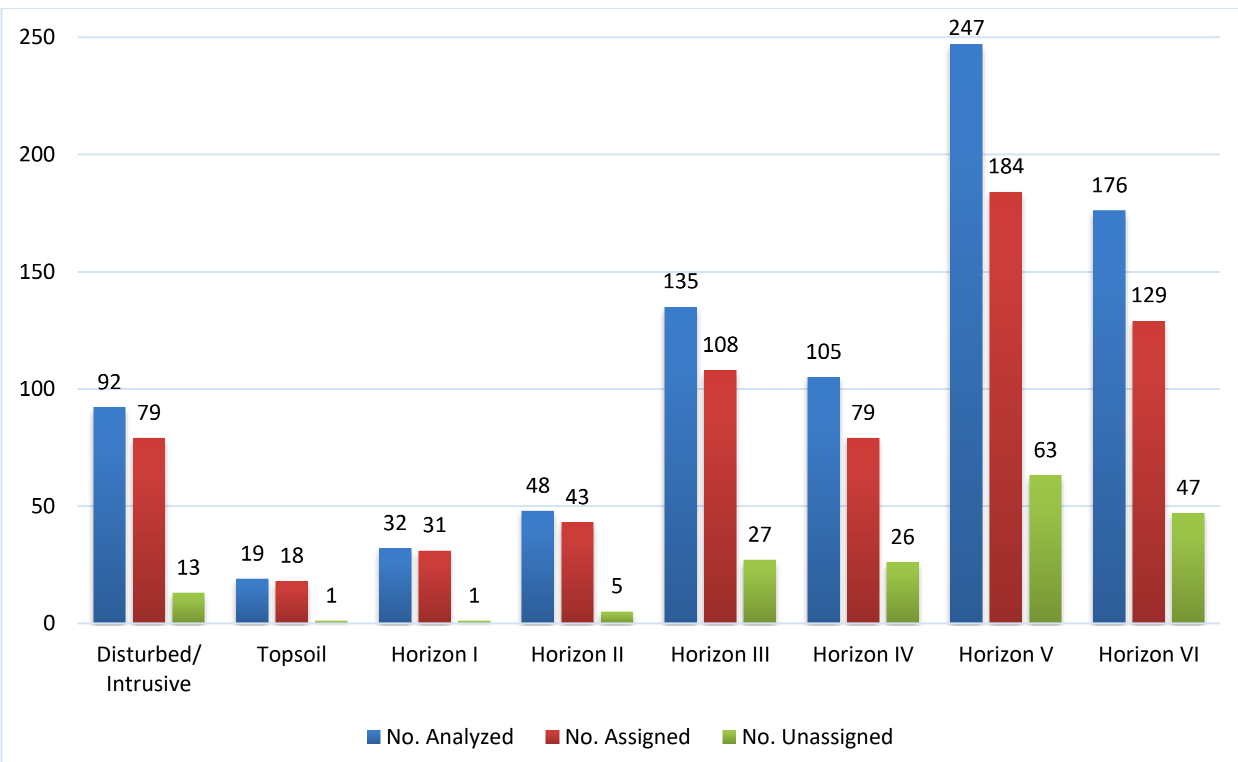

Figure 6.23 – Distribution of Masis Blur obsidian artifacts (n=854) analyzed in this study by context.

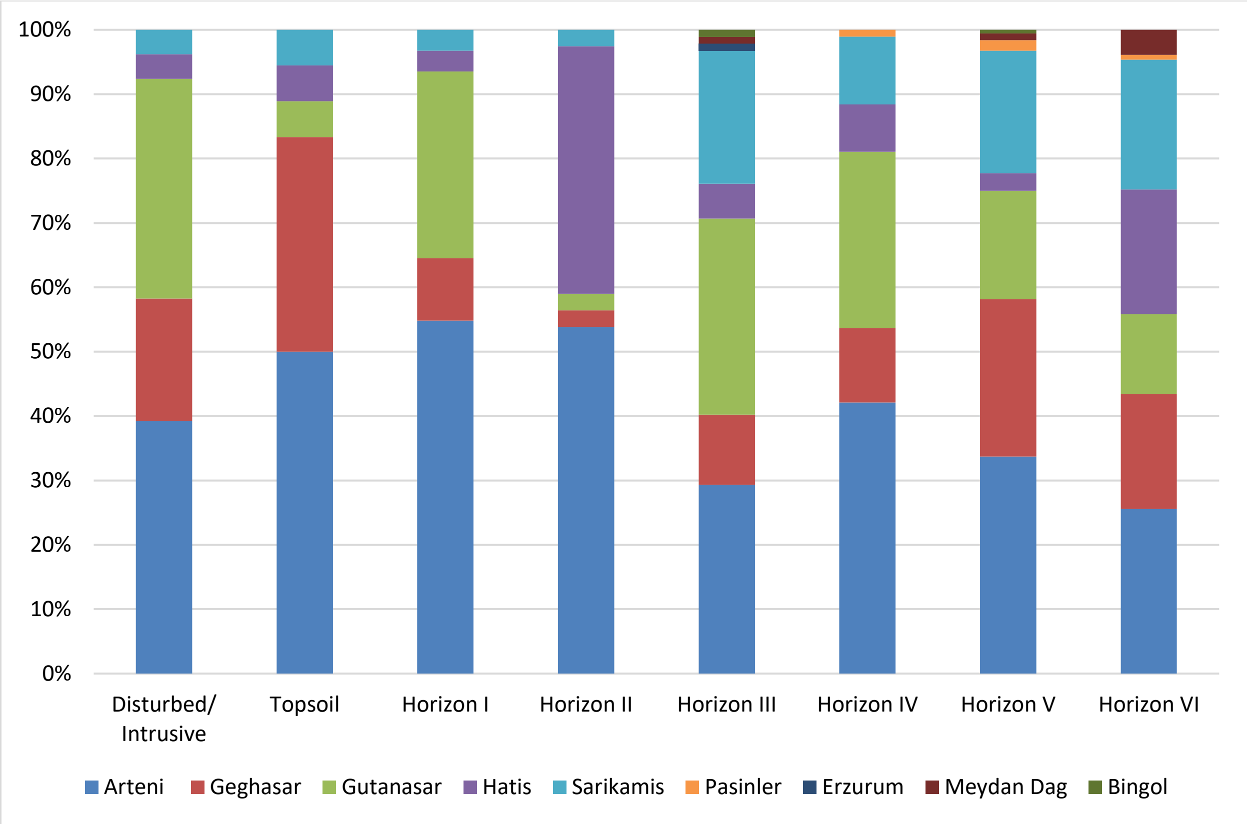

Figure 6.24 – Distribution of sources identified in the Masis Blur obsidian artifacts by context.

6.6 Summary of Results

A number of interesting observations can be made based on the compositional analysis of the geological and archaeological materials. First, analysis of a significantly larger archaeological dataset confirms results obtained from analysis of only a few dozen artifacts, namely that the inhabitants of the Ararat plain, did not exploit obsidian sources located in northern Armenia and Georgia, nor those located in Syunik. Second, the artifacts attributed to Pokr Arteni fallow the trend observed in the geological specimens. They split into two similar compositional groups and are attributed to Arteni-3 through Arteni-5 subgroups of Pokr Arteni (Figure 6.25). The confirmation of this pattern by artifacts suggests that the observed gap in the geological sample is not likely to be a result of sampling strategy. Rather this gap is either the result of the formation processes of the obsidian flow or the segment of the flow which can fill in the gap was inaccessible already during the Neolithic. Whether the similar composition represents two different eruption events with slightly different magma geochemical magma evolution or a single event with a continuous yet changing composition of the magma cannot be determined at this time. A more nuanced understanding of the formation of the Arteni volcanic complex and a more through sampling approach is needed. Finally, this study revealed the presence of eastern Turkish obsidian sources beyond Sarikamiş, adding four sources previously unidentified within assemblage from the Southern Caucuses with the furthest source located over 375 km SW of Masis Blur.

Using a combined statistical method approach, which includes log-transformation, principal components analysis (PCA), and group membership probability using Mahalanobis distances, I attributed 79% (n=671) of the analyzed Masis Blur artifacts to nine different sources in Armenia and eastern Turkey. Four sources located in Armenia – Arteni (28%), Gutanasar (16%), Hatis (7%), and Geghasar (13%) – provide 64% of the raw material of obsidian artifacts from Masis Blur. Among these four greater preference was given to obsidian from Arteni. Five sources in eastern Turkey provided an additional 13% of the raw material with Sarikamiş being the source of choice for the inhabitants of Masis Blur. The remaining 13% of the analyzed artifacts could not be attributed to any of the sources analyzed in this study. The presence of obsidian from Bingöl A, one of the two known peralkaline sources in the Near East, and located over 375 km (linear distance; much farther via actual travel routes) southwest of Masis Blur is very interesting and suggests that the beginnings of long-distance contact and exchange between the Southern Caucasus and the Near East can be traced back to the Neolithic period. The implications of these sourcing results, considered in light of their contextual information and general observations on the obsidian industry of the settlement, for the Southern Caucasus in general and Masis Blur in particular are discussed in Chapter 7.

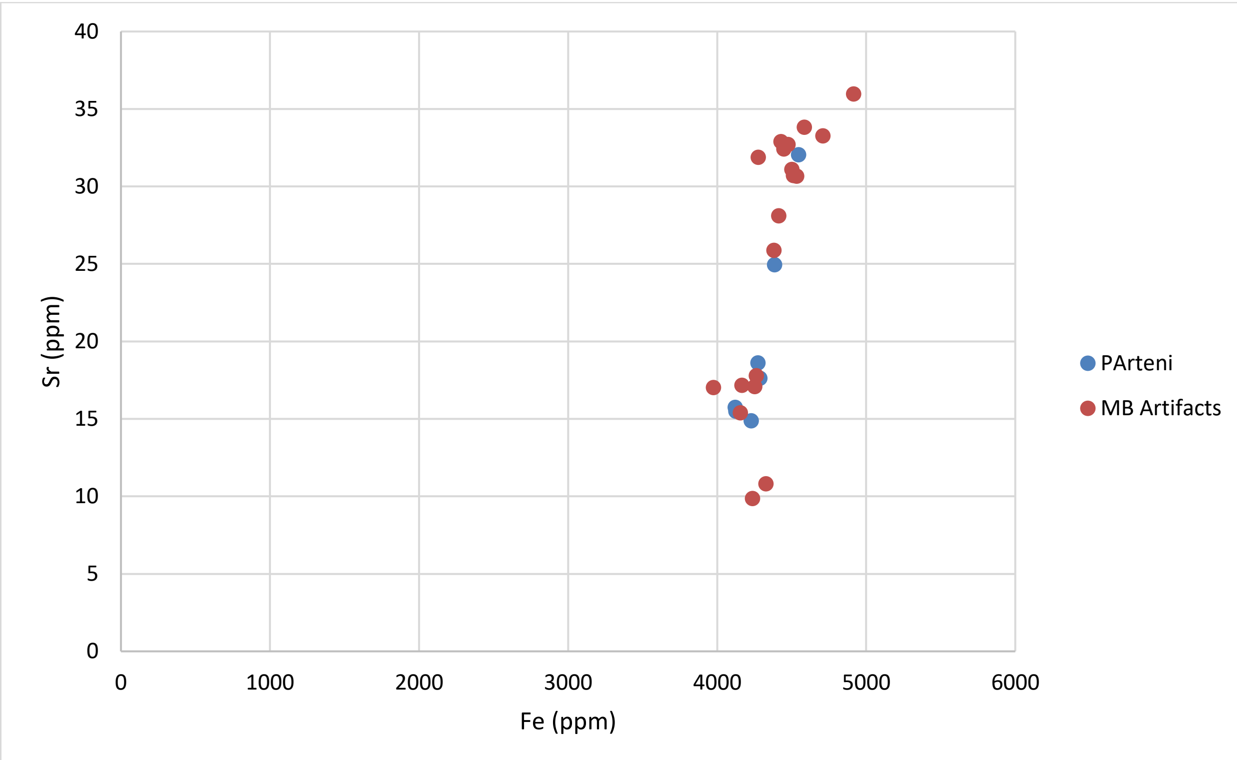

Figure 6.25 – Bivariate scatter plots of Fe versus Sr concentrations illustrating the attribution of Masis Blur artifacts to the Pokr Arteni obsidian source. Note that the attributed artifacts follow the trend observed in the grouping of geological specimens.

CHAPTER 7: IMPLICATIONS OF SOURCING RESULTS

7.1 Evidence of Contact and Exchange at Masis Blur

There is very limited evidence of contact, and even less for exchange, at Masis Blur and other Neolithic settlements of the Ararat Plain with communities of the greater Near East. Most of the prior archaeological evidence is in the form of rare pottery fragments belonging to the Halaf culture. Typically defined as a North Mesopotamian tradition, Halaf wares, more often fragments with the characteristic geometric patterns or animal motifs, have been identified throughout Neolithic settlements of the Southern Caucasus. Tilkitepe, located on the south-eastern shore of Lake Van, is identified as a Halaf site (Korfmann 1982) and represents the northernmost reach of the tradition. The only known complete Halaf pot in the Southern Caucasus was discovered at Kültepe in Azerbaijan; a handful of painted fragments have been found at Arukhlo, Aknashen, and Aratashen in Armenia. Likewise, we have excavated two fragments from Masis Blur. Some of the bearers of the Halaf tradition were mobile groups, perhaps as a result of 6200 BCE climatic event, which caused aridification of the land in northern Mesopotamia, forcing settled agriculturalist in the region to adapt to the changing environment or to move to new ecological niches. This mobility would have resulted in increasing interactions with settled communities farther out and the spread of Halaf materials.

Another possible line of evidence for contact between the Southern Caucasus and Mesopotamia are specific elements of the lithic assemblages. The production of long blades, often over 15 cm long, using pressure technique with a lever has been investigated as a possible influence of Southern Caucasus on Mesopotamia. Chabot and Pelegrin (2012) show technical parallels between the 6th millennium BCE obsidian blades found at Aratashen in Armenia (also present at Masis Blur) and the production of “Canannean blades” of Mesopotamia. However, the study only highlights the production technique involved and does not allow for a direct correlation between the two areas. It is also important to note that blades were produced by pressure in south-eastern Turkey and Mesopotamia between the 8th and 7th millennia BCE and again in the 4th millennium BCE, thus there are no contemporaneous parallels with the 6th millennium Southern Caucasian production of these blades. It is not unlikely that this technique was developed independently in the three regions at different times. Another aspect of the lithic technology that has the potential to show connections between the two regions is a visually very distinct tool type. Arimura et al. (2012) addressed the possible connections between the Kmlo tools discovered in Mesolithic/Neolithic sites in Armenia, the Paluri “hooked” tools of Georgia, the Çayönü tools of south-eastern Turkey. Based on technological and use-wear analysis they concluded that while these tools share morphological likeness, the tools share neither the *chaîne opératoire* nor function between groups from the South Caucasus or southeast Turkey.

Many, if not most, of the materials exchanged by prehistoric societies are archaeologically invisible. Agricultural and animal products not available locally, various mineral products, such as salt and spices, were likely traded throughout the region, though have left no visible evidence. The obsidian sourcing results from Masis Blur offer more concrete evidence of contact, which lasted nearly a millennium, between the inhabitants of Masis Blur and those either settled or seasonally occupying lands near obsidian sources around Lake Van and further north. The kind of data obsidian sourcing can provide is currently unparalleled.

The paucity of obsidian from the most distant sources, such as Bingöl and Erzurum suggest that the inhabitants of Masis Blur did not visit the sources themselves but rather obtained the obsidian artifacts through indirect procurement.

7.2 Implications of Sourcing Results

The results presented in Chapter 5 clearly illustrate that a large number of sources are represented among the obsidian artifacts of Masis Blur. Depending on how one defines a source, there are at least nine or ten sources identified within the analyzed assemblage. If we also consider the likelihood of a number of artifacts forming distinct groups, which I could not attribute to a geological source in this study, this final number of sources will be even higher. Prior sourcing studies of obsidian artifacts from Neolithic and Chalcolithic sites of the Southern Caucasus have identified only between three to six sources at a given site. I believe that the diversity of sources identified in this research, at least in part, may be a result of studying 854 artifacts from a single site, as opposed to five or ten. Similarly, based on a handful of artifacts, prior sourcing research on obsidian artifacts from prehistoric sites located in the Ararat plain, including Masis Blur, concluded that the obsidian of Arteni volcanic complex was the dominant source, providing between 65 to 76 percent of the total assemblage. My research shows, that while at Masis Blur obsidian from Arteni sources is present in slightly higher numbers, at 28% it certainly is not the main source utilized at Masis Blur.

Overall, the use of obsidian sources at Masis Blur is largely consistent over nearly one thousand years of occupation, with the exception of Eastern Turkish sources, which, so far, are present in fewer numbers in the later occupational horizons. This is in contrast to other lines of evidence, which suggest increased inter-regional contact during the end of the Late Neolithic and early Chalcolithic periods. However, this might be a factor of limited exposure of these horizons, resulting in a smaller number of analyzed artifacts. As archaeological excavations expose larger area of the last occupational phases of Masis Blur, it will be interesting to see how patterns compares.

The presence of obsidian from farther sources, such as ones in eastern Turkey, does not seem to be context driven either. The artifacts attributed to these sources occur in household contexts, open courtyard areas, storages bins, middens, as well as among the artifacts deposited with the adult male burial excavated in 2014.

The inhabitants of Masis Blur utilized a multi-source raw material procurement strategy, obtaining 69% of the total analyzed obsidian from four different sources – Arteni, Gutanasar, Geghasar, and Sarikamiş – with each source contributing between 28 to 11 percent. The results of the sourcing data do not match Renfrew's Law of Monotonic Decrement model, which argues that the frequency of obsidian diminishes linearly as distance from source increases (Renfrew, et al. 1968). In this model, Renfrew defined the "supply zone" where the quantity of obsidian represents more than 80% of an assemblage and this zone can stretch up to 250 km. We can see that none of the sources located within the 250 km range, or even those located within a 50 km range, supplied more than 80% of the raw material to Masis Blur. A supply zone of up to 250 km is indeed too great a distance to travel for largely sedentary communities, particularly when the resource in question is a non-luxury good, which might have made the long journey economically or socio-politically profitable.

Obsidian artifacts attributed to these sources are represented as blades, blade fragments (both blanks and tools) and more rarely flakes and chunks. The near absence of cortical flakes indicates that initial knapping took place at the raw material source and core preforms were brought back to the settlement for further reduction. Obsidian from all the sources utilized by the inhabitants occur in all occupational phases and in all context, indicating that no one source was preferred for a specific tool type or specific context. As observed by other researchers, the selection criteria of a raw material source and its use for knapping blanks and tools were not driven solely or even largely by the proximity of the site to the source with high quality obsidian. Similarly, visual attributes, such as color or internal patterning of obsidian could not explain multi-source obsidian procurement strategies, as the Arteni volcanic complex alone can provide high quality obsidian in a wide variety of colors and patterns ranging from nearly colorless transparent obsidian to reds, browns, blacks, and various combinations of these. The only obsidian varieties absent at Arteni are the silvery-grays and greenish-grays, which can be found at Hatis. However, since these types were used for making tools of everyday use and were not reserved for specific tool types or none utilitarian objects (or what Appadurai might call "common" and "luxury" goods), I do not believe that Hatis sources were utilized for the specific color ranges, which do not occur at Arteni.

Based on the sourcing results, I argue that acquisition of obsidian had a more complex structure and was not driven by a single factor. The Arteni volcanic complex (highest peak: 2047 m) was likely exploited because of its ease of accessibility. This source is located a 2-days' journey (about 15 hours on foot) from Masis Blur and it is a rather undemanding expedition along the valley floor with virtually no gain in elevation until one reaches the foothills of the volcanic complex. Additionally, during the winter months, when all other sources in the region are under snow cover and inaccessible for exploitation, Arteni's moderate snow cover and the extension of its obsidian bearing flows into the Ararat plain make obsidian procurement possible. Hatis (2528 m), Sarikamiş (2632 m), Gutanasar (2992 m), and Geghasar (3443 m) receive heavy snow coverage by October-November and remain inaccessible through March-April. Although some of the obsidian flows of Hatis and Gutanasar do reach the periphery of the Ararat plain, access to the sources is more difficult and involves a noticeable elevation gain as one travels east along the steep canyons. The presence of obsidian from distinct sub-sources of Hatis and Arteni, some of which are geographically confined and separate from one another, indicates that the inhabitants of Masis Blur were not collecting the raw material from the flows which extend into the plain, a strategy which would make the most sense if procurement of obsidian was the sole purpose of the journey, but rather from a number of different locations on the volcano itself. The sourcing results suggest that direct procurement of obsidian was practiced for the Arteni, Gutanasar, Geghasar, and Hatis sources. I propose that exploitation of these sources was likely aligned with seasonal herding of livestock on nearby mountain ranges. The Ararat plain is too arid in the summer months to support animal husbandry, thus inhabitants of Masis Blur likely practiced short-range vertical transhumance.

Historical and ethnographic sources provide evidence of seasonal transhumance, necessitated by climatic and environmental conditions, practiced by the farmer-herders of the Ararat plain (Mkrtumyan 1974). While I do not presume continuities in pastoral practices through time or timeless homogeneity of farmer-herder communities, these sources still provide useful information regarding the trajectory of animal husbandry practices in the region. Every spring, village-based shepherds and their families take the herds up to the summer pastures located on high plateaus, whereas the majority of the village's residents stay in the lowlands to tend to the crops and the properties. Isotopic evidence from Neolithic sites in south-eastern Turkey suggests that livestock were moved to more productive grazing areas seasonally. For example, research from Çatalhöyük suggests that pastoral mobility was generally limited to areas located within two days' walk from the settlement itself (Baird, et al. 2011). Similarly, isotopic evidence from Köşk Höyük suggests that the inhabitants practiced seasonal vertical transhumance in which the herds were taken to the upland summer pastures for grazing (Makarewicz and Arbuckle 2009; Meiggs and Arbuckle 2010 as cited in Hammer and Arbuckle

2017). A similar scenario can be proposed for Neolithic inhabitants of Masis Blur. The zooarchaeological evidence from Masis Blur suggest that animal husbandry, particularly sheep and goat, was an important component of the subsistence system; thus, to realize the potential of a large herd the inhabitants of Masis Blur would have to take their herd to the mountain pastures in the summer months, many of which are located near obsidian sources. It is on their journey back to the lowland settlement that they would have brought down the obsidian preforms. There is no evidence to suggest that pack animals were in use, so the shepherds could bring down only what they could carry themselves. The presence of obsidian from multiple sources, all located within 2-days' walk from the site and along upland pasture routs combined with the zooarchaeological evidence, seem to suggest that direct raw material procurement was a secondary activity aligned with animal herding practices.

By the 7th millennium BC pastoralism begins to spread, moving into new environments and more distant lands (Conolly, et al. 2012), thus increasing interactions with populations in neighboring regions. In south-east Turkey, within the Halaf cultural area, a shift towards long-distance transhumance would facilitate movement of goods between regions. Obsidian from variety of sources would likely have been transported by transhumant groups. It is through these groups that rare obsidian artifacts from sources such as Bingöl, Erzurum, and Pasinler, as well as the fragments of Halaf pottery made their way into Neolithic settlements of the Ararat plain and beyond. These artifacts are merely one-end product of complex patterns of interactions during the Neolithic, almost all of which surely involved reciprocal exchange. These token exchanges of obsidian artifacts, a raw material which is abundantly available in Armenia, did not carry any economic benefit itself, but rather were a symbol of maintaining and defining wider socio-economic relations. Based on current archaeological evidence, it is difficult to ascertain if these exchanges took place during seasonal encounters in the summer grazing areas, near other raw material sources such as salt, planned gatherings for the purpose of selecting marriage partners, or feasts celebrating marriage and other significant events. It is also possible that these artifacts came to Masis Blur as dowry or bride-wealth. They could have been transported as physical and symbolic like to one's region of origin, a practice which has been recorded among native communities of Australia (Gould et al., 1971). Social drivers behind reciprocal exchange are difficult to discern in the archaeological record, particularly for prehistoric sites, but in the absence of political hierarchy or economic trade, social drivers are a more likely possibility.

7.3 Concluding Remarks

The results of my sourcing research based on 854 obsidian artifacts from six occupational horizons of Masis Blur reveal a complex raw material accusation pattern at the settlement. It is evident that no one source was given preference over other sources present within a two-day's walk from the site. There is also no correlation between artifact type and source, indicating that raw material from all the sources utilized were treated in the same manner by the inhabitants of Masis Blur. The method of direct acquisition was used for sources located within a two-days' walk (or 50-70 km) from the site and unsurprisingly material from these sources is represented in greater quantities. Obsidian, either in raw or finished form, from farther sources is represented by a handful of samples and was likely obtained through indirect procurement. I argue that these artifacts made their way into the Neolithic settlement as products of reciprocal exchange. Ultimately, the question of *why* these rare obsidian artifacts from remote eastern Turkish sources, along with painted Halaf pottery fragments, were transported over hundreds of kilometers to the Ararat plain must remain open for the immediate future, as the lithic assemblage of only a single site has received detailed attention. The research and interpretations I present in this dissertation represent a first attempt of a large-scale sourcing research for the Neolithic period in the Southern Caucasus, an area which has not benefited from similar work that has been undertaken in Mesopotamia or the Mediterranean. As Figure 7.1 also illustrates, there is a surprising lack of evidence of Neolithic occupation in eastern and north-eastern Turkey to correlate data from this region with neighboring archaeological records. However, Neolithic research in Armenia, as well as the Southern Caucasus is vibrant and growing. Data provided in this dissertation will be augmented by ongoing archaeological excavations and analysis. While my research has begun to address this, the analysis of a single site cannot hope to provide anything more than site-specific patterns of a complex regional phenomenon. It is my hope that this research will serve as an example of what can be accomplished and can illustrate the potential of large-scale collaborative research.

Figure 7.1 – Distribution of Late Neolithic sites in the Southern Caucasus and Eastern Turkey.

APPENDICES

Appendix 1: Element Concentrations of Geological Specimens (n=167) from Armenia, Georgia, and eastern Turkey (in parts per million).

Specimen ID	Element Concentration (ppm)									
	Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
Aghvorik.1.076	502	11725	66	19	16	99	180	19	229	19
Aghvorik.2.077	517	12061	66	17	13	99	180	21	239	16
Aghvorik.3.078	721	11723	75	23	27	98	178	23	225	17
Aghvorik.4.106.1	686	11756	41	17	17	98	177	19	221	16
Aghvorik.4.106.2	605	11784	57	21	16	101	177	18	225	18
Aghvorik.4.106.3	530	11957	54	17	17	98	181	19	228	19
Aghvorik.4.106.4	569	11849	56	18	14	100	187	21	227	19
Aghvorik.5.107	517	11788	63	16	14	104	185	22	231	20
Aghvorik.general	537	11720	67	18	17	101	177	20	229	19
Mean	576	11818	60	18	17	100	180	20	228	18
STDV	74	112	9	2	4	2	3	2	5	1
Bazenk.1.014	560	4514	48	15	30	177	4	12	95	36
Bazenk.3.016	441	4236	47	18	28	179	4	11	94	35
Bazenk.4.017	475	4448	32	18	26	182	4	12	99	37
Bazenk.5.018	533	4484	35	19	27	180	4	10	97	38
Brusok.1.090.1	696	3950	43	17	15	134	15	34	84	39
Brusok.1.090.2	639	3661	43	20	13	145	10	32	69	37
Brusok.1.090.3	737	3807	34	18	12	150	10	31	77	38
Brusok.2.091	614	4126	37	16	16	133	23	29	74	35
Mean	587	4153	40	18	21	160	9	21	86	37
STDV	97	304	6	2	7	20	7	10	11	1
Chikiani.1.110	450	5124	52	17	14	131	66	17	86	19
Chikiani.2.111	386	5361	43	17	15	129	70	17	91	22
Chikiani.3.112	502	7794	39	19	12	111	143	13	147	17
Chikiani.4.113	465	5208	58	16	13	136	68	18	86	19
Chikiani.5.114.1	461	5376	44	17	12	125	72	18	92	21
Chikiani.5.114.2	575	5254	59	15	13	130	72	15	88	21
Chikiani.5.115	481	5469	51	19	16	127	77	16	95	21
Mean	474	5655	50	17	13	127	81	16	98	20
STDV	53	880	7	1	1	7	26	2	20	2
Damlik.2.100.1	466	5842	27	18	19	107	145	14	109	23
Damlik.2.100.2	454	5902	31	17	21	107	144	12	100	22
Damlik.2.100.3	460	5755	33	16	18	109	144	14	104	20
Damlik.2.100.4	416	5807	36	17	18	111	146	15	102	20
Mean	449	5826	32	17	19	109	145	14	104	21
STDV	19	53	3	1	1	1	1	1	3	1
ErzrumSouth.BaskoyKusakli.167	367	9450	57	18	19	157	11	38	221	24
ErzrumWest.Sogultu.176	533	16728	82	20	24	178	0	57	516	34
Mean	450	13089	70	19	22	167	6	48	369	29
STDV	83	3639	12	1	2	11	5	10	148	5
Geghasar.055.1.gen	644	3894	45	20	27	196	7	27	77	53

Specimen ID	Element Concentration (ppm)									
	Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
Geghasar.055.2.gen	600	3945	38	16	26	199	9	25	80	50
Geghasar.055.3.gen	597	4028	40	18	27	202	10	23	74	51
Geghasar.055.4.gen	676	4002	43	14	25	195	10	22	77	49
Geghasar.1.050.1	614	3997	33	17	26	203	9	26	80	50
Geghasar.1.050.2	641	3956	42	17	24	207	10	23	78	51
Geghasar.1.051	598	4069	43	16	24	194	8	27	79	50
Geghasar.2.052	564	4002	39	16	27	201	8	25	75	50
Geghasar.2.053.1	617	3893	41	14	24	195	9	26	81	50
Geghasar.2.053.2	636	3979	29	19	27	203	8	24	81	51
Geghasar.3.054	668	4021	41	16	25	195	11	23	80	50
Geghasar.flake	646	4247	49	21	24	205	9	23	79	54
Mean	625	4003	40	17	26	199	9	24	79	51
STDV	31	89	5	2	1	4	1	2	2	1
Gutanasar.1.059	585	8035	49	14	16	137	113	27	164	37
Gutanasar.10.074.1	623	8114	47	16	17	137	113	24	168	39
Gutanasar.10.074.2	596	7979	52	20	17	142	117	26	163	35
Gutanasar.2.061.1	657	8103	55	18	21	144	116	24	164	36
Gutanasar.2.061.2	555	8164	58	17	17	134	116	26	160	36
Gutanasar.4.064	594	8347	47	16	16	138	110	23	169	35
Gutanasar.7.069	564	7826	39	19	15	137	108	23	165	34
Mean	596	8081	50	17	17	138	113	25	165	36
STDV	32	150	6	2	2	3	3	1	3	2
Hatis.1.035	481	6188	57	19	18	106	102	19	97	24
Hatis.10.44	611	6173	39	17	15	111	101	18	94	23
Hatis.13.047.1	498	6269	31	13	15	106	99	18	95	24
Hatis.13.047.2	403	6551	42	19	18	114	102	19	95	23
Hatis.13.047.3	562	6163	46	12	18	108	92	18	92	20
Hatis.14.048.1	522	6869	37	18	16	112	99	20	96	24
Hatis.14.048.2	501	6305	43	17	16	114	104	20	99	22
Hatis.15.049	526	7145	30	13	17	105	110	19	101	25
Hatis.16.079	386	8448	47	14	18	98	148	16	109	21
Hatis.16.080	495	9967	40	18	16	97	170	19	124	22
Hatis.17.081	490	8828	42	14	16	95	155	18	117	22
Hatis.18.082.1	599	11208	47	22	14	95	213	16	138	22
Hatis.18.082.2	588	11364	39	19	13	93	220	17	140	22
Hatis.19.083	496	8814	39	22	16	104	153	19	114	20
Hatis.2.036	500	6229	34	15	14	111	100	19	98	24
Hatis.20.084	527	8059	32	20	19	103	132	21	109	21
Hatis.21.085	524	8057	38	16	12	105	134	16	107	24
Hatis.22.086	474	8127	43	18	11	102	130	19	111	21
Hatis.23.087.1	522	8300	41	17	15	107	131	17	109	21
Hatis.23.087.2	553	7884	48	16	14	107	135	15	107	21
Hatis.23.087.3	487	8116	45	22	16	101	140	17	109	21
Hatis.24.088	646	11695	45	15	14	97	171	20	119	21

Specimen ID	Element Concentration (ppm)									
	Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
Hatis.25.089.1	507	6475	46	20	16	112	105	20	99	24
Hatis.25.089.2	444	9650	59	17	14	100	174	17	118	23
Hatis.25.089.3	443	9195	50	16	16	91	167	17	122	20
Hatis.25.089.4	569	6350	42	18	14	114	102	18	100	21
Hatis.3.037	466	6176	40	14	17	113	101	17	96	24
Hatis.4.038	514	6360	33	16	18	113	102	19	98	21
Hatis.5.039.1	697	9274	35	12	16	95	168	19	124	21
Hatis.5.039.2	573	6617	39	18	18	110	100	19	99	25
Hatis.6.040	528	9595	42	14	17	101	169	16	121	20
Hatis.7.041	534	9447	50	20	13	98	174	16	123	23
Hatis.8.042.1	432	9600	39	15	14	97	170	17	118	22
Mean	518	8045	42	17	16	104	136	18	109	22
STDV	64	1650	7	3	2	7	35	1	13	1
Khorapor.1.104	357	4118	32	20	30	206	4	17	86	37
Khorapor.2.105	438	4256	40	21	29	211	2	15	90	36
Mean	397	4187	36	21	29	208	3	16	88	36
STDV	40	69	4	1	0	2	1	1	2	0
Mets Arteni.1.029	735	3816	54	15	13	137	9	33	67	37
Mets Arteni.2.030	647	3783	46	14	17	141	9	35	70	35
Mets Arteni.3.031	642	3867	50	15	15	133	9	32	71	39
Mets Arteni.4.032.1	712	3899	51	12	12	139	8	31	74	41
Mets Arteni.4.032.2	707	3919	52	18	15	148	9	33	72	37
Mets Arteni.4.032.3	707	3862	43	17	10	147	8	31	73	38
Mets Arteni.5.033	670	3794	49	17	15	145	10	32	75	39
Mets Arteni.7.092	540	4560	34	18	14	118	33	25	89	28
Mets Arteni.8.093	568	4198	35	16	19	130	20	29	85	32
Mean	659	3966	46	16	15	138	13	31	75	36
STDV	63	240	7	2	2	9	8	3	7	4
Mets Satanakar.1.001	511	5397	39	16	27	187	8	14	94	36
Mets Satanakar.2.002.1	486	4833	39	21	34	183	9	15	97	36
Mets Satanakar.2.002.2	464	4700	35	16	33	192	9	11	103	37
Mets Satanakar.2.004	526	4662	40	19	33	191	7	13	97	38
Mets Satanakar.3.005.1	505	4677	35	15	33	186	8	14	100	37
Mets Satanakar.3.005.2	555	4672	48	19	29	192	8	11	99	37
Mean	508	4823	39	18	32	189	8	13	99	37
STDV	29	263	5	2	3	3	1	2	3	1
Pasinler.154	422	7362	42	17	29	174	2	36	166	27
Pasinler.155	364	7518	46	21	31	191	1	33	169	27
Mean	393	7440	44	19	30	183	2	35	168	27
STDV	29	78	2	2	1	8	1	2	1	0
Pokr Arteni.1.022	610	4287	41	19	11	131	18	28	83	34
Pokr Arteni.10.097.1	518	4607	42	18	15	122	34	25	91	28
Pokr Arteni.10.097.2	619	4647	39	19	16	125	30	23	89	29
Pokr Arteni.11.098	518	4607	42	18	15	122	34	25	91	28

Specimen ID	Element Concentration (ppm)									
	Mn	**Fe**	**Zn**	**Ga**	**Th**	**Rb**	**Sr**	**Y**	**Zr**	**Nb**
Pokr Arteni.2.023	526	4121	49	17	11	139	16	25	89	34
Pokr Arteni.3.024	651	4124	48	14	17	139	16	29	83	32
Pokr Arteni.4.025	565	4227	51	15	15	133	15	26	87	34
Pokr Arteni.5.026	621	4273	37	18	12	127	19	29	82	32
Pokr Arteni.7.028	575	4386	43	15	12	122	25	28	89	29
Pokr Arteni.8.094	489	4546	43	17	15	124	32	24	92	27
Pokr Arteni.9.095	503	4592	47	16	11	124	31	26	87	29
Pokr Arteni.9.096	547	4515	39	17	13	119	30	25	89	29
Mean	562	4411	43	17	13	127	25	26	88	30
STDV	51	189	4	2	2	6	7	2	3	3
SarikamisNorth.135	644	7690	88	23	21	158	1	49	197	32
SarikamisNorth.164	618	7681	60	18	17	132	2	49	222	32
SarikamisSouth.129.1	366	5943	33	19	16	136	22	24	103	15
SarikamisSouth.129.2	297	6068	30	22	16	135	23	24	111	14
SarikamisSouth.131	421	5957	31	22	14	158	22	23	103	18
SarikamisSouth.GA.1	322	5835	32	18	15	128	24	25	108	15
SarikamisSouth.GA.10	309	6008	40	14	17	126	22	24	109	12
SarikamisSouth.GA.11	199	5651	32	18	14	131	25	22	115	14
SarikamisSouth.GA.12	322	5804	37	19	19	131	23	23	110	13
SarikamisSouth.GA.13	368	5630	38	13	18	120	21	22	105	13
SarikamisSouth.GA.2	216	5602	37	16	18	122	22	25	109	11
SarikamisSouth.GA.3	381	5652	31	18	19	130	24	23	109	14
SarikamisSouth.GA.4	343	5979	35	19	15	122	24	25	108	14
SarikamisSouth.GA.5	344	5751	32	16	16	126	23	26	111	12
SarikamisSouth.GA.6	324	5672	38	13	17	122	25	24	111	14
SarikamisSouth.GA.7	320	5859	41	19	19	125	23	27	110	14
SarikamisSouth.GA.8	326	5641	33	17	14	123	23	26	108	12
SarikamisSouth.GA.9	393	5717	40	14	16	125	24	23	112	13
Mean	362	6008	39	18	17	131	21	27	120	16
STDV	109	610	13	3	2	11	7	8	32	6
Sevkar.1.006	366	4903	39	17	28	172	13	16	104	33
Sevkar.2.007	459	5029	37	15	26	168	15	15	102	32
Sevkar.3.008.1	428	4994	39	16	29	172	15	12	104	34
Sevkar.3.008.2	477	5043	43	12	29	171	14	14	104	34
Sevkar.3.008.3	365	4781	40	15	31	168	15	13	104	32
Sevkar.3.009	445	4841	40	23	28	166	16	14	105	33
Sevkar.3.010.1	378	5249	45	14	32	168	16	14	105	34
Sevkar.3.010.2	576	4989	41	17	32	173	16	15	105	34
Sevkar.4.011.1	459	4951	49	18	29	172	19	14	104	33
Sevkar.4.011.2	413	4846	38	17	30	170	15	14	103	35
Mean	437	4962	41	17	29	170	15	14	104	33
STDV	60	126	4	3	2	2	1	1	1	1
Sizavet.1.108	615	11532	58	17	16	97	183	24	228	17
Sizavet.1.109.1	558	11616	55	18	15	103	181	18	225	18

Specimen ID	Element Concentration (ppm)									
	Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
Sizavet.1.109.2	427	11802	51	19	11	105	182	18	229	19
Mean	533	11650	55	18	14	102	182	20	227	18
STDV	79	113	3	1	2	3	1	3	2	1
Spitakasar.1.019.1	766	3914	43	16	17	183	9	21	62	50
Spitakasar.1.019.2	836	3860	31	17	17	178	9	22	62	50
Spitakasar.1.019.3	816	3997	38	17	19	178	9	24	64	48
Spitakasar.2.020.1	784	3969	51	15	18	176	8	23	61	47
Spitakasar.2.020.2	773	4078	43	16	17	182	7	24	67	50
Spitakasar.2.020.3	719	3926	33	17	20	170	8	23	60	49
Spitakasar.3.021.1	770	3999	45	20	17	177	8	23	63	48
Spitakasar.3.021.2	791	3774	37	16	18	167	7	22	60	47
Spitakasar.3.021.3	746	3481	46	14	13	160	7	21	56	44
Mean	778	3889	41	17	17	174	8	23	62	48
STDV	33	166	6	2	2	7	1	1	3	2
Ttujur.1.101.1	448	6292	29	19	24	93	161	11	110	24
Ttujur.1.101.2	503	6283	40	16	26	98	167	11	109	22
Ttujur.1.101.3	468	6272	37	18	25	92	170	14	112	23
Ttujur.1.101.4	460	6239	36	14	27	95	169	12	109	25
Ttujur.1.101.5	432	6320	34	19	28	95	169	13	114	26
Ttujur.1.101.6	451	6356	33	18	22	97	169	11	105	23
Ttujur.1.101.7	401	6248	34	16	22	88	165	14	111	24
Ttujur.1.101.8	479	6293	39	16	25	93	172	12	108	24
Ttujur.2.102	576	6355	31	17	23	96	174	14	111	22
Ttujur.2.102.1	576	6355	31	17	23	96	174	14	111	22
Ttujur.2.102.2	544	6461	40	18	28	97	176	13	108	22
Ttujur.3.103	451	6374	33	19	27	92	166	12	113	24
Mean	483	6321	35	17	25	94	169	12	110	23
STDV	54	60	4	1	2	3	4	1	2	1
Yaglica Dag.146	513	8329	36	17	16	106	101	20	181	20
Yaglica Dag.151	421	6551	45	14	17	119	65	22	138	15
Mean	467	7440	41	15	16	113	83	21	160	17
STDV	46	889	4	1	0	6	18	1	22	2

Appendix 2: Elemental Concentrations of Masis Blur Artifacts (in parts per million)

				Element Concentration (ppm)									
ANID	Artifact ID	Trench	Horizon	Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
1	MB2012.L10/4.100.1003.1	L10/4	Topsoil	732	3932	42	19	25	202	10	27	76	48
2	MB2012.L10/4.100.1003.2	L10/4	Topsoil	636	3991	31	17	24	200	9	26	78	50
3	MB2012.L10/4.100.1003.3	L10/4	Topsoil	480	4915	44	21	11	123	36	24	95	27
4	MB2012.L10/4.100.1003.4	L10/4	Topsoil	460	4706	45	16	15	127	33	23	91	29
5	MB2012.L10/4.100.1003.5	L10/4	Topsoil	638	3919	40	17	26	210	9	24	79	56
6	MB2012.L10/4.106.1026.1	L10/4	IVB	494	4418	37	18	11	123	29	26	91	30
7	MB2012.L10/4.106.1039.25	L10/4	IVB	565	4909	46	19	11	129	34	25	94	30
8	MB2012.L10/4.106.1044.1	L10/4	IVB	527	8159	55	22	19	140	115	27	163	39
9	MB2012.L10/4.111.1055.40	L10/4	IVB	602	8630	46	22	17	150	124	27	176	39
10	MB2012.L10/4.111.1075	L10/4	IVB	504	9575	90	20	22	196	13	58	269	32
11	MB2012.M10/1.300.3003.2	M10/1	Topsoil	440	7120	39	14	18	104	116	16	99	22
12	MB2012.M10/1.301.3008.7	M10/1	Disturbed	677	3912	30	17	23	194	10	26	76	47
13	MB2012.M10/1.307.3066.2*	M10/1	IVB	544	8571	42	20	19	145	131	22	174	39
14	MB2012.M10/1.307.3066.3	M10/1	IVB	561	4910	38	18	14	127	34	26	92	31
15	MB2012.M10/1.308.3033.1	M10/1	IVB	596	4832	46	21	14	119	35	27	93	29
16	MB2012.M10/1.310.3036.99	M10/1	IVB	613	4165	35	14	14	137	17	26	86	33
17	MB2012.M10/1.316.3053.1	M10/1	IVB	540	10686	44	24	17	105	192	20	132	22
18	MB2012.M10/1.319.3078.126	M10/1	IVB	437	6884	41	17	16	107	111	18	102	22
19	MB2012.M10/1.322.3125	M10/1	IVB	309	7685	60	24	29	184	3	36	170	30
20	MB2012.M10/1.323.3134	M10/1	IVB	653	7627	92	28	16	159	1	50	199	33
21	MB2012.M10/1.MissingInfo	M10/1	Disturbed	680	8065	47	19	19	142	119	26	165	36
22	MB2012.M11/1.000.0003.10	M11/1	Topsoil	586	4004	39	21	25	208	12	21	83	48
23	MB2012.M11/1.000.0003.11	M11/1	Topsoil	503	4466	44	14	14	125	31	24	89	28
24	MB2012.M11/1.000.0003.156	M11/1	Topsoil	609	4575	47	14	15	122	31	22	90	29
25	MB2012.M11/1.000.0003.157	M11/1	Topsoil	525	4697	45	18	14	126	33	25	96	30
26	MB2012.M11/1.000.0003.6	M11/1	Topsoil	488	4599	44	15	17	119	31	26	92	30
27	MB2012.M11/1.000.0003.7	M11/1	Topsoil	554	7448	67	21	18	151	2	47	179	29
28	MB2012.M11/1.001.0009.210	M11/1	Disturbed	628	8034	56	16	13	137	116	23	171	34
29	MB2012.M11/1.001.0009.211	M11/1	Disturbed	481	4701	46	16	14	120	35	24	95	30
30	MB2012.M11/1.001.0009.212*	M11/1	Disturbed	598	9453	53	18	16	145	133	25	179	38
31	Mb2012.M11/1.001.0009.213	M11/1	Disturbed	488	4533	34	16	15	120	31	23	92	27
32	MB2012.M11/1.001.0009.214	M11/1	Disturbed	475	4803	42	14	14	129	32	26	95	32
33	MB2012.M11/1.001.0009.215	M11/1	Disturbed	457	4523	52	16	16	114	35	23	91	26
34	MB2012.M11/1.003.0039	M11/1	IVA	601	7929	92	22	18	141	3	47	224	29
35	MB2012.M11/1.004.0079.15	M11/1	Disturbed	639	4528	37	16	14	117	32	26	88	31
36	MB2012.M11/1.006.0046	M11/1	Disturbed	505	7858	58	18	19	142	114	23	163	37
37	MB2012.M11/1.006.0061	M11/1	Disturbed	440	4903	57	20	15	126	40	20	97	29
38	MB2012.M11/1.006.0062	M11/1	Disturbed	605	4525	53	19	14	124	31	24	91	29
39	MB2012.M11/1.006.0063*	M11/1	Disturbed	553	5066	52	29	16	134	37	29	103	31
40	MB2012.M11/1.009.0085	M11/1	Disturbed	622	8232	56	19	18	144	117	25	169	37
41	MB2012.M11/1.010.0074	M11/1	Disturbed	495	4554	48	19	12	122	31	25	93	29
42	MB2012.M11/1.010.0075	M11/1	Disturbed	522	4721	60	21	13	131	31	25	94	28
43	MB2012.M11/1.010.0076*	M11/1	Disturbed	605	5366	63	24	13	152	38	26	99	33
44	MB2012.M11/1.010.0077*	M11/1	Disturbed	584	5347	55	23	14	131	41	28	102	31
45	MB2012.M11/1.014.0104	M11/1	Disturbed	517	4829	50	18	12	109	43	25	102	25
46	MB2012.M11/1.014.0177	M11/1	Disturbed	464	4554	62	20	11	122	31	23	93	30
47	MB2012.M11/1.016.0170.14	M11/1	IIIA	610	8578	49	20	16	144	120	24	171	37
48	MB2012.M11/1.016.0170.15	M11/1	IIIA	559	10073	49	15	16	96	188	15	126	21
49	MB2012.M11/1.016.0170.16	M11/1	IIIA	622	8220	47	20	17	145	121	25	169	38
50	MB2012.M11/1.016.0171	M11/1	IIIA	539	4533	64	15	12	116	31	27	91	29
51	MB2012.M11/1.016.0178	M11/1	IIIA	523	6735	80	20	16	140	2	49	178	29
52	MB2012.M11/1.016.0179	M11/1	IIIA	656	3833	51	18	29	200	9	24	79	51
53	MB2012.M11/1.016.0181	M11/1	IIIA	510	4447	55	18	17	117	32	24	92	28
54	MB2012.M11/1.Pit2.MissingInfo	M11/1	Disturbed	673	4170	46	23	26	206	9	25	79	55
55	MB2012.M9/1.200.2003.10	M9/1	Topsoil	567	5117	53	20	13	130	37	23	97	30
56	MB2012.M9/1.200.2003.11	M9/1	Topsoil	635	4079	43	16	28	203	9	26	79	51
57	MB2012.M9/1.200.2003.6	M9/1	Topsoil	485	5217	50	16	14	119	31	27	88	29
58	MB2012.M9/1.200.2003.7	M9/1	Topsoil	693	4031	37	16	27	208	8	24	82	47
59	MB2012.M9/1.200.2003.8	M9/1	Topsoil	556	4581	49	16	14	127	25	27	93	33
60	MB2012.M9/1.200.2003.9	M9/1	Topsoil	568	8453	52	16	18	142	114	24	164	38
61	MB2012.M9/1.201.2007.1	M9/1	Disturbed	631	8482	40	19	18	144	118	28	169	40

				Element Concentration (ppm)									
ANID	Artifact ID	Trench	Horizon	Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
62	MB2012.M9/1.201.2007.10	M9/1	Disturbed	640	8067	53	14	15	136	112	22	167	39
63	MB2012.M9/1.201.2007.2	M9/1	Disturbed	485	4413	38	15	15	117	28	24	88	25
64	MB2012.M9/1.201.2007.3	M9/1	Disturbed	724	9063	47	23	17	155	129	28	181	40
65	MB2012.M9/1.201.2007.4	M9/1	Disturbed	591	8003	52	17	16	140	120	25	168	36
66	MB2012.M9/1.201.2007.5	M9/1	Disturbed	752	4204	44	20	24	217	9	28	80	52
67	MB2012.M9/1.201.2007.6*	M9/1	Disturbed	632	5304	57	20	18	152	9	49	140	35
68	MB2012.M9/1.201.2007.7	M9/1	Disturbed	517	4582	40	18	12	122	31	25	90	27
69	MB2012.M9/1.201.2007.8	M9/1	Disturbed	612	8630	46	23	16	153	119	24	171	37
70	MB2012.M9/1.201.2007.9	M9/1	Disturbed	488	4543	43	16	15	121	33	25	92	31
71	MB2012.M9/1.201.2011.1	M9/1	Disturbed	519	4519	50	21	13	120	34	24	89	27
72	MB2012.M9/1.201.2011.10	M9/1	Disturbed	531	4179	32	21	30	217	10	26	82	58
73	MB2012.M9/1.201.2011.11	M9/1	Disturbed	602	4473	47	23	14	117	30	24	89	28
74	MB2012.M9/1.201.2011.12	M9/1	Disturbed	756	3797	38	15	25	204	10	23	79	49
75	MB2012.M9/1.201.2011.2	M9/1	Disturbed	592	8437	50	23	17	143	119	28	172	38
76	MB2012.M9/1.201.2011.3	M9/1	Disturbed	426	9725	54	16	15	101	179	19	127	21
77	MB2012.M9/1.201.2011.4	M9/1	Disturbed	502	8260	47	20	17	138	130	27	173	34
78	MB2012.M9/1.201.2011.5*	M9/1	Disturbed	380	5124	42	13	13	131	20	22	89	15
79	MB2012.M9/1.201.2011.6	M9/1	Disturbed	694	8219	54	20	19	140	123	27	165	37
80	MB2012.M9/1.201.2011.7	M9/1	Disturbed	605	4268	43	21	26	203	9	25	82	51
81	MB2012.M9/1.201.2011.9	M9/1	Disturbed	465	4413	41	20	12	118	33	25	90	28
82	MB2012.M9/1.205.2027.2	M9/1	Disturbed	735	3881	58	21	17	141	13	29	85	34
83	MB2012.M9/1.205.2057.1	M9/1	Disturbed	604	4655	37	19	10	128	30	26	86	35
84	MB2012.M9/1.207.2052.1	M9/1	Disturbed	555	4925	42	18	15	129	29	24	92	28
85	MB2012.M9/1.207.2052.3	M9/1	Disturbed	515	4757	46	23	15	126	34	25	94	30
86	MB2012.M9/1.207.2052.4	M9/1	Disturbed	626	7942	33	17	14	138	119	26	165	38
87	MB2012.M9/1.207.2052.5	M9/1	Disturbed	701	4399	47	23	28	221	10	26	86	57
88	MB2012.M9/1.207.2052.6	M9/1	Disturbed	634	8248	41	16	15	142	117	26	168	38
89	MB2012.M9/1.207.2052.7	M9/1	Disturbed	581	4380	47	21	13	128	26	25	92	31
90	MB2012.M9/1.209.2063.1	M9/1	Disturbed	443	5772	42	22	15	140	21	23	100	14
91	MB2012.M9/1.209.2063.3	M9/1	Disturbed	526	3912	42	18	24	203	10	24	81	53
92	MB2012.M9/1.209.2063.4	M9/1	Disturbed	731	4288	32	21	28	214	12	27	85	53
93	MB2012.M9/1.209.2063.5	M9/1	Disturbed	673	8331	50	19	13	142	127	24	175	37
94	MB2013.M11/1.017.0347.1	M11/1	IVA	722	8661	64	23	17	149	122	27	178	39
95	MB2013.M11/1.017.0347.2	M11/1	IVA	464	4569	58	17	12	124	33	24	92	29
96	MB2013.M11/1.017.0347.3	M11/1	IVA	678	3854	51	19	24	200	9	24	81	50
97	MB2013.M11/1.017.0347.4	M11/1	IVA	537	4771	51	24	15	123	31	25	91	31
98	MB2013.M11/1.017.0347.5	M11/1	IVA	346	5190	46	15	15	126	18	25	93	13
99	MB2013.M11/1.017.0347.6	M11/1	IVA	557	4058	53	22	25	199	9	25	80	48
100	MB2013.M11/1.017.0347.7	M11/1	IVA	650	3870	63	16	25	194	8	23	77	50
101	MB2013.M11/1.017.0347.8	M11/1	IVA	512	4532	49	18	14	121	33	24	91	31
102	MB2013.M11/1.019.0261.1	M11/1	IVA	521	4974	62	25	16	130	33	25	99	30
103	MB2013.M11/1.019.0261.10	M11/1	IVA	589	7802	72	19	17	138	6	50	240	33
104	MB2013.M11/1.019.0261.11*	M11/1	IVA	623	11432	95	25	16	138	42	45	227	26
105	MB2013.M11/1.019.0261.12*	M11/1	IVA	620	10664	79	19	19	132	35	40	233	23
106	MB2013.M11/1.019.0261.13	M11/1	IVA	579	7902	65	17	13	132	117	26	163	35
107	MB2013.M11/1.019.0261.14*	M11/1	IVA	694	10065	86	24	16	127	38	41	215	25
108	MB2013.M11/1.019.0261.2	M11/1	IVA	557	4987	64	24	12	127	36	26	99	31
109	MB2013.M11/1.019.0261.3	M11/1	IVA	554	5266	62	26	16	134	34	26	100	32
110	MB2013.M11/1.019.0261.4	M11/1	IVA	622	3914	48	19	22	202	9	26	82	52
111	MB2013.M11/1.019.0261.5	M11/1	IVA	608	3967	50	24	23	213	9	26	79	53
112	MB2013.M11/1.019.0261.6	M11/1	IVA	632	3962	46	17	26	202	10	25	82	51
113	MB2013.M11/1.019.0261.7*	M11/1	IVA	729	5475	80	21	18	161	9	49	145	37
114	MB2013.M11/1.019.0261.8	M11/1	IVA	661	7433	78	21	16	146	3	53	198	33
115	MB2013.M11/1.019.0261.9	M11/1	IVA	633	7404	82	22	15	138	11	49	227	32
116	MB2013.M11/1.019.0385	M11/1	IVA	486	4631	62	19	13	124	35	23	93	28
117	MB2013.M11/1.019.0386	M11/1	IVA	641	7041	75	21	20	143	2	50	181	32
118	MB2013.M11/1.019.0388	M11/1	IVA	721	7511	106	23	21	155	2	53	188	35
119	MB2013.M11/1.019.0389*	M11/1	IVA	725	10464	89	19	15	132	39	45	235	21
120	MB2013.M11/1.019.0390*	M11/1	IVA	350	5056	46	21	12	140	22	26	93	14
121	MB2013.M11/1.019.0391	M11/1	IVA	475	4408	62	20	12	126	31	27	88	29
122	MB2013.M11/1.019.0392	M11/1	IVA	302	5753	62	23	16	129	23	26	117	14

				Element Concentration (ppm)									
ANID	Artifact ID	Trench	Horizon	Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
123	MB2013.M11/1.019.0393*	M11/1	IVA	386	5069	49	15	15	135	18	24	93	15
124	MB2013.M11/1.019.0394*	M11/1	IVA	532	7488	85	23	19	143	6	49	220	30
125	MB2013.M11/1.019.0395	M11/1	IVA	746	10163	76	22	16	130	40	43	226	24
126	MB2013.M11/1.019.0396*	M11/1	IVA	344	5177	56	17	14	133	19	24	90	13
127	MB2013.M11/1.021.0356.1	M11/1	IIIB	619	8078	72	18	18	132	113	25	160	37
128	MB2013.M11/1.021.0356.2	M11/1	IIIB	496	6503	56	17	20	113	103	20	102	23
129	MB2013.M11/1.021.0356.3	M11/1	IIIB	443	4699	58	21	15	127	33	25	92	28
130	MB2013.M11/1.021.0356.4*	M11/1	IIIB	406	5284	52	16	12	137	20	24	93	15
131	MB2013.M11/1.021.0356.5	M11/1	IIIB	374	5546	44	19	16	128	22	21	109	12
132	MB2013.M11/1.021.0356.6	M11/1	IIIB	502	4724	62	19	12	127	34	27	90	30
133	MB2013.M11/1.021.0356.7*	M11/1	IIIB	946	5250	61	26	34	264	11	28	93	60
134	MB2013.M11/1.025.0263.1	M11/1	IIIB	528	9118	62	15	12	98	157	16	118	20
135	MB2013.M11/1.025.0263.10*	M11/1	IIIB	427	5812	52	18	22	112	147	13	106	21
136	MB2013.M11/1.025.0263.11	M11/1	IIIB	585	10218	65	18	17	102	176	19	125	21
137	MB2013.M11/1.025.0263.12	M11/1	IIIB	535	7951	62	16	20	141	118	25	161	35
138	MB2013.M11/1.025.0263.13*	M11/1	IIIB	342	8718	63	27	21	151	56	17	150	18
139	MB2013.M11/1.025.0263.14	M11/1	IIIB	637	7668	77	24	16	139	4	51	235	30
140	MB2013.M11/1.025.0263.16*	M11/1	IIIB	751	11565	91	22	20	141	41	49	265	24
141	MB2013.M11/1.025.0263.2	M11/1	IIIB	357	9131	63	19	16	97	161	19	119	22
142	MB2013.M11/1.025.0263.20	M11/1	IIIB	561	7770	64	16	14	133	112	24	159	38
143	MB2013.M11/1.025.0263.21	M11/1	IIIB	698	8593	65	22	20	148	116	24	175	36
144	MB2013.M11/1.025.0263.22	M11/1	IIIB	613	8324	65	20	17	144	118	28	165	39
145	MB2013.M11/1.025.0263.23	M11/1	IIIB	656	7632	63	17	15	139	107	23	159	36
146	MB2013.M11/1.025.0263.25	M11/1	IIIB	589	8291	72	22	18	146	124	24	170	36
147	MB2013.M11/1.025.0263.26	M11/1	IIIB	605	8687	71	23	20	147	124	28	172	39
148	MB2013.M11/1.025.0263.27*	M11/1	IIIB	761	9595	65	32	18	165	132	27	191	42
149	MB2013.M11/1.025.0263.28*	M11/1	IIIB	693	9424	72	29	22	157	133	28	185	42
150	MB2013.M11/1.025.0263.29	M11/1	IIIB	667	4810	56	20	16	124	33	24	91	31
151	MB2013.M11/1.025.0263.3*	M11/1	IIIB	299	7468	44	16	17	141	20	29	157	16
152	MB2013.M11/1.025.0263.30	M11/1	IIIB	679	4086	52	23	26	211	11	24	78	52
153	MB2013.M11/1.025.0263.32	M11/1	IIIB	564	8022	64	17	17	136	109	26	163	37
154	MB2013.M11/1.025.0263.33	M11/1	IIIB	581	8000	59	17	15	141	115	25	162	35
155	MB2013.M11/1.025.0263.34	M11/1	IIIB	678	7647	68	20	17	140	3	48	234	32
156	MB2013.M11/1.025.0263.35	M11/1	IIIB	509	8191	65	20	18	139	116	24	172	38
157	MB2013.M11/1.025.0263.36	M11/1	IIIB	604	4299	56	21	15	134	19	32	95	32
158	MB2013.M11/1.025.0263.37*	M11/1	IIIB	709	5585	75	20	17	162	8	51	152	35
159	MB2013.M11/1.025.0263.38	M11/1	IIIB	393	5783	47	20	14	124	25	24	114	14
160	MB2013.M11/1.025.0263.39	M11/1	IIIB	491	4545	60	21	12	121	31	23	91	29
161	MB2013.M11/1.025.0263.4	M11/1	IIIB	337	7393	52	17	32	165	2	35	177	27
162	MB2013.M11/1.025.0263.40	M11/1	IIIB	557	4584	56	21	11	122	34	28	91	26
163	MB2013.M11/1.025.0263.41	M11/1	IIIB	610	4924	64	20	15	133	35	26	97	32
164	MB2013.M11/1.025.0263.42*	M11/1	IIIB	594	5213	56	24	18	145	36	27	98	31
165	MB2013.M11/1.025.0263.43	M11/1	IIIB	517	4752	62	22	10	127	33	28	95	29
166	MB2013.M11/1.025.0263.44*	M11/1	IIIB	550	6380	76	26	20	154	86	18	112	22
167	MB2013.M11/1.025.0263.46*	M11/1	IIIB	624	8369	73	20	16	141	132	24	180	42
168	MB2013.M11/1.025.0263.48	M11/1	IIIB	611	8319	69	18	18	140	120	27	172	38
169	MB2013.M11/1.025.0263.49*	M11/1	IIIB	327	6283	56	20	19	131	25	26	119	14
170	MB2013.M11/1.025.0263.5	M11/1	IIIB	623	7473	95	26	20	156	2	51	190	31
171	MB2013.M11/1.025.0263.50	M11/1	IIIB	625	8077	66	20	15	138	116	23	164	36
172	MB2013.M11/1.025.0263.53	M11/1	IIIB	481	4675	52	17	13	123	33	23	90	28
173	MB2013.M11/1.025.0263.54	M11/1	IIIB	585	4568	48	16	16	129	31	25	90	30
174	MB2013.M11/1.025.0263.55	M11/1	IIIB	499	4653	48	17	15	124	32	23	92	28
175	MB2013.M11/1.025.0263.56	M11/1	IIIB	525	4570	50	23	15	124	31	25	96	27
176	MB2013.M11/1.025.0263.57	M11/1	IIIB	525	4474	57	17	12	120	33	22	90	27
177	MB2013.M11/1.025.0263.58	M11/1	IIIB	449	4650	47	20	11	125	33	25	93	30
178	MB2013.M11/1.025.0263.59	M11/1	IIIB	625	4915	54	25	14	131	33	25	94	29
179	MB2013.M11/1.025.0263.6*	M11/1	IIIB	668	10684	92	23	15	137	39	43	222	25
180	MB2013.M11/1.025.0263.61	M11/1	IIIB	592	4734	61	23	15	126	31	26	95	28
181	MB2013.M11/1.025.0263.62	M11/1	IIIB	691	4298	59	26	29	224	12	25	88	59
182	MB2013.M11/1.025.0263.63	M11/1	IIIB	745	4306	49	24	26	219	11	28	86	57
183	MB2013.M11/1.025.0263.65	M11/1	IIIB	600	4987	57	26	15	129	35	25	98	31

				Element Concentration (ppm)									
ANID	Artifact ID	Trench	Horizon	Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
184	MB2013.M11/1.025.0263.7*	M11/1	IIIB	773	10247	87	25	10	127	39	42	226	22
185	MB2013.M11/1.025.0263.8*	M11/1	IIIB	392	7109	62	11	22	125	49	22	128	13
186	MB2013.M11/1.025.0263.9*	M11/1	IIIB	350	7170	44	18	15	120	45	21	131	17
187	MB2013.M11/1.026.0274.1	M11/1	IVA	636	7865	51	20	17	141	115	23	170	40
188	MB2013.M11/1.026.0274.10	M11/1	IVA	622	8479	64	26	16	151	125	27	174	37
189	MB2013.M11/1.026.0274.11	M11/1	IVA	636	4048	52	23	29	199	10	27	80	51
190	MB2013.M11/1.026.0274.12	M11/1	IVA	542	4601	54	17	15	116	33	26	88	28
191	MB2013.M11/1.026.0274.13	M11/1	IVA	699	3921	46	20	30	207	9	22	81	54
192	MB2013.M11/1.026.0274.14	M11/1	IVA	518	7381	57	16	15	110	111	18	103	22
193	MB2013.M11/1.026.0274.15*	M11/1	IVA	699	5380	71	19	20	160	7	47	138	32
194	MB2013.M11/1.026.0274.16	M11/1	IVA	588	4262	56	21	11	128	18	27	87	33
195	MB2013.M11/1.026.0274.18	M11/1	IVA	643	8739	66	24	21	144	120	25	175	40
196	MB2013.M11/1.026.0274.19	M11/1	IVA	518	4818	67	20	13	135	26	26	91	33
197	MB2013.M11/1.026.0274.2	M11/1	IVA	708	7770	72	25	20	144	5	54	220	29
198	MB2013.M11/1.026.0274.20*	M11/1	IVA	731	5785	90	26	22	175	7	49	152	37
199	MB2013.M11/1.026.0274.21	M11/1	IVA	613	3907	49	21	29	199	10	21	79	47
200	MB2013.M11/1.026.0274.22*	M11/1	IVA	728	9099	74	29	14	152	131	27	186	39
201	MB2013.M11/1.026.0274.23	M11/1	IVA	507	6418	53	18	15	115	101	19	100	25
202	MB2013.M11/1.026.0274.25	M11/1	IVA	417	8219	51	29	34	196	3	38	179	31
203	MB2013.M11/1.026.0274.26	M11/1	IVA	509	4555	52	22	16	121	31	26	89	30
204	MB2013.M11/1.026.0274.27	M11/1	IVA	558	4793	52	21	13	130	30	24	95	30
205	MB2013.M11/1.026.0274.28*	M11/1	IVA	518	5174	65	24	13	124	40	26	99	31
206	MB2013.M11/1.026.0274.29	M11/1	IVA	562	4856	59	19	14	131	34	26	91	30
207	MB2013.M11/1.026.0274.3	M11/1	IVA	626	7417	88	23	17	140	7	48	212	31
208	MB2013.M11/1.026.0274.30	M11/1	IVA	581	4587	60	17	14	127	33	23	93	30
209	MB2013.M11/1.026.0274.32	M11/1	IVA	583	4301	54	18	13	136	17	27	81	35
210	MB2013.M11/1.026.0274.33	M11/1	IVA	659	4598	61	18	16	122	36	26	94	30
211	MB2013.M11/1.026.0274.34	M11/1	IVA	489	4698	51	20	12	130	32	25	90	30
212	MB2013.M11/1.026.0274.35	M11/1	IVA	538	4714	65	22	15	129	37	24	97	28
213	MB2013.M11/1.026.0274.37	M11/1	IVA	517	4486	61	19	11	121	31	22	89	28
214	MB2013.M11/1.026.0274.4*	M11/1	IVA	745	11113	102	24	17	137	40	46	221	26
215	MB2013.M11/1.026.0274.5*	M11/1	IVA	806	10998	97	25	20	134	39	44	236	25
216	MB2013.M11/1.026.0274.9*	M11/1	IVA	314	8049	61	21	18	134	56	21	143	18
217	MB2013.M11/1.026.0358.1*	M11/1	IVA	395	5253	46	15	13	136	18	25	92	14
218	MB2013.M11/1.026.0358.2	M11/1	IVA	561	4408	49	14	14	122	33	25	91	30
219	MB2013.M11/1.026.0358.3	M11/1	IVA	564	4275	56	20	14	116	32	26	89	27
220	MB2013.M11/1.026.0358.4	M11/1	IVA	721	4135	52	16	24	216	9	22	81	53
221	MB2013.M11/1.026.0358.5	M11/1	IVA	681	4171	61	23	29	213	9	23	82	54
222	MB2013.M11/1.026.FT2.0362.10	M11/1	IVA	401	5580	59	15	16	128	21	23	104	15
223	MB2013.M11/1.026.FT2.0362.11*	M11/1	IVA	413	5058	60	20	12	136	22	24	95	16
224	MB2013.M11/1.026.FT2.0362.12	M11/1	IVA	581	4092	53	17	23	191	9	25	76	50
225	MB2013.M11/1.026.FT2.0362.14*	M11/1	IVA	569	4762	65	27	16	148	23	31	102	35
226	MB2013.M11/1.026.FT2.0362.15	M11/1	IVA	672	4237	50	22	25	218	10	27	84	55
227	MB2013.M11/1.026.FT2.0362.17	M11/1	IVA	672	4014	49	22	26	203	9	26	83	54
228	MB2013.M11/1.026.FT2.0362.18	M11/1	IVA	579	3931	55	20	22	201	10	26	80	50
229	MB2013.M11/1.026.FT2.0362.19	M11/1	IVA	703	4275	54	24	25	216	11	26	84	53
230	MB2013.M11/1.026.FT2.0362.2	M11/1	IVA	640	8076	55	23	14	140	122	27	171	39
231	MB2013.M11/1.026.FT2.0362.20*	M11/1	IVA	559	5915	59	26	20	129	59	26	117	31
232	MB2013.M11/1.026.FT2.0362.21	M11/1	IVA	456	4379	61	15	15	114	36	23	97	27
233	MB2013.M11/1.026.FT2.0362.22	M11/1	IVA	663	4485	53	18	11	121	30	25	91	30
234	MB2013.M11/1.026.FT2.0362.23*	M11/1	IVA	388	6058	49	24	17	130	25	27	119	15
235	MB2013.M11/1.026.FT2.0362.24	M11/1	IVA	655	3886	51	20	23	198	10	26	82	54
236	MB2013.M11/1.026.FT2.0362.25	M11/1	IVA	621	3763	60	14	23	195	9	26	78	51
237	MB2013.M11/1.026.FT2.0362.27	M11/1	IVA	629	8366	62	16	17	138	116	25	165	38
238	MB2013.M11/1.026.FT2.0362.28*	M11/1	IVA	305	5522	40	19	20	132	20	27	103	15
239	MB2013.M11/1.026.FT2.0362.29	M11/1	IVA	597	7933	96	24	18	146	8	50	221	34
240	MB2013.M11/1.026.FT2.0362.3	M11/1	IVA	553	9614	88	21	21	204	17	52	270	34
241	MB2013.M11/1.026.FT2.0362.30	M11/1	IVA	613	8107	87	21	19	146	6	49	223	32
242	MB2013.M11/1.026.FT2.0362.32*	M11/1	IVA	656	4799	53	28	33	248	10	26	92	61
243	MB2013.M11/1.026.FT2.0362.34	M11/1	IVA	507	4686	57	17	15	119	34	28	92	29
244	MB2013.M11/1.026.FT2.0362.4	M11/1	IVA	646	8416	66	17	15	145	115	24	168	40

ANID	Artifact ID	Trench	Horizon	Element Concentration (ppm) Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
245	MB2013.M11/1.028.0368.1	M11/1	IIIA	462	4581	58	17	11	118	32	24	92	29
246	MB2013.M11/1.028.0368.2	M11/1	IIIA	522	5357	55	20	16	111	50	24	102	27
247	MB2013.M11/1.ST003.0372	M11/1	IVA	649	3906	53	20	23	203	9	25	78	51
248	MB2013.M11/1.TP(E).0330.1	M11/1	IIA?	613	7831	53	16	14	130	117	25	164	34
249	MB2013.M11/1.TP(E).0330.10	M11/1	IIA?	458	4650	53	20	15	122	33	25	91	28
250	MB2013.M11/1.TP(E).0330.11	M11/1	IIA?	449	5794	55	19	14	129	22	21	104	15
251	MB2013.M11/1.TP(E).0330.12	M11/1	IIA?	482	4740	54	14	11	116	37	24	93	29
252	MB2013.M11/1.TP(E).0330.13*	M11/1	IIA?	283	6389	54	22	18	145	25	26	117	15
253	MB2013.M11/1.TP(E).0330.14	M11/1	IIA?	645	4326	57	25	29	220	11	28	84	59
254	MB2013.M11/1.TP(E).0330.15	M11/1	IIA?	587	10629	102	24	26	211	26	55	276	36
255	MB2013.M11/1.TP(E).0330.17	M11/1	IIA?	516	4380	59	14	12	111	30	24	88	27
256	MB2013.M11/1.TP(E).0330.19	M11/1	IIA?	510	4651	58	17	14	127	34	24	96	29
257	MB2013.M11/1.TP(E).0330.2*	M11/1	IIA?	751	5903	60	35	13	160	40	27	104	34
258	MB2013.M11/1.TP(E).0330.20	M11/1	IIA?	625	4157	51	24	24	214	10	25	79	54
259	MB2013.M11/1.TP(E).0330.21	M11/1	IIA?	614	3986	65	18	22	199	9	26	79	46
260	MB2013.M11/1.TP(E).0330.3*	M11/1	IIA?	643	9745	80	21	15	127	35	41	225	23
261	MB2013.M11/1.TP(E).0330.4	M11/1	IIA?	346	13509	56	23	27	219	47	31	326	20
262	MB2013.M11/1.TP(E).0330.5	M11/1	IIA?	506	4529	49	17	14	123	31	25	88	27
263	MB2013.M11/1.TP(E).0330.6	M11/1	IIA?	753	7906	58	18	16	140	118	24	164	38
264	MB2013.M11/1.TP(E).0330.7	M11/1	IIA?	649	8398	64	21	18	140	122	24	173	37
265	MB2013.M11/1.TP(E).0330.8	M11/1	IIA?	638	6975	88	17	16	133	9	46	219	31
266	MB2013.M11/1.TP(E).0330.9	M11/1	IIA?	723	8139	59	20	15	134	108	25	160	38
267	MB2013.M11/1.TP(E).0332.1	M11/1	IIB?	657	8149	62	22	19	142	113	23	167	37
268	MB2013.M11/1.TP(E).0332.10	M11/1	IIB?	433	4260	52	18	16	117	31	23	89	26
269	MB2013.M11/1.TP(E).0332.11	M11/1	IIB?	232	5878	56	22	19	131	23	23	115	13
270	MB2013.M11/1.TP(E).0332.12	M11/1	IIB?	349	5886	59	23	15	133	23	26	103	14
271	MB2013.M11/1.TP(E).0332.13*	M11/1	IIB?	370	5224	52	19	15	139	18	24	87	15
272	MB2013.M11/1.TP(E).0332.15	M11/1	IIB?	688	8086	50	19	15	144	117	22	164	38
273	MB2013.M11/1.TP(E).0332.17	M11/1	IIB?	747	3912	52	21	25	199	10	26	82	52
274	MB2013.M11/1.TP(E).0332.18	M11/1	IIB?	686	8039	85	23	20	147	2	54	241	32
275	MB2013.M11/1.TP(E).0332.19	M11/1	IIB?	478	9895	56	19	16	97	174	17	125	21
276	MB2013.M11/1.TP(E).0332.2	M11/1	IIB?	581	8549	52	20	18	139	122	28	175	34
277	MB2013.M11/1.TP(E).0332.20*	M11/1	IIB?	251	7547	58	19	26	158	16	32	148	17
278	MB2013.M11/1.TP(E).0332.21	M11/1	IIB?	525	4706	55	21	15	131	35	25	97	31
279	MB2013.M11/1.TP(E).0332.22	M11/1	IIB?	510	4744	62	17	13	118	36	24	97	29
280	MB2013.M11/1.TP(E).0332.23	M11/1	IIB?	656	8564	88	27	18	152	3	51	263	30
281	MB2013.M11/1.TP(E).0332.24	M11/1	IIB?	605	7901	58	19	12	135	113	22	162	38
282	MB2013.M11/1.TP(E).0332.25*	M11/1	IIB?	701	4299	56	29	31	235	11	25	86	56
283	MB2013.M11/1.TP(E).0332.26	M11/1	IIB?	498	4984	61	25	13	131	34	27	97	32
284	MB2013.M11/1.TP(E).0332.3	M11/1	IIB?	609	8472	54	21	18	141	112	26	168	36
285	MB2013.M11/1.TP(E).0332.4*	M11/1	IIB?	373	5306	53	16	14	134	19	22	93	14
286	MB2013.M11/1.TP(E).0332.5*	M11/1	IIB?	418	5717	56	15	15	104	92	15	88	22
287	MB2013.M11/1.TP(E).0332.6	M11/1	IIB?	559	6521	49	24	17	114	105	17	103	24
288	MB2013.M11/1.TP(E).0332.7	M11/1	IIB?	346	5431	42	19	18	138	19	23	95	14
289	MB2013.M11/1.TP(E).0332.8	M11/1	IIB?	352	5755	55	20	15	123	24	24	113	12
290	MB2013.M11/1.TP(E).0332.9	M11/1	IIB?	513	4154	58	17	12	129	15	25	90	33
291	MB2013.M11/1.TP(E).0341.2*	M11/1	IVB?	563	4979	60	25	14	139	28	27	92	34
292	MB2013.M11/1.TP(E).0341.3	M11/1	IVB?	664	7978	88	23	18	148	6	54	218	31
293	MB2013.M11/1.TP(E).0341.4*	M11/1	IVB?	612	5117	59	20	13	140	36	24	101	33
294	MB2013.M11/1.TP(E).0343.1*	M11/1	IVC?	321	7294	43	19	17	137	23	28	155	16
295	MB2013.M11/1.TP(E).0343.10	M11/1	IVC?	690	7886	88	25	19	151	3	52	207	34
296	MB2013.M11/1.TP(E).0343.12*	M11/1	IVC?	639	4538	52	20	12	122	30	26	91	28
297	MB2013.M11/1.TP(E).0343.13	M11/1	IVC?	655	6166	85	26	21	174	8	54	148	37
298	MB2013.M11/1.TP(E).0343.14	M11/1	IVC?	654	3862	36	23	25	199	8	24	79	49
299	MB2013.M11/1.TP(E).0343.16	M11/1	IVC?	630	4210	48	25	26	212	9	27	83	54
300	MB2013.M11/1.TP(E).0343.17	M11/1	IVC?	612	3895	54	18	24	205	9	25	82	51
301	MB2013.M11/1.TP(E).0343.18	M11/1	IVC?	479	4706	50	19	15	124	34	24	90	31
302	MB2013.M11/1.TP(E).0343.19	M11/1	IVC?	650	8131	56	19	14	144	114	25	167	38
303	MB2013.M11/1.TP(E).0343.20	M11/1	IVC?	651	7970	62	24	17	142	117	25	177	38
304	MB2013.M11/1.TP(E).0343.21	M11/1	IVC?	535	3890	52	24	26	199	10	26	78	49
305	MB2013.M11/1.TP(E).0343.22	M11/1	IVC?	590	4552	56	22	14	133	25	25	92	32

				Element Concentration (ppm)									
ANID	Artifact ID	Trench	Horizon	Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
306	MB2013.M11/1.TP(E).0343.23	M11/1	IVC?	611	3844	55	21	26	195	10	24	79	51
307	MB2013.M11/1.TP(E).0343.25	M11/1	IVC?	590	8837	64	24	15	152	129	26	180	40
308	MB2013.M11/1.TP(E).0343.26	M11/1	IVC?	637	8097	64	23	19	141	121	25	173	41
309	MB2013.M11/1.TP(E).0343.27*	M11/1	IVC?	333	7499	59	21	18	131	50	18	133	18
310	MB2013.M11/1.TP(E).0343.28	M11/1	IVC?	499	4560	53	18	15	125	32	24	88	29
311	MB2013.M11/1.TP(E).0343.29	M11/1	IVC?	579	4713	52	22	13	135	27	26	94	31
312	MB2013.M11/1.TP(E).0343.5	M11/1	IVC?	566	3881	44	21	25	201	9	27	80	48
313	MB2013.M11/1.TP(E).0343.6	M11/1	IVC?	497	4710	51	21	12	130	33	22	91	29
314	MB2013.M11/1.TP(E).0343.7	M11/1	IVC?	458	4653	58	22	13	121	35	28	91	27
315	MB2013.M11/1.TP(E).0343.8	M11/1	IVC?	695	4160	53	21	27	199	13	27	80	50
316	MB2013.M11/1.TP(E).0343.9*	M11/1	IVC?	418	6230	62	20	15	134	23	25	121	15
317	MB2013.M11/1.TP.0271.1*	M11/1	IIA	346	5575	48	18	14	133	20	23	99	14
318	MB2013.M11/1.TP.0271.11*	M11/1	IIA	466	5000	50	22	16	137	32	23	97	32
319	MB2013.M11/1.TP.0271.12	M11/1	IIA	598	6997	73	24	19	147	3	50	182	34
320	MB2013.M11/1.TP.0271.13	M11/1	IIA	533	4595	55	25	14	128	30	27	91	31
321	MB2013.M11/1.TP.0271.14	M11/1	IIA	610	5427	78	28	19	142	37	30	101	34
322	MB2013.M11/1.TP.0271.15*	M11/1	IIA	689	5254	64	28	15	142	38	28	101	31
323	MB2013.M11/1.TP.0271.2	M11/1	IIA	327	5862	43	14	18	124	22	27	109	14
324	MB2013.M11/1.TP.0271.3*	M11/1	IIA	573	5991	56	16	16	114	47	26	118	29
325	MB2013.M11/1.TP.0271.4*	M11/1	IIA	370	6117	55	21	16	132	22	22	116	14
326	MB2013.M11/1.TP.0271.5	M11/1	IIA	540	4422	59	22	14	129	26	22	87	29
327	MB2013.M11/1.TP.0271.6	M11/1	IIA	625	4728	45	23	16	129	34	26	97	29
328	MB2013.M11/1.TP.0271.7	M11/1	IIA	323	5781	55	22	17	134	23	24	104	16
329	MB2013.M11/1.TP.0271.8*	M11/1	IIA	758	9391	72	27	19	163	134	30	187	41
330	MB2013.M11/1.TP.0279.1	M11/1	IIA?	639	8073	49	23	15	142	114	23	167	38
331	MB2013.M11/1.TP.0279.2*	M11/1	IIA?	258	8195	54	24	18	159	28	31	168	18
332	MB2013.M11/1.TP.0279.3*	M11/1	IIA?	167	6971	52	21	20	150	18	28	138	17
333	MB2013.M11/1.TP.0279.4	M11/1	IIA?	626	3900	46	20	22	203	8	23	78	52
334	MB2013.M11/1.TP.0285.1	M11/1	IIB?	557	7833	50	18	16	134	113	28	166	36
335	MB2013.M11/1.TP.0285.10	M11/1	IIB?	473	4416	54	19	13	116	31	25	90	28
336	MB2013.M11/1.TP.0285.12*	M11/1	IIB?	547	7520	104	20	17	144	14	47	234	31
337	MB2013.M11/1.TP.0285.2	M11/1	IIB?	560	4895	60	23	16	127	33	25	95	32
338	MB2013.M11/1.TP.0285.3	M11/1	IIB?	736	7956	56	20	15	135	113	25	166	38
339	MB2013.M11/1.TP.0285.4	M11/1	IIB?	522	4428	62	17	15	118	33	23	89	28
340	MB2013.M11/1.TP.0285.5	M11/1	IIB?	350	6016	49	22	17	133	25	24	115	15
341	MB2013.M11/1.TP.0285.6	M11/1	IIB?	676	7739	82	27	21	162	3	54	193	34
342	MB2013.M11/1.TP.0285.7*	M11/1	IIB?	223	8463	54	24	23	152	24	32	174	19
343	MB2013.M11/1.TP.0285.8	M11/1	IIB?	627	7663	87	23	19	142	2	53	238	30
344	MB2013.M11/1.TP.0285.9*	M11/1	IIB?	359	5486	52	16	14	141	19	23	95	15
345	MB2013.M11/1.TP.0294.1	M11/1	IIB?	564	8037	87	23	16	144	4	48	242	32
346	MB2013.M11/1.TP.0294.2	M11/1	IIB?	681	8118	78	21	14	146	2	49	235	33
347	MB2013.M11/1.TP.0294.3	M11/1	IIB?	681	7019	72	20	16	138	2	46	185	28
348	MB2013.M11/1.TP.0294.5	M11/1	IIB?	486	4019	46	19	15	135	18	27	85	33
349	MB2013.M11/1.TP.0300.1	M11/1	IIB?	584	6793	68	22	20	141	3	47	175	31
350	MB2013.M11/1.TP.0300.10	M11/1	IIB?	773	4340	55	25	28	221	11	24	85	54
351	MB2013.M11/1.TP.0300.2	M11/1	IIB?	636	8184	61	21	16	149	122	23	175	39
352	MB2013.M11/1.TP.0300.3	M11/1	IIB?	507	7282	76	20	19	136	10	50	210	31
353	MB2013.M11/1.TP.0300.4	M11/1	IIB?	511	5971	50	16	16	113	99	16	97	21
354	MB2013.M11/1.TP.0300.5	M11/1	IIB?	627	8031	58	17	16	143	113	27	168	37
355	MB2013.M11/1.TP.0300.6	M11/1	IIB?	669	8709	66	20	18	147	118	27	167	39
356	MB2013.M11/1.TP.0300.7	M11/1	IIB?	524	8006	60	20	12	134	118	27	167	39
357	MB2013.M11/1.TP.0300.8*	M11/1	IIB?	484	4827	63	21	12	124	32	25	92	27
358	MB2013.M11/1.TP.0300.9	M11/1	IIB?	468	4629	53	19	13	122	34	22	93	29
359	MB2013.M11/1.TP.0302.1*	M11/1	III?	587	8186	55	20	19	144	124	24	175	37
360	MB2013.M11/1.TP.0302.2*	M11/1	III?	617	8509	67	21	20	148	126	22	174	39
361	MB2013.M11/1.TP.0302.3	M11/1	III?	649	6703	78	18	15	141	1	47	172	29
362	MB2013.M11/1.TP.0302.4*	M11/1	III?	363	6178	50	19	17	136	26	25	122	15
363	MB2013.M11/1.TP.0302.5*	M11/1	III?	601	3792	50	17	29	198	9	23	78	50
364	MB2013.M11/1.TP.0302.6	M11/1	III?	664	8072	69	19	17	141	114	26	165	40
365	MB2013.M11/1.TP.0310a.2*	M11/1	IVB?	519	7091	50	25	17	127	115	17	104	27
366	MB2013.M11/1.TP.0310a.3*	M11/1	IVB?	729	5580	81	20	21	170	6	47	151	37

				Element Concentration (ppm)									
ANID	Artifact ID	Trench	Horizon	Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
367	MB2013.M11/1.TP.0310a.4*	M11/1	IVB?	672	8590	57	20	20	145	130	25	181	40
368	MB2013.M11/1.TP.0310a.5	M11/1	IVB?	611	8304	99	29	23	168	2	54	220	34
369	MB2013.M11/1.TP.0310a.6*	M11/1	IVB?	773	10292	96	22	15	132	41	40	207	23
370	MB2013.M11/1.TP.0310a.7	M11/1	IVB?	504	19158	187	24	21	205	1	120	1057	66
371	MB2013.M11/1.TP.0321.10.SC	M11/1	Disturbed	645	8233	62	19	19	135	113	26	167	37
372	MB2013.M11/1.TP.0321.11.SC*	M11/1	Disturbed	846	8855	65	25	17	157	127	29	185	41
373	MB2013.M11/1.TP.0321.12.SC*	M11/1	Disturbed	519	8474	63	19	18	139	125	26	173	39
374	MB2013.M11/1.TP.0321.13.SC	M11/1	Disturbed	715	7981	59	18	16	135	113	24	164	38
375	MB2013.M11/1.TP.0321.14.SC*	M11/1	Disturbed	461	7454	54	19	16	110	126	19	104	23
376	MB2013.M11/1.TP.0321.15.SC	M11/1	Disturbed	455	9335	49	17	14	96	166	17	123	22
377	MB2013.M11/1.TP.0321.16.SC	M11/1	Disturbed	709	3825	54	21	25	203	9	27	78	51
378	MB2013.M11/1.TP.0321.17.SC	M11/1	Disturbed	682	4179	53	20	26	211	11	24	82	54
379	MB2013.M11/1.TP.0321.18.SC	M11/1	Disturbed	499	4428	58	17	15	120	31	25	90	30
380	MB2013.M11/1.TP.0321.19.SC	M11/1	Disturbed	658	4066	57	20	23	195	10	25	80	47
381	MB2013.M11/1.TP.0321.20.SC	M11/1	Disturbed	573	4755	59	23	14	129	36	24	93	33
382	MB2013.M11/1.TP.0321.21.SC	M11/1	Disturbed	688	7891	79	17	14	141	4	49	244	29
383	MB2013.M11/1.TP.0321.22.SC	M11/1	Disturbed	535	4539	65	18	14	114	29	23	90	28
384	MB2013.M11/1.TP.0321.23.SC*	M11/1	Disturbed	327	5105	44	18	13	134	20	22	91	14
385	MB2013.M11/1.TP.0321.24.SC	M11/1	Disturbed	711	8039	57	20	15	139	116	22	165	37
386	MB2013.M11/1.TP.0321.25.SC	M11/1	Disturbed	608	4501	57	17	14	119	31	26	89	27
387	MB2013.M11/1.TP.0321.26.SC	M11/1	Disturbed	749	4089	52	23	27	212	9	25	80	49
388	MB2013.M11/1.TP.0321.27.SC	M11/1	Disturbed	614	7775	52	20	17	141	108	25	164	34
389	MB2013.M11/1.TP.0321.28.SC	M11/1	Disturbed	561	4694	58	17	15	126	31	24	92	29
390	MB2013.M11/1.TP.0321.29.SC	M11/1	Disturbed	543	4210	35	17	13	112	30	21	86	28
391	MB2013.M11/1.TP.0321.3.SC	M11/1	Disturbed	596	8071	58	22	18	135	119	25	170	40
392	MB2013.M11/1.TP.0321.30.SC	M11/1	Disturbed	671	3938	46	22	23	194	8	27	80	50
393	MB2013.M11/1.TP.0321.31.SC	M11/1	Disturbed	591	8325	76	24	18	153	119	24	172	41
394	MB2013.M11/1.TP.0321.32.SC	M11/1	Disturbed	612	8025	72	21	16	136	110	23	164	37
395	MB2013.M11/1.TP.0321.33.SC	M11/1	Disturbed	445	4544	55	19	12	123	31	24	90	27
396	MB2013.M11/1.TP.0321.34.SC	M11/1	Disturbed	548	8250	61	22	17	135	116	24	161	37
397	MB2013.M11/1.TP.0321.35.SC	M11/1	Disturbed	637	8438	66	21	13	136	118	25	168	38
398	MB2013.M11/1.TP.0321.36.SC	M11/1	Disturbed	662	3975	54	20	11	131	17	25	82	29
399	MB2013.M11/1.TP.0321.4.SC	M11/1	Disturbed	757	8397	60	22	20	153	127	26	172	40
400	MB2013.M11/1.TP.0321.5.SC*	M11/1	Disturbed	488	7630	57	20	27	96	232	13	145	20
401	MB2013.M11/1.TP.0321.6.SC*	M11/1	Disturbed	461	9620	61	19	15	101	168	18	125	21
402	MB2013.M11/1.TP.0321.7.SC	M11/1	Disturbed	342	7664	60	18	15	143	22	32	171	18
403	MB2013.M11/1.TP.0321.8.SC	M11/1	Disturbed	704	7767	95	28	18	161	4	50	190	32
404	MB2013.M11/1.TP.0322.1	M11/1	IIA	576	3917	36	18	25	193	10	23	79	51
405	MB2013.M11/1.TP.0322.2	M11/1	IIA	554	4201	45	17	15	133	21	24	85	32
406	MB2013.M11/1.TP.0322.3	M11/1	IIA	601	4118	46	22	24	196	8	27	79	52
407	MB2013.M11/1.TP.0324.1*	M11/1	IVC	557	8723	65	21	18	136	124	23	172	37
408	MB2013.M11/1.TP.0324.10	M11/1	IVC	653	4190	57	19	29	210	11	26	83	53
409	MB2013.M11/1.TP.0324.12	M11/1	IVC	617	4260	57	24	32	228	8	28	85	58
410	MB2013.M11/1.TP.0324.13	M11/1	IVC	308	6165	56	18	16	135	26	26	115	14
411	MB2013.M11/1.TP.0324.14	M11/1	IVC	698	8402	62	22	16	148	122	25	168	38
412	MB2013.M11/1.TP.0324.15	M11/1	IVC	586	4024	62	20	25	199	10	27	82	51
413	MB2013.M11/1.TP.0324.16	M11/1	IVC	563	4117	62	25	11	134	16	28	88	37
414	MB2013.M11/1.TP.0324.17	M11/1	IVC	592	4312	70	18	15	150	16	28	90	35
415	MB2013.M11/1.TP.0324.18	M11/1	IVC	505	7506	69	19	19	132	109	22	161	34
416	MB2013.M11/1.TP.0324.19	M11/1	IVC	579	8081	64	19	11	138	122	28	166	37
417	MB2013.M11/1.TP.0324.2*	M11/1	IVC	547	11897	108	32	27	245	21	63	313	37
418	MB2013.M11/1.TP.0324.20	M11/1	IVC	653	4237	55	21	24	214	9	24	80	54
419	MB2013.M11/1.TP.0324.21	M11/1	IVC	645	4113	66	21	12	131	17	27	82	32
420	MB2013.M11/1.TP.0324.3*	M11/1	IVC	818	10868	131	34	22	192	3	58	286	37
421	MB2013.M11/1.TP.0324.4	M11/1	IVC	319	5830	41	19	17	118	21	25	114	14
422	MB2013.M11/1.TP.0324.5	M11/1	IVC	446	7299	63	18	14	105	118	17	104	23
423	MB2013.M11/1.TP.0324.6	M11/1	IVC	582	7714	83	18	19	141	3	52	204	31
424	MB2013.M11/1.TP.0324.9	M11/1	IVC	804	4053	52	20	26	212	11	23	77	55
425	MB2013.M11/1.TP.0327.1	M11/1	IVC	693	4244	56	24	27	210	9	25	78	53
426	MB2013.M11/1.TP.0327.2	M11/1	IVC	714	4158	62	21	26	214	11	25	85	54
427	MB2013.M11/1.TP.0327.4*	M11/1	IVC	498	9096	84	21	22	188	13	54	260	34

ANID	Artifact ID	Trench	Horizon	Element Concentration (ppm) Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
428	MB2013.M11/1.TP.0327.5	M11/1	IVC	689	8414	63	21	18	148	124	21	170	39
429	MB2013.M11/1.TP.0327.6*	M11/1	IVC	385	7072	58	19	15	123	49	18	132	17
430	MB2013.M11/1.TP.0327.7	M11/1	IVC	673	8467	56	19	15	140	112	27	161	36
431	MB2013.M11/1.TP.0327.8	M11/1	IVC	621	8462	63	18	16	143	115	23	161	38
432	MB2013.M11/1.TP.0349.1	M11/1	IVC	593	8265	71	20	17	140	122	24	169	39
433	MB2013.M11/1.TP.0349.2	M11/1	IVC	643	8296	58	18	19	145	121	25	162	35
434	MB2013.M11/1.TP.0349.3*	M11/1	IVC	256	6780	35	19	22	148	18	28	138	16
435	MB2013.M11/1.TP.0349.4	M11/1	IVC	608	7580	83	24	21	152	3	49	206	33
436	MB2013.M11/1.TP.0349.5	M11/1	IVC	710	8224	63	20	16	147	117	26	171	39
437	MB2013.M11/1.TP.0468.1*	M11/1	IVB?	657	10356	76	18	17	127	37	41	205	21
438	MB2013.M11/1.TP.0468.2	M11/1	IVB?	617	7835	65	18	20	136	114	24	166	37
439	MB2013.M11/1.TP.0468.3*	M11/1	IVB?	617	5421	79	23	19	158	10	50	147	34
440	MB2013.M11/1.TP.0468.4	M11/1	IVB?	546	7902	61	17	15	135	113	23	167	36
441	MB2013.M9/5.706B.7062.1	M9/5	Disturbed	677	4782	61	22	16	131	34	24	94	30
442	MB2013.M9/5.FT1.7108.1	M9/5	V	647	8253	88	24	22	150	2	53	229	33
443	MB2013.M9/5.FT1.7108.2*	M9/5	V	665	5487	88	21	22	163	11	51	151	37
444	MB2013.M9/5.FT1.7108.3	M9/5	V	614	4252	58	21	12	141	17	28	85	36
445	MB2013.M9/5.FT1.7108.6*	M9/5	V	694	5505	57	30	16	151	36	25	99	32
446	MB2013.M9/5.FT3.7100.1	M9/5	V	619	3858	46	22	23	195	8	25	76	49
447	MB2013.M9/5.FT3.7100.11	M9/5	V	488	7279	54	20	16	113	113	17	99	24
448	MB2013.M9/5.FT3.7100.12	M9/5	V	585	3885	53	19	24	200	9	25	73	48
449	MB2013.M9/5.FT3.7100.13	M9/5	V	545	3979	50	21	27	197	10	25	77	49
450	MB2013.M9/5.FT3.7100.15	M9/5	V	723	3821	53	17	15	144	10	31	74	40
451	MB2013.M9/5.FT3.7100.16	M9/5	V	559	4557	48	22	15	123	34	24	92	29
452	MB2013.M9/5.FT3.7100.17*	M9/5	V	601	5486	68	23	17	142	37	29	107	34
453	MB2013.M9/5.FT3.7100.18*	M9/5	V	599	7013	59	17	26	99	144	14	105	25
454	MB2013.M9/5.FT3.7100.19	M9/5	V	463	7103	44	16	16	104	101	17	99	23
455	MB2013.M9/5.FT3.7100.2	M9/5	V	652	4073	46	20	27	208	11	22	78	50
456	MB2013.M9/5.FT3.7100.20	M9/5	V	701	4096	52	17	28	209	12	27	79	55
457	MB2013.M9/5.FT3.7100.21	M9/5	V	669	4208	55	19	28	212	8	24	84	55
458	MB2013.M9/5.FT3.7100.22*	M9/5	V	707	4881	52	36	31	255	10	29	90	59
459	MB2013.M9/5.FT3.7100.23	M9/5	V	497	4435	58	18	16	124	31	27	87	29
460	MB2013.M9/5.FT3.7100.24*	M9/5	V	585	5092	54	23	14	139	36	23	100	32
461	MB2013.M9/5.FT3.7100.26	M9/5	V	571	3880	55	17	25	201	10	23	79	50
462	MB2013.M9/5.FT3.7100.27	M9/5	V	576	4036	49	19	15	134	17	26	84	35
463	MB2013.M9/5.FT3.7100.28	M9/5	V	582	4300	48	20	15	128	22	28	89	32
464	MB2013.M9/5.FT3.7100.29	M9/5	V	596	3880	50	20	22	195	9	25	79	48
465	MB2013.M9/5.FT3.7100.3	M9/5	V	597	4114	50	22	28	207	12	25	85	51
466	MB2013.M9/5.FT3.7100.31	M9/5	V	620	8379	67	18	15	144	116	22	165	35
467	MB2013.M9/5.FT3.7100.32*	M9/5	V	727	9158	60	28	20	169	135	22	188	42
468	MB2013.M9/5.FT3.7100.4	M9/5	V	619	3767	50	24	27	195	9	21	80	51
469	MB2013.M9/5.FT3.7100.5	M9/5	V	526	10381	62	20	16	102	183	17	126	22
470	MB2013.M9/5.FT3.7100.6	M9/5	V	563	7964	53	15	14	141	111	25	156	36
471	MB2013.M9/5.FT3.7100.7	M9/5	V	853	7647	93	22	18	145	9	46	219	32
472	MB2013.M9/5.FT3.7100.8	M9/5	V	619	8276	80	24	18	153	2	51	229	33
473	MB2013.M9/5.FT3.7100.9	M9/5	V	568	7111	73	20	22	132	9	48	200	31
474	MB2013.M9/6.704.7068.1	M9/6	V	639	3921	48	19	26	202	8	25	77	51
475	MB2013.M9/6.704.7073.1	M9/6	V	594	4612	62	19	16	121	31	23	91	27
476	MB2014.M10/2.903.9052.1	M10/2	Disturbed	586	7846	59	19	17	132	111	25	163	38
477	MB2014.M10/2.903.9052.2	M10/2	Disturbed	663	8013	69	21	18	140	113	25	169	38
478	MB2014.M10/2.903.9052.3	M10/2	Disturbed	511	3710	53	17	25	194	9	23	79	48
479	MB2014.M10/2.903.9052.4*	M10/2	Disturbed	727	8939	73	22	15	147	129	28	179	38
480	MB2014.M10/2.911.9042.1	M10/2	IIIB	529	4441	50	20	16	118	29	22	92	32
481	MB2014.M10/2.911.9042.2	M10/2	IIIB	689	4256	47	19	14	127	22	24	87	34
482	MB2014.M10/2.911.9042.3*	M10/2	IIIB	441	7359	61	17	25	92	224	12	146	21
483	MB2014.M10/2.911.9042.4	M10/2	IIIB	634	4660	43	21	17	117	33	25	92	29
484	MB2014.M10/2.911.9042.5	M10/2	IIIB	620	4514	52	18	12	125	21	28	90	30
485	MB2014.M10/2.911.9042.6*	M10/2	IIIB	669	6102	91	27	23	187	8	51	164	37
486	MB2014.M10/2.911.9042.8	M10/2	IIIB	446	9671	68	26	32	192	3	41	241	29
487	MB2014.M10/2.915.9097.1	M10/2	IIIB	604	7631	93	18	14	139	5	53	222	31
488	MB2014.M10/2.915.9097.2	M10/2	IIIB	470	7010	51	22	16	109	116	18	100	22

ANID	Artifact ID	Trench	Horizon	Element Concentration (ppm)									
				Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
489	MB2014.M10/2.915.9097.3	M10/2	IIIB	604	7060	45	22	16	122	110	20	105	28
490	MB2014.M10/2.915.9097.4*	M10/2	IIIB	764	9241	62	29	14	154	142	27	187	37
491	MB2014.M10/2.915.9097.5	M10/2	IIIB	470	4439	57	20	14	122	30	25	87	27
492	MB2014.M10/2.915.9097.6	M10/2	IIIB	474	4865	51	21	12	114	45	24	97	24
493	MB2014.M10/2.918.9093.1*	M10/2	IIIB	541	6997	50	20	13	108	126	18	102	23
494	MB2014.M10/2.918.9093.10	M10/2	IIIB	651	4263	55	22	28	212	11	23	83	52
495	MB2014.M10/2.918.9093.2	M10/2	IIIB	531	8219	62	19	18	144	118	24	169	39
496	MB2014.M10/2.918.9093.3	M10/2	IIIB	694	8903	68	22	18	150	128	29	174	39
497	MB2014.M10/2.918.9093.4*	M10/2	IIIB	481	6174	54	22	21	119	154	14	103	22
498	MB2014.M10/2.918.9093.5	M10/2	IIIB	600	8423	57	24	17	145	123	26	174	39
499	MB2014.M10/2.918.9093.6	M10/2	IIIB	546	8299	66	17	16	137	117	23	170	38
500	MB2014.M10/2.918.9093.7	M10/2	IIIB	670	8639	60	24	18	151	126	29	177	40
501	MB2014.M10/2.918.9093.8	M10/2	IIIB	531	4378	63	16	13	119	31	22	89	29
502	MB2014.M10/2.918.9093.9	M10/2	IIIB	530	4448	54	16	14	121	36	24	91	27
503	MB2014.M10/3.1304.13028.1	M10/3	IIB	506	4495	43	15	12	111	29	25	82	26
504	MB2014.M10/3.1304.13028.2	M10/3	IIB	606	4732	47	19	11	130	32	25	95	31
505	MB2014.M10/3.1304.13028.3*	M10/3	IIB	631	8490	50	13	16	146	127	25	180	37
506	MB2014.M10/3.1304.13028.4	M10/3	IIB	569	4597	39	17	13	121	31	22	96	31
507	MB2014.M10/3.1304.13028.7*	M10/3	IIB	684	10465	76	22	19	122	38	47	240	24
508	MB2014.M10/3.1304.13033.1	M10/3	IIB	685	8988	58	21	20	145	125	25	176	42
509	MB2014.M10/3.1305.13035.1	M10/3	IIB	708	8144	57	18	18	136	110	25	161	34
510	MB2014.M10/3.1305.13035.10	M10/3	IIB	672	8376	34	16	19	144	118	23	169	39
511	MB2014.M10/3.1305.13035.11	M10/3	IIB	671	8339	59	19	18	147	117	25	169	39
512	MB2014.M10/3.1305.13035.12	M10/3	IIB	504	4489	45	15	9	114	31	25	88	28
513	MB2014.M10/3.1305.13035.13	M10/3	IIB	547	4715	48	17	13	124	33	27	90	28
514	MB2014.M10/3.1305.13035.14	M10/3	IIB	562	4633	39	17	15	126	35	25	97	29
515	MB2014.M10/3.1305.13035.15	M10/3	IIB	619	8073	38	19	17	147	118	26	169	40
516	MB2014.M10/3.1305.13035.17	M10/3	IIB	547	4746	56	18	12	124	34	22	94	30
517	MB2014.M10/3.1305.13035.18	M10/3	IIB	547	4469	38	17	17	122	32	25	91	29
518	MB2014.M10/3.1305.13035.19	M10/3	IIB	524	4547	39	17	12	121	31	27	91	31
519	MB2014.M10/3.1305.13035.2	M10/3	IIB	649	8283	44	20	16	139	121	26	169	36
520	MB2014.M10/3.1305.13035.20	M10/3	IIB	430	6102	45	19	15	129	88	17	107	21
521	MB2014.M10/3.1305.13035.22	M10/3	IIB	499	4853	42	21	16	130	34	29	97	31
522	MB2014.M10/3.1305.13035.24	M10/3	IIB	650	8418	65	19	15	138	121	26	169	39
523	MB2014.M10/3.1305.13035.25	M10/3	IIB	757	4075	32	21	24	200	10	24	78	51
524	MB2014.M10/3.1305.13035.26	M10/3	IIB	706	8315	40	15	16	141	109	28	166	37
525	MB2014.M10/3.1305.13035.3	M10/3	IIB	655	4047	36	21	26	198	9	25	75	48
526	MB2014.M10/3.1305.13035.30	M10/3	IIB	452	4559	35	22	13	121	33	28	91	30
527	MB2014.M10/3.1305.13035.4	M10/3	IIB	572	7770	57	13	17	140	110	22	159	37
528	MB2014.M10/3.1305.13035.5	M10/3	IIB	485	9232	54	16	16	99	165	19	119	22
529	MB2014.M10/3.1305.13035.6	M10/3	IIB	600	8131	53	12	15	139	119	23	166	36
530	MB2014.M10/3.1305.13035.7	M10/3	IIB	661	8417	59	22	18	147	119	28	172	36
531	MB2014.M10/3.1305.13035.8	M10/3	IIB	569	8269	53	20	16	145	115	25	175	36
532	MB2014.M10/3.1305.13035.9	M10/3	IIB	670	8294	60	16	15	135	117	29	170	39
533	MB2014.M10/3.1308.13061.1.core	M10/3	I	511	6450	40	19	17	106	103	20	98	21
534	MB2014.M10/3.1308.13061.11	M10/3	I	613	8272	60	23	18	145	121	25	168	34
535	MB2014.M10/3.1308.13061.12	M10/3	I	554	4767	34	18	12	119	41	24	96	26
536	MB2014.M10/3.1308.13061.14	M10/3	I	609	4858	47	19	13	126	38	24	96	29
537	MB2014.M10/3.1308.13061.17	M10/3	I	599	6596	34	19	17	113	111	20	100	24
538	MB2014.M10/3.1308.13061.18	M10/3	I	517	6140	49	16	13	112	96	17	96	22
539	MB2014.M10/3.1308.13061.19	M10/3	I	567	4574	48	19	13	119	30	26	93	31
540	MB2014.M10/3.1308.13061.2	M10/3	I	576	4761	58	18	15	129	33	23	91	31
541	MB2014.M10/3.1308.13061.20*	M10/3	I	652	9176	49	23	18	157	128	27	180	41
542	MB2014.M10/3.1308.13061.21	M10/3	I	599	8622	56	22	16	147	120	26	168	37
543	MB2014.M10/3.1308.13061.22	M10/3	I	564	8440	47	19	18	144	123	26	173	38
544	MB2014.M10/3.1308.13061.3	M10/3	I	533	4487	36	21	14	116	30	21	90	30
545	MB2014.M10/3.1308.13061.4	M10/3	I	505	6963	42	20	16	120	109	18	102	25
546	MB2014.M10/3.1308.13061.40	M10/3	I	594	8341	50	20	16	143	118	27	170	36
547	MB2014.M10/3.1308.13061.41	M10/3	I	486	5074	41	15	16	109	47	24	101	25
548	MB2014.M10/3.1308.13061.5	M10/3	I	509	7715	51	17	15	111	125	14	105	24
549	MB2014.M10/3.1308.13061.6	M10/3	I	524	4105	42	17	13	126	15	29	82	31

				Element Concentration (ppm)									
ANID	Artifact ID	Trench	Horizon	Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
550	MB2014.M10/3.1308.13061.7	M10/3	I	681	4068	31	23	24	208	10	28	82	51
551	MB2014.M10/3.1308.13061.9	M10/3	I	649	7478	71	25	18	154	2	52	187	32
552	MB2014.M10/3.1308.13074. *	M10/3	I	528	4223	37	16	10	119	31	24	90	28
553	MB2014.M10/3.1308.13074.10	M10/3	I	679	4938	46	24	16	133	31	24	90	30
554	MB2014.M10/3.1308.13074.12	M10/3	I	578	4555	44	17	14	128	29	25	89	31
555	MB2014.M10/3.1308.13074.19	M10/3	I	504	6508	44	13	15	112	103	18	99	23
556	MB2014.M10/3.1308.13074.2	M10/3	I	565	6097	42	18	20	106	100	18	101	25
557	MB2014.M10/3.1308.13074.20	M10/3	I	595	6733	40	19	17	113	100	18	100	23
558	MB2014.M10/3.1308.13074.23	M10/3	I	512	6408	43	19	16	115	100	17	96	22
559	MB2014.M10/3.1308.13074.27	M10/3	I	514	10530	54	19	18	98	185	16	126	20
560	MB2014.M10/3.1308.13074.28	M10/3	I	554	6459	33	19	14	115	103	17	98	26
561	MB2014.M10/3.1308.13074.29	M10/3	I	539	6709	34	22	17	119	103	18	104	26
562	MB2014.M10/3.1308.13074.3	M10/3	I	441	6631	33	18	14	114	102	16	96	24
563	MB2014.M10/3.1308.13074.34	M10/3	I	529	6348	45	18	16	114	104	19	101	26
564	MB2014.M10/3.1308.13074.35	M10/3	I	576	6506	39	20	16	106	96	19	103	23
565	MB2014.M10/3.1308.13074.36*	M10/3	I	367	5651	53	17	13	141	20	24	93	15
566	MB2014.M10/3.1308.13074.37	M10/3	I	593	5052	44	21	11	122	38	23	98	29
567	MB2014.M10/3.1308.13074.38	M10/3	I	506	4883	44	19	16	125	32	27	96	32
568	MB2014.M10/3.1308.13074.39	M10/3	I	604	4384	37	21	12	133	22	26	92	32
569	MB2014.M10/3.1308.13074.4	M10/3	I	513	4346	34	17	12	121	32	26	91	26
570	MB2014.M10/3.1308.13074.40	M10/3	I	567	4514	41	21	13	132	22	25	86	33
571	MB2014.M10/3.1308.13074.5	M10/3	I	597	4748	43	18	14	127	35	21	95	27
572	MB2014.M10/3.1308.13074.50	M10/3	I	480	4872	43	21	12	124	33	27	92	29
573	MB2014.M10/3.1308.13074.51	M10/3	I	596	4553	46	20	13	120	30	25	93	30
574	MB2014.M10/3.1308.13074.6	M10/3	I	537	4413	40	16	13	117	31	25	88	29
575	MB2014.M11/1.019.0434.1	M11/1	IVA	507	3880	43	20	26	201	9	22	80	51
576	MB2014.M11/1.019.0434.10	M11/1	IVA	599	4508	58	22	13	128	33	24	92	31
577	MB2014.M11/1.019.0434.11	M11/1	IVA	572	4754	48	18	17	124	33	25	91	28
578	MB2014.M11/1.019.0434.12	M11/1	IVA	363	6259	56	24	13	144	23	29	109	15
579	MB2014.M11/1.019.0434.13	M11/1	IVA	442	4673	62	20	14	126	33	27	96	29
580	MB2014.M11/1.019.0434.14	M11/1	IVA	533	4783	61	19	13	125	32	27	92	32
581	MB2014.M11/1.019.0434.15	M11/1	IVA	602	4698	53	21	12	127	31	26	96	30
582	MB2014.M11/1.019.0434.16*	M11/1	IVA	275	4997	63	17	15	136	20	23	89	13
583	MB2014.M11/1.019.0434.17	M11/1	IVA	581	4462	51	19	14	128	34	25	91	30
584	MB2014.M11/1.019.0434.18*	M11/1	IVA	393	5523	63	22	13	145	20	26	97	15
585	MB2014.M11/1.019.0434.19*	M11/1	IVA	234	7713	51	18	21	146	21	29	155	19
586	MB2014.M11/1.019.0434.2	M11/1	IVA	681	3964	46	25	27	195	9	28	81	52
587	MB2014.M11/1.019.0434.20	M11/1	IVA	362	5588	45	15	15	129	22	24	104	14
588	MB2014.M11/1.019.0434.21	M11/1	IVA	401	5359	43	16	11	128	21	24	100	14
589	MB2014.M11/1.019.0434.22	M11/1	IVA	578	3943	32	15	28	188	11	23	78	47
590	MB2014.M11/1.019.0434.23	M11/1	IVA	521	4597	50	23	16	114	31	24	91	27
591	MB2014.M11/1.019.0434.24	M11/1	IVA	454	4648	69	22	15	126	34	26	94	31
592	MB2014.M11/1.019.0434.25	M11/1	IVA	657	4084	54	24	30	219	11	25	84	56
593	MB2014.M11/1.019.0434.26	M11/1	IVA	607	3886	45	19	21	194	9	25	83	54
594	MB2014.M11/1.019.0434.27	M11/1	IVA	690	7991	66	22	17	142	119	22	164	38
595	MB2014.M11/1.019.0434.28*	M11/1	IVA	648	11055	114	21	21	134	38	44	218	25
596	MB2014.M11/1.019.0434.29	M11/1	IVA	350	7494	58	23	32	182	1	39	167	28
597	MB2014.M11/1.019.0434.3*	M11/1	IVA	683	6294	55	17	13	109	47	29	120	30
598	MB2014.M11/1.019.0434.30*	M11/1	IVA	718	4328	59	26	30	230	11	26	87	55
599	MB2014.M11/1.019.0434.31	M11/1	IVA	727	8180	88	24	24	150	5	52	239	33
600	MB2014.M11/1.019.0434.32*	M11/1	IVA	829	10982	131	33	26	189	7	57	256	34
601	MB2014.M11/1.019.0434.33	M11/1	IVA	571	8145	57	22	19	137	114	26	165	40
602	MB2014.M11/1.019.0434.34	M11/1	IVA	521	4410	52	20	13	122	31	23	85	28
603	MB2014.M11/1.019.0434.35	M11/1	IVA	364	4504	47	20	14	116	37	25	96	28
604	MB2014.M11/1.019.0434.36	M11/1	IVA	522	4447	61	19	16	125	29	26	87	31
605	MB2014.M11/1.019.0434.37*	M11/1	IVA	361	5586	53	20	16	143	21	28	96	16
606	MB2014.M11/1.019.0434.38*	M11/1	IVA	282	5186	64	17	14	139	21	25	93	14
607	MB2014.M11/1.019.0434.39	M11/1	IVA	564	6908	81	19	17	137	4	49	173	30
608	MB2014.M11/1.019.0434.4	M11/1	IVA	431	4661	55	20	14	117	29	23	92	29
609	MB2014.M11/1.019.0434.40	M11/1	IVA	616	3832	42	19	23	198	9	25	82	53
610	MB2014.M11/1.019.0434.41	M11/1	IVA	342	5621	48	15	19	124	23	24	112	12

				Element Concentration (ppm)									
ANID	Artifact ID	Trench	Horizon	Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
611	MB2014.M11/1.019.0434.5	M11/1	IVA	599	7517	73	17	18	135	5	49	214	28
612	MB2014.M11/1.019.0434.6*	M11/1	IVA	589	3864	48	20	24	195	9	23	78	50
613	MB2014.M11/1.019.0434.7	M11/1	IVA	573	4863	52	22	17	129	33	24	95	32
614	MB2014.M11/1.019.0434.8	M11/1	IVA	582	4366	59	21	16	139	21	26	90	34
615	MB2014.M11/1.019.0434.9	M11/1	IVA	351	5322	48	19	19	144	21	26	94	14
616	MB2014.M11/1.021.0399.1	M11/1	IIIB	636	7073	78	22	19	153	3	44	204	33
617	MB2014.M11/1.021.0399.2*	M11/1	IIIB	683	8859	74	23	19	152	128	29	181	39
618	MB2014.M11/1.021.0407.1*	M11/1	IIIB	475	5395	64	14	13	138	20	22	94	14
619	MB2014.M11/1.021.0407.2	M11/1	IIIB	516	8452	66	23	20	146	123	25	172	40
620	MB2014.M11/1.021.0407.3	M11/1	IIIB	701	4217	60	24	26	217	11	24	86	57
621	MB2014.M11/1.026.0412.1	M11/1	IVA	540	4474	52	18	11	119	31	22	90	26
622	MB2014.M11/1.026.0412.2	M11/1	IVA	718	4134	59	26	28	215	9	25	82	50
623	MB2014.M11/1.026.0412.3	M11/1	IVA	570	4798	66	20	15	134	34	24	92	30
624	MB2014.M11/1.026.0412.4*	M11/1	IVA	351	5564	55	18	13	140	21	28	99	16
625	MB2014.M11/1.026.0412.5	M11/1	IVA	657	4061	51	18	26	202	9	23	79	55
626	MB2014.M11/1.026.0418.1*	M11/1	IVA	448	7396	57	19	19	125	48	19	136	17
627	MB2014.M11/1.026.0418.2*	M11/1	IVA	191	7492	54	21	20	141	20	31	156	17
628	MB2014.M11/1.026.0418.4*	M11/1	IVA	363	5328	47	14	15	129	23	23	96	14
629	MB2014.M11/1.026.0418.5	M11/1	IVA	328	5948	55	20	18	137	25	24	117	14
630	MB2014.M11/1.026.0418.6	M11/1	IVA	317	5793	53	18	16	143	21	25	99	13
631	MB2014.M11/1.026.0429.1	M11/1	IVA	544	7319	78	26	22	164	4	51	199	33
632	MB2014.M11/1.026.0429.2*	M11/1	IVA	614	4584	73	25	12	129	32	24	94	30
633	MB2014.M11/1.026.0429.4	M11/1	IVA	466	6670	64	27	16	168	26	28	106	16
634	MB2014.M11/1.026.0429.5	M11/1	IVA	399	6078	54	27	18	161	23	28	105	19
635	MB2014.M11/1.026.0437.1	M11/1	IVA	535	7920	55	19	19	139	115	25	166	40
636	MB2014.M11/1.026.0437.10*	M11/1	IVA	301	5339	52	22	16	135	21	24	91	15
637	MB2014.M11/1.026.0437.11	M11/1	IVA	368	5754	52	15	16	125	22	25	105	15
638	MB2014.M11/1.026.0437.12*	M11/1	IVA	332	6479	41	20	14	135	22	21	118	12
639	MB2014.M11/1.026.0437.13	M11/1	IVA	683	8747	63	23	16	158	129	26	179	40
640	MB2014.M11/1.026.0437.15	M11/1	IVA	638	3766	59	16	24	191	9	23	78	51
641	MB2014.M11/1.026.0437.16	M11/1	IVA	694	4672	78	32	30	249	11	31	86	61
642	MB2014.M11/1.026.0437.17	M11/1	IVA	513	5319	58	23	15	125	43	26	104	29
643	MB2014.M11/1.026.0437.18	M11/1	IVA	621	5656	71	29	17	141	42	25	108	35
644	MB2014.M11/1.026.0437.19	M11/1	IVA	705	8214	61	22	16	140	125	27	178	37
645	MB2014.M11/1.026.0437.2	M11/1	IVA	610	8092	61	20	16	144	123	24	171	38
646	MB2014.M11/1.026.0437.20	M11/1	IVA	567	8067	61	19	15	145	118	23	168	38
647	MB2014.M11/1.026.0437.21	M11/1	IVA	533	4525	55	19	14	129	32	24	93	29
648	MB2014.M11/1.026.0437.3	M11/1	IVA	579	4659	64	23	15	123	32	27	91	30
649	MB2014.M11/1.026.0437.4	M11/1	IVA	766	4090	48	23	29	204	10	26	86	53
650	MB2014.M11/1.026.0437.5*	M11/1	IVA	535	5120	57	22	15	141	36	26	100	34
651	MB2014.M11/1.026.0437.6	M11/1	IVA	507	4190	60	19	14	127	22	25	91	29
652	MB2014.M11/1.026.0437.7	M11/1	IVA	569	4373	54	17	12	130	20	27	90	31
653	MB2014.M11/1.026.0437.8	M11/1	IVA	663	4033	55	21	22	207	10	26	81	49
654	MB2014.M11/1.026.0437.9	M11/1	IVA	560	4836	67	23	13	137	28	27	92	31
655	MB2014.M11/1.028.0409.1	M11/1	IIIA	410	4511	53	19	12	124	31	24	96	28
656	MB2014.M11/1.028.0409.2	M11/1	IIIA	613	4439	58	21	17	134	23	25	88	34
657	MB2014.M11/1.028.0409.3	M11/1	IIIA	573	4554	50	20	15	125	33	25	93	30
658	MB2014.M11/1.028.0409.4	M11/1	IIIA	692	8114	72	17	16	143	116	27	167	39
659	MB2014.M11/1.028.0409.5	M11/1	IIIA	659	8435	67	20	19	152	126	28	174	40
660	MB2014.M11/1.028.0409.6	M11/1	IIIA	562	4908	63	22	15	127	34	26	94	30
661	MB2014.M11/1.028.0409.7*	M11/1	IIIA	555	5025	67	24	14	137	37	28	96	33
662	MB2014.M11/1.030.0401.1	M11/1	IIIA	603	3901	41	24	23	197	9	29	79	50
663	MB2014.M11/1.030.0401.2	M11/1	IIIA	653	4043	41	23	27	207	10	27	79	52
664	MB2014.M11/1.030.0401.3	M11/1	IIIA	600	4734	52	22	15	132	31	23	98	33
665	MB2014.M11/1.030.0401.4	M11/1	IIIA	312	6160	55	19	18	140	24	27	112	16
666	MB2014.M11/1.030.0401.5	M11/1	IIIA	654	7988	59	17	17	141	111	25	164	38
667	MB2014.M11/1.030.0423.1	M11/1	IIIA	470	4650	56	15	12	121	32	21	87	31
668	MB2014.M11/1.030.0423.2	M11/1	IIIA	599	4773	55	19	10	126	30	24	88	29
669	MB2014.M11/1.030.0423.3	M11/1	IIIA	642	3973	52	19	27	203	11	27	79	49
670	MB2014.M11/1.030.0423.4	M11/1	IIIA	308	5786	61	20	17	136	26	24	115	16
671	MB2014.M11/1.030.0423.5	M11/1	IIIA	633	8141	61	21	14	143	117	27	166	37

				Element Concentration (ppm)									
ANID	Artifact ID	Trench	Horizon	Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
672	MB2014.M11/1.030.0423.6	M11/1	IIIA	721	4440	53	28	27	223	9	26	83	54
673	MB2014.M11/1.031.0445.2*	M11/1	IIIB	632	10610	63	21	18	128	35	39	209	24
674	MB2014.M11/1.031.0445.3*	M11/1	IIIB	656	10093	94	21	17	121	50	40	204	23
675	MB2014.M11/1.031.0445.4	M11/1	IIIB	394	4375	62	19	12	126	31	24	90	30
676	MB2014.M11/1.031.0445.5	M11/1	IIIB	644	4649	59	21	12	127	32	23	96	30
677	MB2014.M11/1.031.0445.6	M11/1	IIIB	502	4480	53	15	12	119	32	26	91	28
678	MB2014.M11/1.031.0445.7	M11/1	IIIB	530	4484	48	19	17	114	34	25	87	28
679	MB2014.M11/1.031.0445.8	M11/1	IIIB	636	4010	42	18	22	202	7	27	79	50
680	MB2014.M9/6.804.8051.1	M9/6	V	485	6457	61	19	17	107	104	19	101	24
681	MB2014.M9/6.804.8051.3	M9/6	V	469	6590	58	21	17	120	104	18	101	25
682	MB2014.M9/6.804.8051.4	M9/6	V	533	6650	51	21	18	115	105	19	101	26
683	MB2014.M9/6.804.8052.1	M9/6	V	688	7497	85	25	15	138	9	50	211	31
684	MB2014.M9/6.804.8052.2	M9/6	V	498	10140	101	20	22	205	21	55	264	34
685	MB2014.M9/6.804.8052.3	M9/6	V	467	6409	51	23	16	114	108	21	101	26
686	MB2014.M9/6.804.8052.4	M9/6	V	309	6183	52	22	21	137	23	26	121	14
687	MB2014.M9/6.804.8054.1	M9/6	V	583	6375	53	25	17	115	104	18	101	25
688	MB2014.M9/6.804.8054.2*	M9/6	V	858	6215	89	30	22	186	7	50	158	38
689	MB2014.M9/6.804.8057.1	M9/6	V	648	3938	58	15	26	195	9	24	79	49
690	MB2014.M9/6.804.8057.11	M9/6	V	687	4157	63	20	28	207	11	26	86	56
691	MB2014.M9/6.804.8057.12*	M9/6	V	494	9823	51	16	15	102	172	18	124	23
692	MB2014.M9/6.804.8057.13*	M9/6	V	695	11111	88	20	14	130	39	45	230	24
693	MB2014.M9/6.804.8057.14	M9/6	V	755	9236	69	27	21	151	128	27	179	38
694	MB2014.M9/6.804.8057.15*	M9/6	V	657	9664	75	30	20	164	144	28	194	41
695	MB2014.M9/6.804.8057.16*	M9/6	V	564	11979	74	28	18	124	205	20	146	26
696	MB2014.M9/6.804.8057.18	M9/6	V	529	4916	62	23	14	134	36	27	100	31
697	MB2014.M9/6.804.8057.19	M9/6	V	544	4835	60	21	14	125	37	26	96	30
698	MB2014.M9/6.804.8057.20	M9/6	V	624	7543	100	25	20	148	8	45	218	32
699	MB2014.M9/6.804.8057.21*	M9/6	V	622	5143	69	28	16	159	20	33	93	41
700	MB2014.M9/6.804.8057.23	M9/6	V	459	6842	51	18	14	108	107	19	102	22
701	MB2014.M9/6.804.8057.3	M9/6	V	557	4305	52	18	14	127	23	26	87	30
702	MB2014.M9/6.804.8057.4	M9/6	V	554	4005	53	19	14	134	18	27	83	37
703	MB2014.M9/6.804.8057.5	M9/6	V	571	4431	52	21	16	125	22	28	89	32
704	MB2014.M9/6.804.8057.6	M9/6	V	387	6260	60	22	17	134	25	26	116	18
705	MB2014.M9/6.804.8057.7	M9/6	V	636	4698	74	27	12	136	26	27	92	33
706	MB2014.M9/6.804.8057.8*	M9/6	V	699	4363	66	30	29	225	12	30	82	55
707	MB2014.M9/6.804.8059.1	M9/6	V	496	9276	91	18	22	196	21	49	267	33
708	MB2014.M9/6.804.8059.2	M9/6	V	707	8467	67	22	21	151	126	27	173	41
709	MB2014.M9/6.804.8059.3	M9/6	V	613	8107	91	28	19	160	10	55	241	37
710	MB2014.M9/6.804.8061.1	M9/6	V	548	8412	63	21	16	149	123	28	178	39
711	MB2014.M9/6.804.8061.2*	M9/6	V	767	9164	113	22	21	159	2	56	272	33
712	MB2014.M9/6.804.8061.3	M9/6	V	621	4763	59	21	15	135	30	25	94	33
713	MB2014.M9/6.804.8061.4	M9/6	V	555	4661	53	19	14	127	32	27	88	30
714	MB2014.M9/6.804.8069.1	M9/6	V	519	6561	53	22	20	117	108	21	99	24
715	MB2014.M9/6.804.8069.14*	M9/6	V	685	9707	64	30	17	166	138	31	185	42
716	MB2014.M9/6.804.8069.3*	M9/6	V	429	7322	74	25	20	126	119	17	110	28
717	MB2014.M9/6.804.8069.4*	M9/6	V	540	7295	65	25	19	129	117	18	108	26
718	MB2014.M9/6.804.8069.5	M9/6	V	471	6773	52	23	15	122	115	19	101	26
719	MB2014.M9/6.804.8069.6	M9/6	V	410	6277	53	20	18	116	103	18	102	24
720	MB2014.M9/6.804.8069.9*	M9/6	V	562	7420	70	27	22	131	120	20	109	26
721	MB2014.M9/6.804.8073.1	M9/6	V	623	7288	84	23	17	144	9	50	216	34
722	MB2014.M9/6.804.8073.13	M9/6	V	631	3805	55	20	23	194	10	24	76	49
723	MB2014.M9/6.804.8073.15	M9/6	V	495	6475	59	18	13	110	104	18	97	24
724	MB2014.M9/6.804.8073.16	M9/6	V	609	4269	45	21	14	138	18	31	91	35
725	MB2014.M9/6.804.8073.17	M9/6	V	567	9404	92	27	23	198	15	55	272	34
726	MB2014.M9/6.804.8073.18	M9/6	V	363	6274	44	21	16	132	26	27	116	14
727	MB2014.M9/6.804.8073.2*	M9/6	V	679	9385	74	19	15	137	25	41	195	22
728	MB2014.M9/6.804.8073.20	M9/6	V	617	8065	68	21	15	139	119	24	166	37
729	MB2014.M9/6.804.8073.21	M9/6	V	556	6329	47	21	14	115	104	18	102	23
730	MB2014.M9/6.804.8073.24	M9/6	V	413	6325	54	20	19	133	27	25	118	15
731	MB2014.M9/6.804.8073.27*	M9/6	V	614	4861	64	22	13	137	27	30	95	36
732	MB2014.M9/6.804.8073.28	M9/6	V	682	4047	51	21	27	206	9	26	82	52

				Element Concentration (ppm)									
ANID	Artifact ID	Trench	Horizon	Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
733	MB2014.M9/6.804.8073.3	M9/6	V	520	9921	105	22	24	215	17	54	277	36
734	MB2014.M9/6.804.8073.31	M9/6	V	541	4507	54	19	17	120	31	23	91	28
735	MB2014.M9/6.804.8073.33*	M9/6	V	210	6704	50	19	18	134	16	30	133	16
736	MB2014.M9/6.804.8073.35	M9/6	V	623	4491	68	19	14	139	17	30	88	35
737	MB2014.M9/6.804.8073.36	M9/6	V	573	4946	58	24	14	135	34	24	95	35
738	MB2014.M9/6.804.8073.4	M9/6	V	654	8209	99	30	20	158	9	52	228	32
739	MB2014.M9/6.804.8073.8	M9/6	V	667	4338	51	26	29	218	10	24	84	52
740	MB2014.M9/6.804.8074.1	M9/6	V	373	5786	51	19	15	130	23	23	108	13
741	MB2014.M9/6.804.8074.2	M9/6	V	622	8035	49	19	17	135	125	25	168	37
742	MB2014.M9/6.804.8074.3	M9/6	V	657	3981	54	20	26	207	9	23	81	54
743	MB2014.M9/6.804.8074.4	M9/6	V	623	7101	83	20	17	145	2	46	188	31
744	MB2014.M9/6.804.8077.1*	M9/6	V	733	10083	79	17	14	127	40	43	216	24
745	MB2014.M9/6.804.8077.2	M9/6	V	596	10090	101	24	25	214	15	61	277	32
746	MB2014.M9/6.804.8077.3*	M9/6	V	798	10506	96	32	18	172	145	30	200	44
747	MB2014.M9/6.804.8077.4*	M9/6	V	604	5763	87	22	18	167	6	52	150	35
748	MB2014.M9/6.804.8092.1	M9/6	V	593	7713	65	29	20	135	123	20	107	27
749	MB2014.M9/6.804.8103.1	M9/6	V	443	6623	53	21	16	118	106	21	102	24
750	MB2014.M9/6.804.8103.2*	M9/6	V	826	9915	62	25	21	167	144	27	187	45
751	MB2014.M9/6.804.8103.3*	M9/6	V	831	5187	75	27	37	263	11	30	90	63
752	MB2014.M9/6.804.8112.1	M9/6	V	563	4335	57	20	16	138	19	27	86	34
753	MB2014.M9/6.804.8112.2	M9/6	V	564	4515	52	22	13	121	27	28	88	30
754	MB2014.M9/6.804.8112.3*	M9/6	V	507	5553	65	25	33	190	18	14	116	38
755	MB2014.M9/6.804.8112.4	M9/6	V	638	7846	78	23	16	150	3	52	220	31
756	MB2014.M9/6.804.8112.6	M9/6	V	578	8680	63	24	16	147	124	29	180	40
757	MB2014.M9/6.805.8085.1	M9/6	V	663	8417	67	24	15	148	120	24	172	37
758	MB2014.M9/6.805.8085.2	M9/6	V	485	6318	51	19	15	112	105	19	101	22
759	MB2014.M9/6.805.8085.3	M9/6	V	686	8033	50	15	19	131	114	23	163	36
760	MB2014.M9/6.805.8085.4	M9/6	V	667	8829	68	22	19	147	129	27	174	41
761	MB2014.M9/6.805.8085.7*	M9/6	V	584	5294	59	22	14	128	41	27	103	29
762	MB2014.M9/6.805.8085.8*	M9/6	V	749	4188	47	22	29	210	11	29	86	54
763	MB2014.M9/6.805.8085.9	M9/6	V	600	7919	60	19	15	140	112	25	163	37
764	MB2014.M9/6.806.8089.1	M9/6	V	675	3850	61	20	25	200	10	22	77	48
765	MB2014.M9/6.806.8089.2	M9/6	V	527	6705	60	18	14	102	111	19	106	24
766	MB2014.M9/6.806.8089.4*	M9/6	V	691	5435	76	22	19	157	8	50	141	34
767	MB2014.M9/6.806.8089.5	M9/6	V	506	4896	62	23	14	128	33	25	92	31
768	MB2014.M9/6.807.8101.1	M9/6	V	475	6669	88	16	19	141	1	47	169	29
769	MB2014.M9/6.807.8101.10	M9/6	V	350	5996	50	18	17	131	22	23	113	15
770	MB2014.M9/6.807.8101.11	M9/6	V	688	8044	57	18	18	137	115	22	166	38
771	MB2014.M9/6.807.8101.13*	M9/6	V	681	5759	77	21	20	162	8	50	144	35
772	MB2014.M9/6.807.8101.14	M9/6	V	570	4437	65	20	11	136	18	27	87	34
773	MB2014.M9/6.807.8101.15	M9/6	V	580	4261	56	16	16	133	19	26	85	32
774	MB2014.M9/6.807.8101.17	M9/6	V	496	4613	61	16	15	126	36	27	95	32
775	MB2014.M9/6.807.8101.18*	M9/6	V	583	8031	72	30	22	142	126	20	117	27
776	MB2014.M9/6.807.8101.19	M9/6	V	689	4103	53	25	29	209	11	24	85	55
777	MB2014.M9/6.807.8101.2*	M9/6	V	177	7455	52	17	17	141	21	27	157	16
778	MB2014.M9/6.807.8101.21*	M9/6	V	675	4755	68	28	15	162	17	32	97	36
779	MB2014.M9/6.807.8101.3	M9/6	V	633	8030	50	15	19	139	119	23	164	34
780	MB2014.M9/6.807.8101.7	M9/6	V	681	3923	55	18	28	197	9	22	76	47
781	MB2014.M9/6.807.8101.8	M9/6	V	656	3992	47	19	25	201	10	25	78	49
782	MB2014.M9/6.807.8116.1	M9/6	V	642	8545	60	21	16	148	114	28	169	38
783	MB2014.M9/6.807.8116.14	M9/6	V	711	7407	87	23	20	149	2	50	214	30
784	MB2014.M9/6.807.8116.15*	M9/6	V	321	6495	55	21	18	139	26	25	117	16
785	MB2014.M9/6.807.8116.16	M9/6	V	547	4829	59	22	11	131	31	24	95	32
786	MB2014.M9/6.807.8116.17	M9/6	V	558	4462	65	26	14	136	25	27	98	32
787	MB2014.M9/6.807.8116.19	M9/6	V	587	4682	54	20	13	126	33	23	91	29
788	MB2014.M9/6.807.8116.2*	M9/6	V	724	9851	78	18	15	128	33	42	215	24
789	MB2014.M9/6.807.8116.20	M9/6	V	666	4183	63	20	12	129	20	24	87	34
790	MB2014.M9/6.807.8116.21	M9/6	V	525	4681	44	19	12	124	31	24	91	31
791	MB2014.M9/6.807.8116.22	M9/6	V	526	4299	53	22	14	113	30	24	89	27
792	MB2014.M9/6.807.8116.3	M9/6	V	669	7460	98	25	18	140	9	49	212	29
793	MB2014.M9/6.807.8116.4	M9/6	V	736	7401	81	25	19	139	9	50	210	32

ANID	Artifact ID	Trench	Horizon	Element Concentration (ppm) Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
794	MB2014.M9/6.807.8116.5	M9/6	V	541	8124	60	20	13	136	116	26	172	39
795	MB2014.M9/6.807.8116.6	M9/6	V	603	7730	58	18	15	141	112	23	158	37
796	MB2014.M9/6.807.8116.7	M9/6	V	474	7341	49	24	17	109	126	17	106	24
797	MB2014.M9/6.807.8116.8*	M9/6	V	532	5716	43	21	16	108	88	17	95	20
798	MB2014.M9/6.807.8116.9	M9/6	V	449	6087	52	18	15	114	94	18	97	23
799	MB2014.M9/6.808.8124*	M9/6	V	659	4876	55	28	33	247	10	29	88	58
800	MB2014.M9/6.809.8127	M9/6	V	562	6278	58	16	16	106	100	19	94	24
801	MB2014.M9/6.FT1.8105.1	M9/6	V	602	6848	67	20	18	144	2	45	166	30
802	MB2014.M9/6.FT1.8105.11	M9/6	V	750	4189	63	22	16	143	13	33	88	39
803	MB2014.M9/6.FT1.8105.2	M9/6	V	372	8122	53	19	32	182	2	37	171	31
804	MB2014.M9/6.FT1.8105.3*	M9/6	V	585	5989	60	20	20	121	153	14	110	22
805	MB2014.M9/6.FT1.8105.4*	M9/6	V	332	7564	54	24	18	131	50	19	137	18
806	MB2014.M9/6.FT1.8105.5*	M9/6	V	714	9047	74	24	21	162	131	28	189	41
807	MB2014.M9/6.FT1.8105.6	M9/6	V	647	7779	88	25	21	142	11	52	229	31
808	MB2014.M9/6.FT1.8105.7*	M9/6	V	506	3758	55	27	27	207	9	33	90	42
809	MB2014.M9/6.FT1.8105.8*	M9/6	V	662	4492	50	28	31	238	9	29	88	57
810	MB2014.M9/6.FT1.8105.9*	M9/6	V	581	5549	81	28	15	151	42	23	102	36
811	MB2014.M9/6.FT2.8095.1	M9/6	V	387	10375	53	26	14	108	184	19	131	22
812	MB2014.M9/6.FT2.8095.2*	M9/6	V	450	5817	61	21	19	112	154	13	106	22
813	MB2014.M9/6.FT2.8095.3*	M9/6	V	492	5882	59	19	20	110	139	14	98	23
814	MB2014.M9/6.FT2.8095.4	M9/6	V	620	4335	60	22	16	144	16	30	94	36
815	MB2014.M9/6.FT2.8095.5	M9/6	V	657	4005	60	24	28	211	8	28	83	50
816	MB2014.M9/6.FT2.8113.1	M9/6	V	733	7437	84	24	20	135	8	49	220	30
817	MB2014.M9/6.FT2.8113.2	M9/6	V	519	7418	62	23	14	117	122	18	108	27
818	MB2014.M9/6.FT2.8113.3	M9/6	V	429	5940	45	17	17	124	23	21	112	13
819	MB2014.M9/6.FT2.8113.4	M9/6	V	322	5494	51	20	15	142	21	23	101	16
820	MB2014.M9/6.FT2.8113.5	M9/6	V	640	4059	59	20	27	204	10	25	81	55
821	MB2014.M9/6.FT3.8115	M9/6	V	513	6256	45	16	15	109	101	19	94	22
822	MB2014.O7/13SE.Burial1.12015.1	O7/13SE	I	481	4393	51	21	16	122	31	24	97	30
823	MB2014.O7/13SE.Burial1.12015.2	O7/13SE	I	497	8092	61	22	14	145	110	26	166	37
824	MB2014.O7/13SE.Burial1.12015.3*	O7/13SE	I	907	4265	71	27	14	165	12	36	84	44
825	MB2014.O7/13SE.Burial1.12015.4	O7/13SE	I	488	4150	55	24	25	196	11	23	82	48
826	MB2014.O7/13SE.Burial1.12015.5	O7/13SE	I	645	4488	45	20	15	137	25	26	90	32
827	MB2014.O7/13SE.Burial1.12015.6	O7/13SE	I	668	4657	63	22	15	133	27	27	94	32
828	MB2014.O7/13SE.Burial1.12015.7	O7/13SE	I	543	4541	59	21	13	122	30	25	94	29
829	MB2014.O7/13SE.Burial1.12041.1	O7/13SE	I	689	4152	58	24	27	215	8	28	84	55
830	MB2014.O7/13SE.Burial1.12041.2	O7/13SE	I	670	3963	53	23	25	208	11	25	80	53
831	MB2014.O7/13SE.Burial1.12042.1	O7/13SE	I	573	4894	55	25	12	126	30	24	98	31
832	MB2014.O7/13SE.Burial1.12044.1	O7/13SE	I	528	4521	60	17	15	126	26	26	89	32
833	MB2014.O7/13SE.Burial1.12044.2	O7/13SE	I	518	4485	50	18	14	126	31	28	92	29
834	MB2014.O7/13SE.FT5.12055.1	O7/13SE	I	588	7782	50	20	14	130	108	22	160	36
835	MB2014.O7/13SE.FT5.12055.3	O7/13SE	I	569	4677	56	17	13	132	29	22	91	32
836	MB2014.O7/13SE.FT5.12055.4	O7/13SE	I	516	4588	62	22	13	126	32	25	92	29
837	MB2014.O7/13SE.FT5.12055.5	O7/13SE	I	613	8882	81	26	18	153	130	27	182	42
838	MB2014.O7/13SE.FT5.12055.6	O7/13SE	I	689	10608	60	18	18	137	114	26	166	39
839	MB2014.O8/1.1007.10102	O8/1	I	563	4528	56	21	14	121	35	22	91	26
840	MB2014.O8/1.FT1.10035.1	O8/1	I	540	5312	61	23	19	124	44	24	104	30
841	MB2014.O8/1.FT3.10068.1	O8/1	I	596	7979	64	17	20	133	109	26	160	34
842	MB2014.O8/1.FT3.10068.3	O8/1	I	580	7870	69	17	14	146	113	27	164	37
843	MB2014.O8/1.FT3.10068.4	O8/1	I	493	4609	58	20	14	117	37	24	94	25
844	MB2014.O8/1.FT3.10068.5	O8/1	I	578	8449	66	20	16	144	114	24	168	35
845	MB2014.O8/1.FT3.10068.6	O8/1	I	402	6193	61	19	18	135	23	27	114	13
846	MB2014.O8/1.FT3.10068.7	O8/1	I	645	8228	56	19	18	144	122	25	171	38
847	MB2014.O8/1.FT3.10068.8	O8/1	I	566	4302	54	17	15	128	20	28	86	35
848	MB2014.O8/1.FT3.10068.9	O8/1	I	575	4642	59	16	15	114	32	27	91	28
849	MB2014.O8/1.FT4.10077.1	O8/1	I	612	8042	51	18	17	134	112	26	162	38
850	MB2014.O8/1.FT4.10077.2	O8/1	I	626	8315	63	22	16	141	117	26	171	37
851	MB2014.O8/1.FT4.10077.4	O8/1	I	511	4521	46	22	17	130	28	27	93	30
852	MB2014.O8/1.FT4.10077.5	O8/1	I	488	4618	56	22	13	124	32	28	91	30
853	MB2014.O8/1.FT4.10077.6	O8/1	I	626	5159	53	23	13	136	36	26	99	34
854	MB2012.pebble.brown*	Surface	Topsoil	677	25802	45	12	16	130	123	30	174	36

Appendix 3: Individual Element Scatter Plots for All Sources Analyzed in This Study.

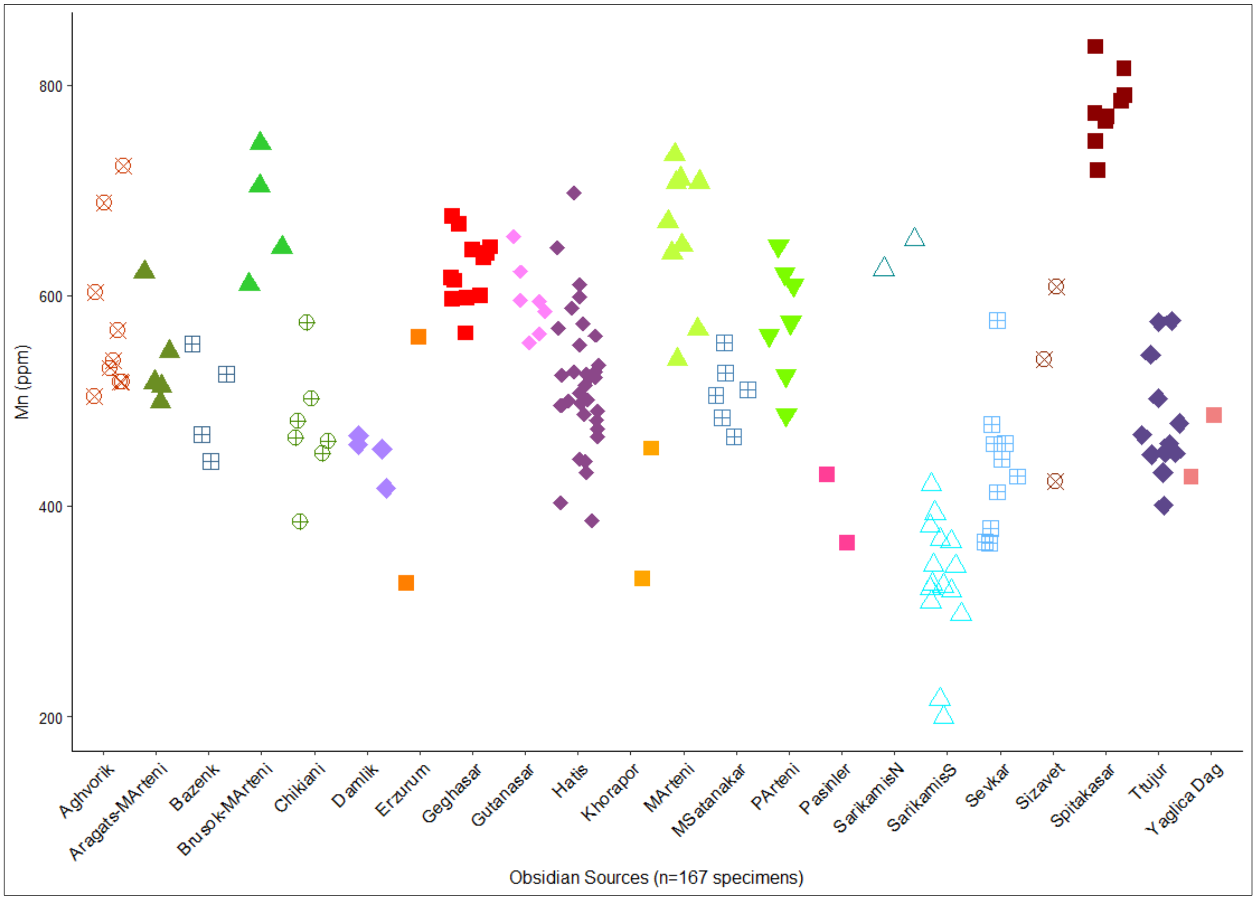

Figure A3.1 – Scatterplot of Mn (ppm) for all specimens analyzed (n=167).

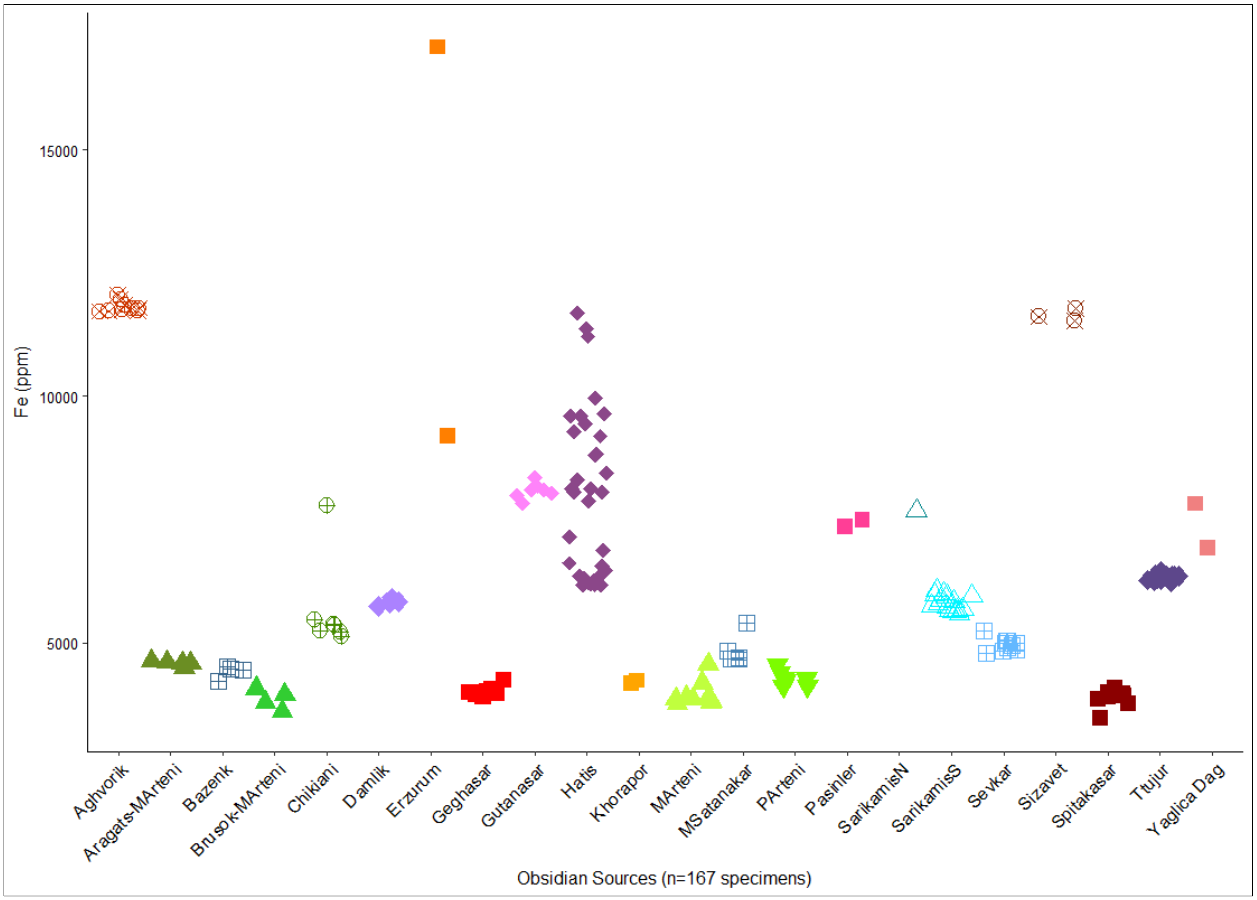

Figure A3.2 – Scatterplot of Fe (ppm) for all specimens analyzed (n=167).

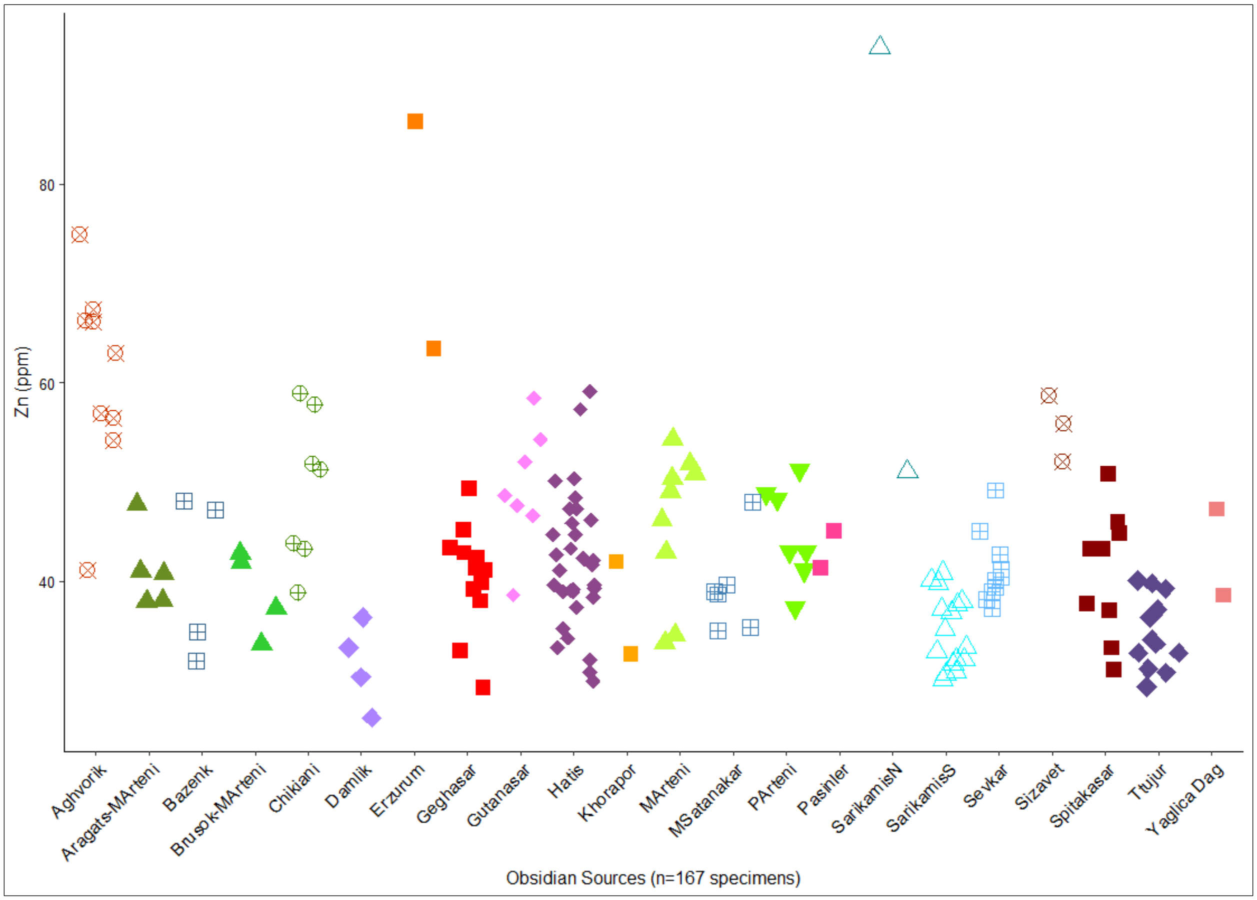

Figure A3.3 – Scatterplot of Zn (ppm) for all specimens analyzed (n=167).

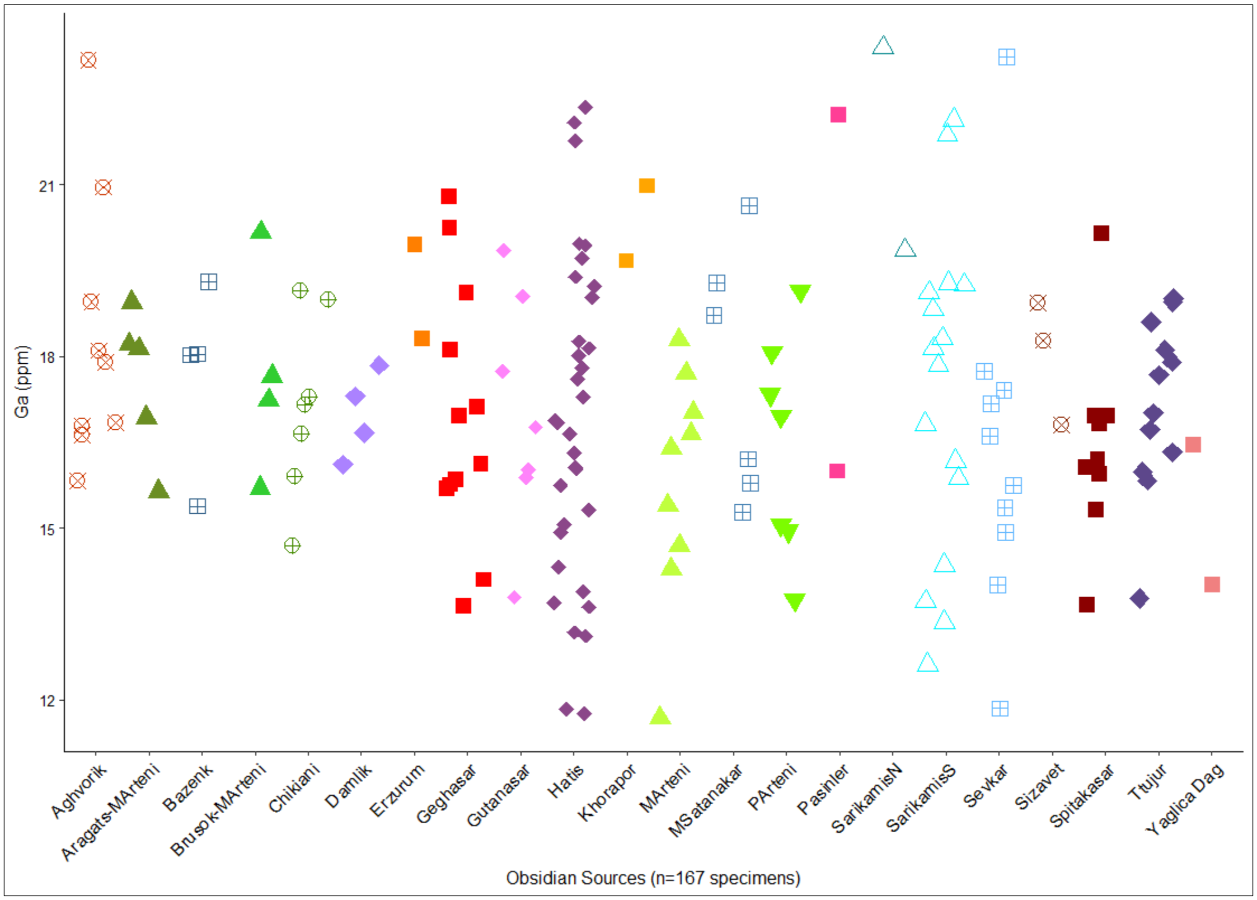

Figure A3.4 – Scatterplot of Ga (ppm) for all specimens analyzed (n=167).

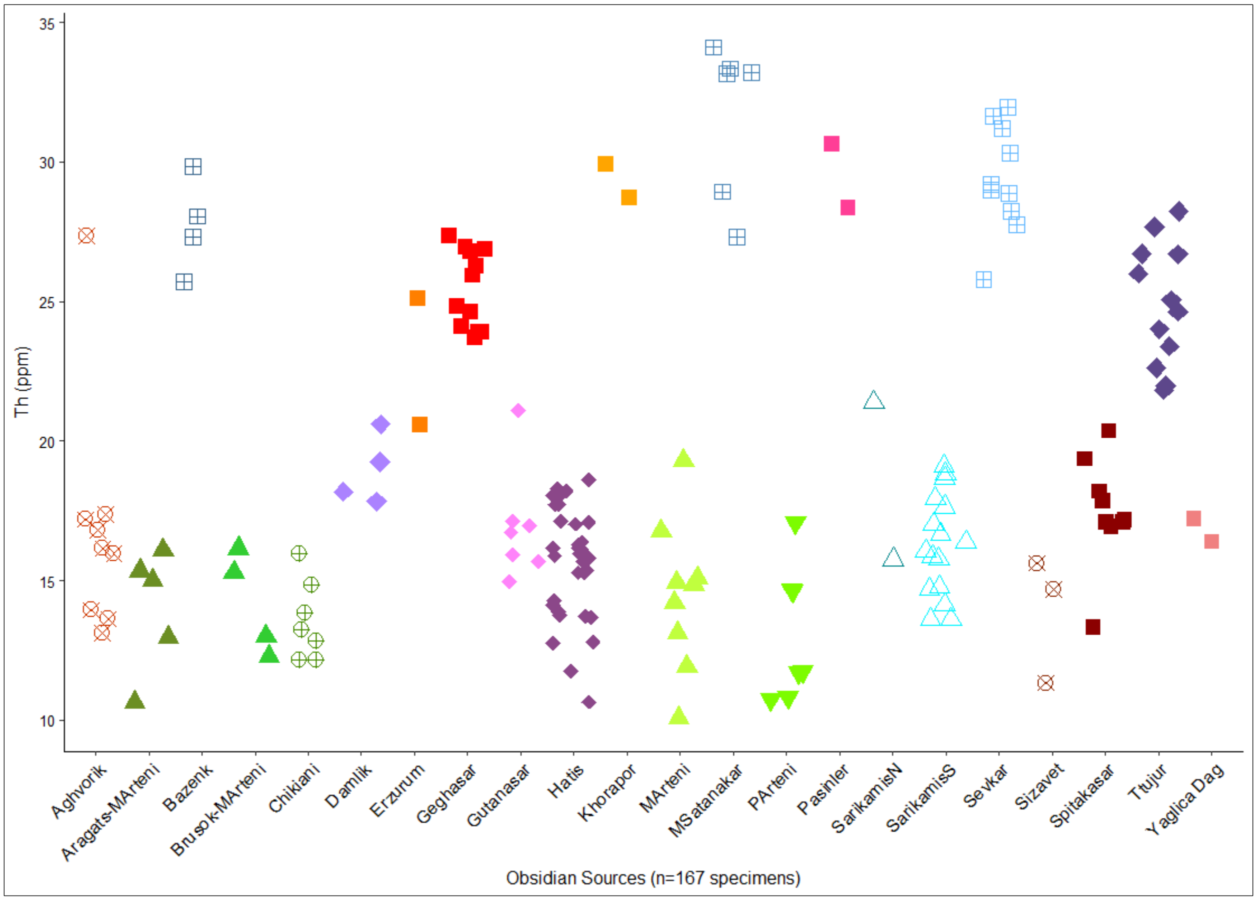

Figure A3.5 – Scatterplot of Th (ppm) for all specimens analyzed (n=167).

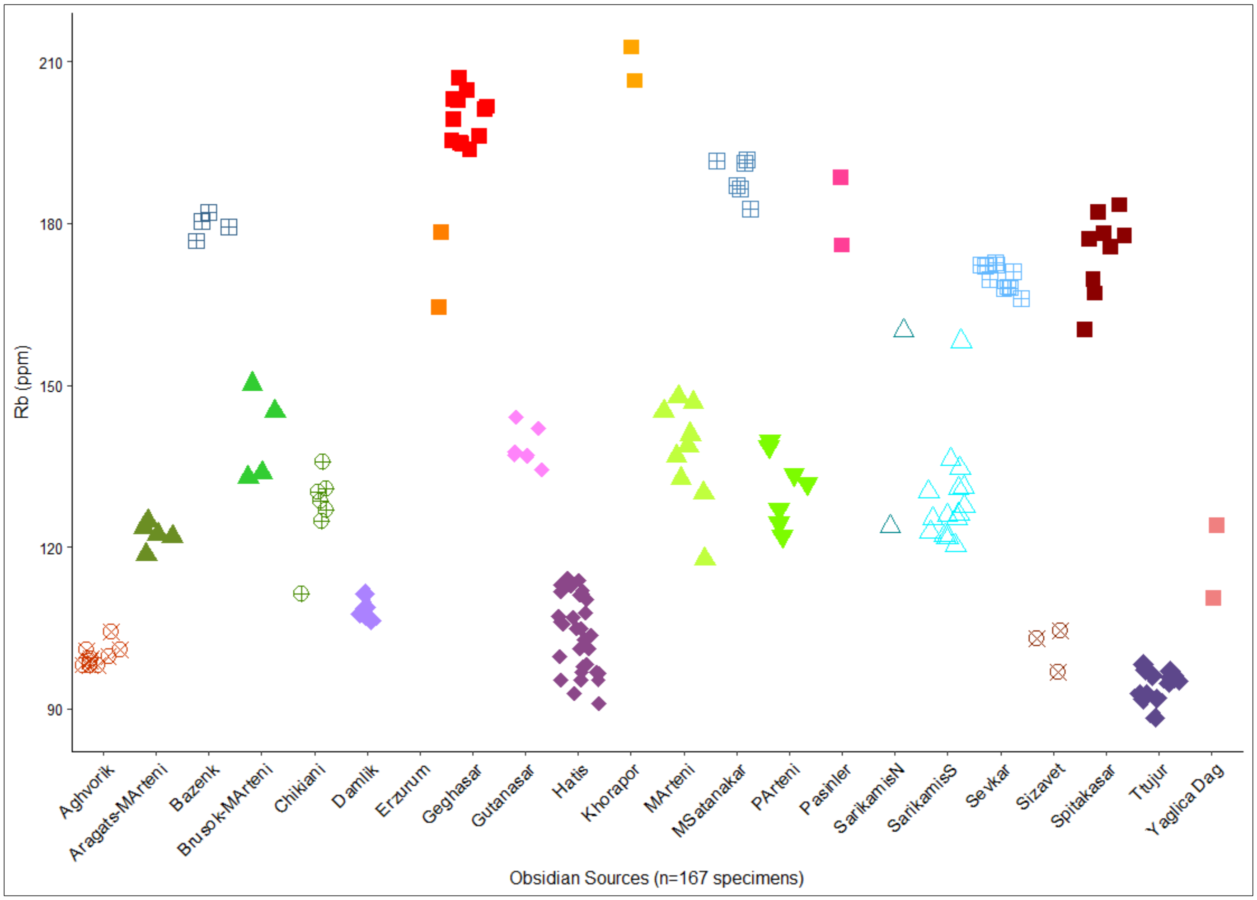

Figure A3.6 – Scatterplot of Rb (ppm) for all specimens analyzed (n=167).

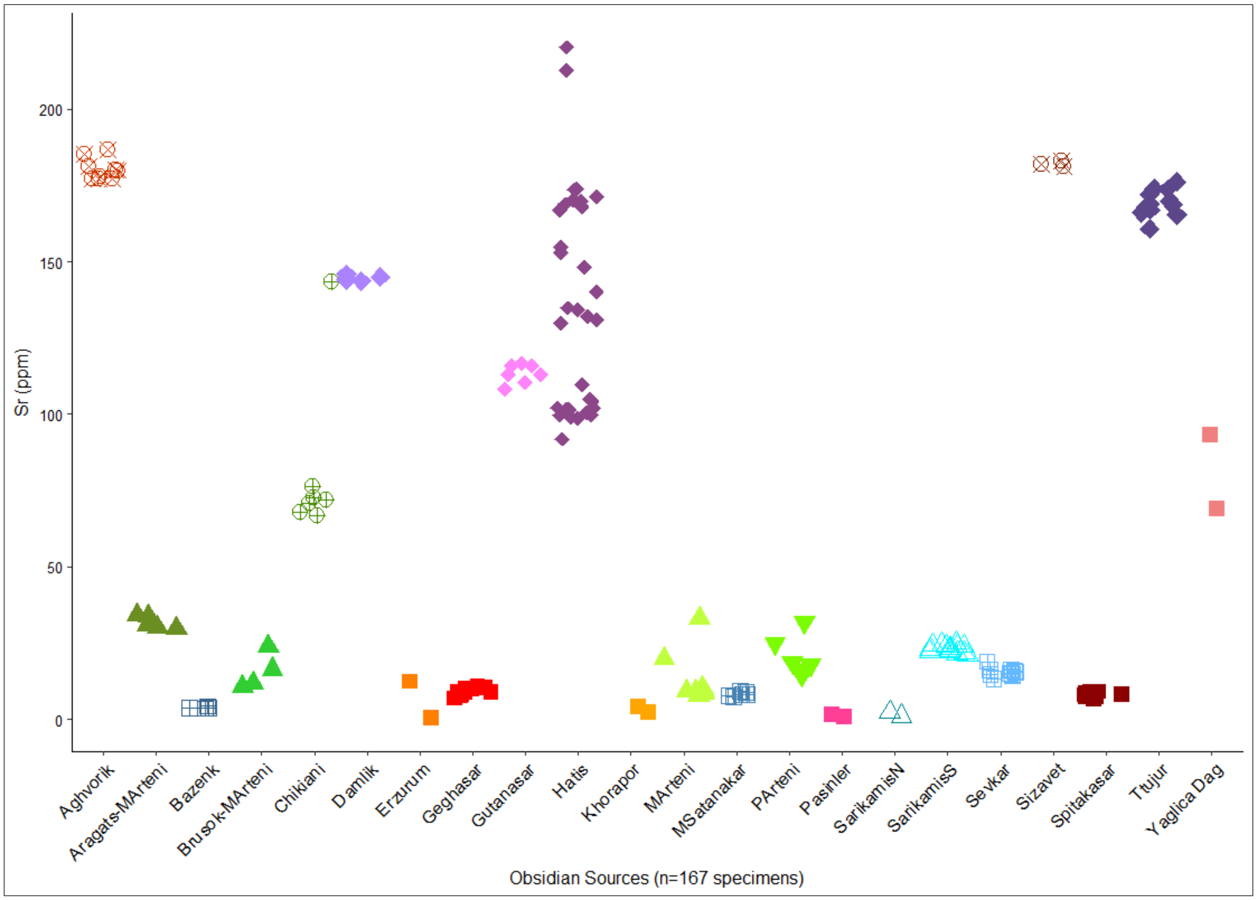

Figure A3.7 – Scatterplot of Sr (ppm) for all specimens analyzed (n=167).

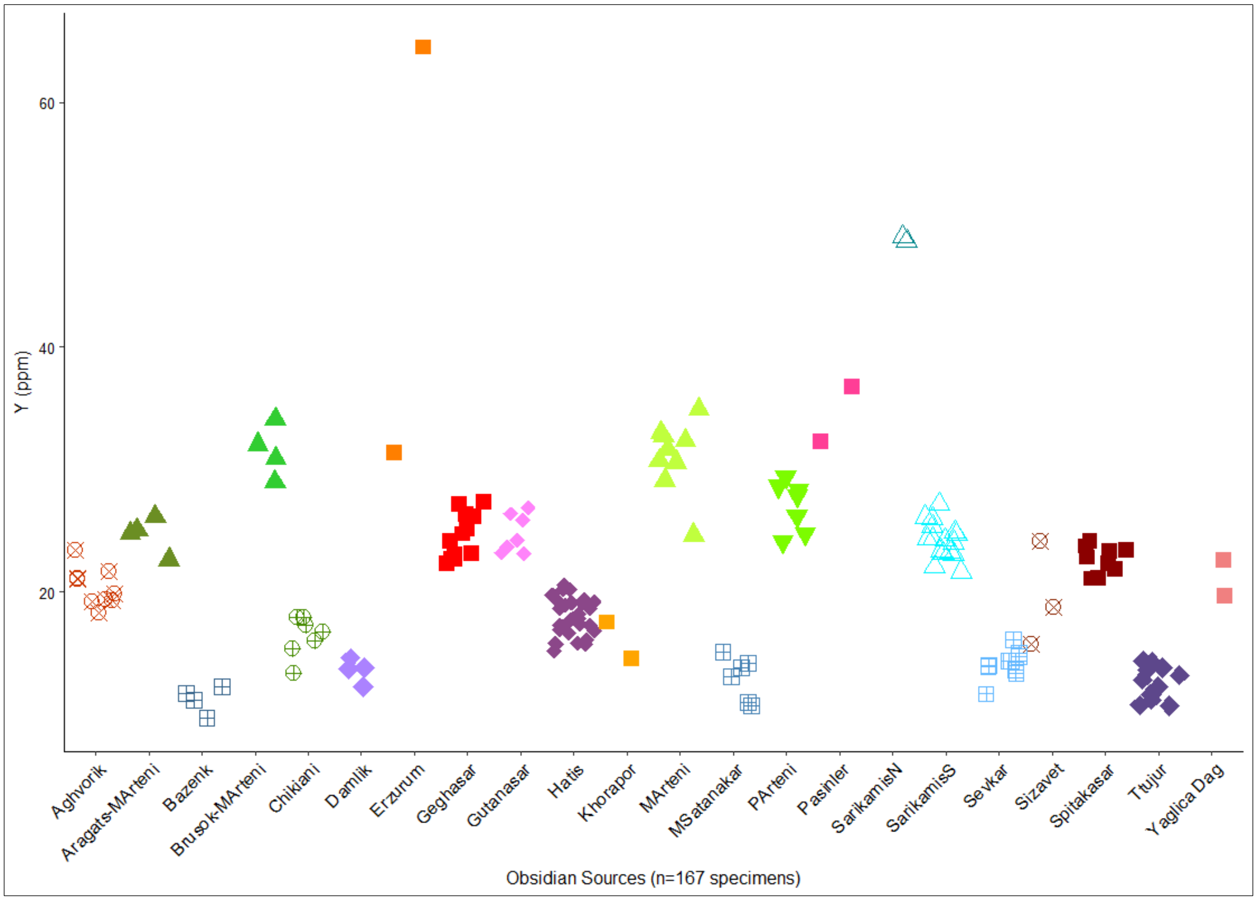

Figure A3.8 – Scatterplot of Y (ppm) for all specimens analyzed (n=167).

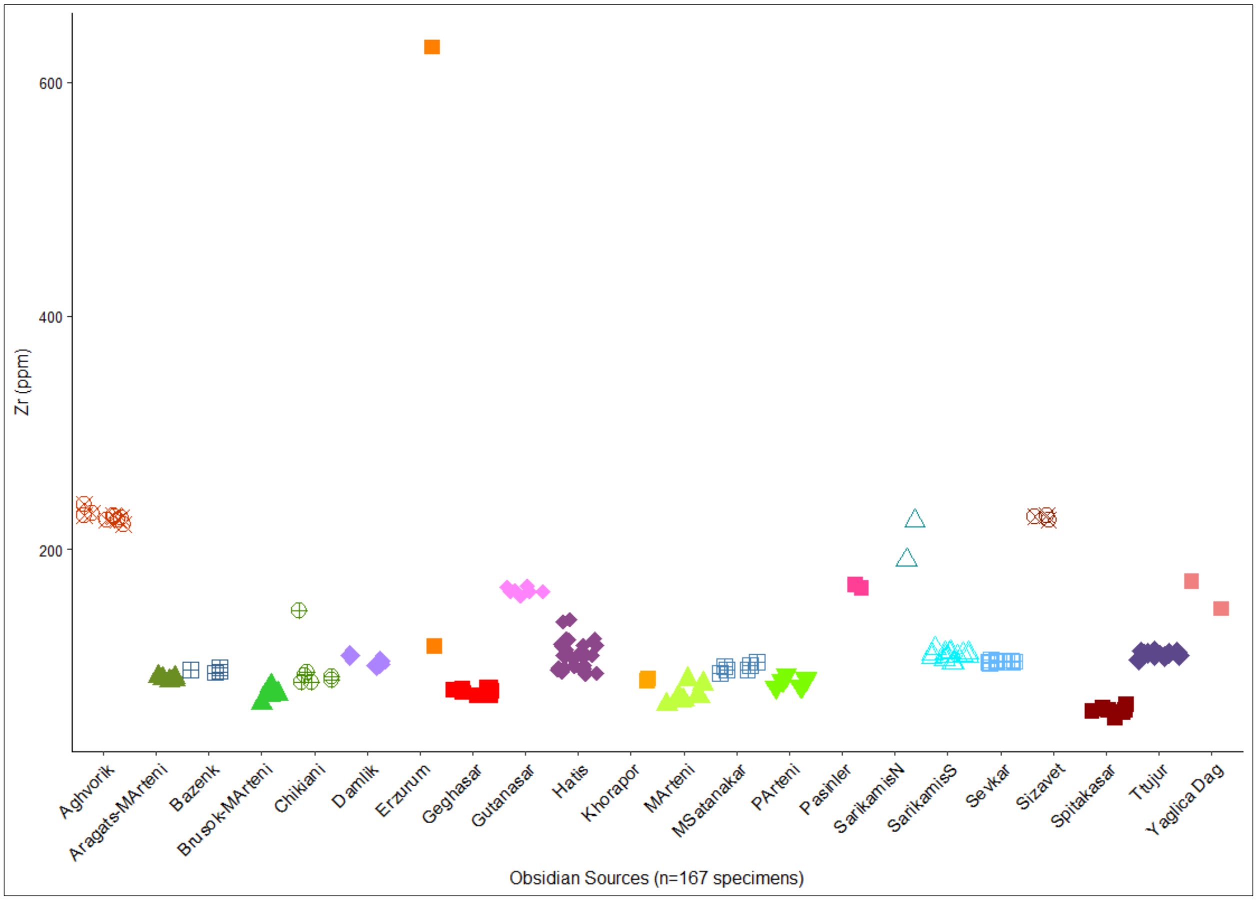

Figure A3.9 – Scatterplot of Zr (ppm) for all specimens analyzed (n=167).

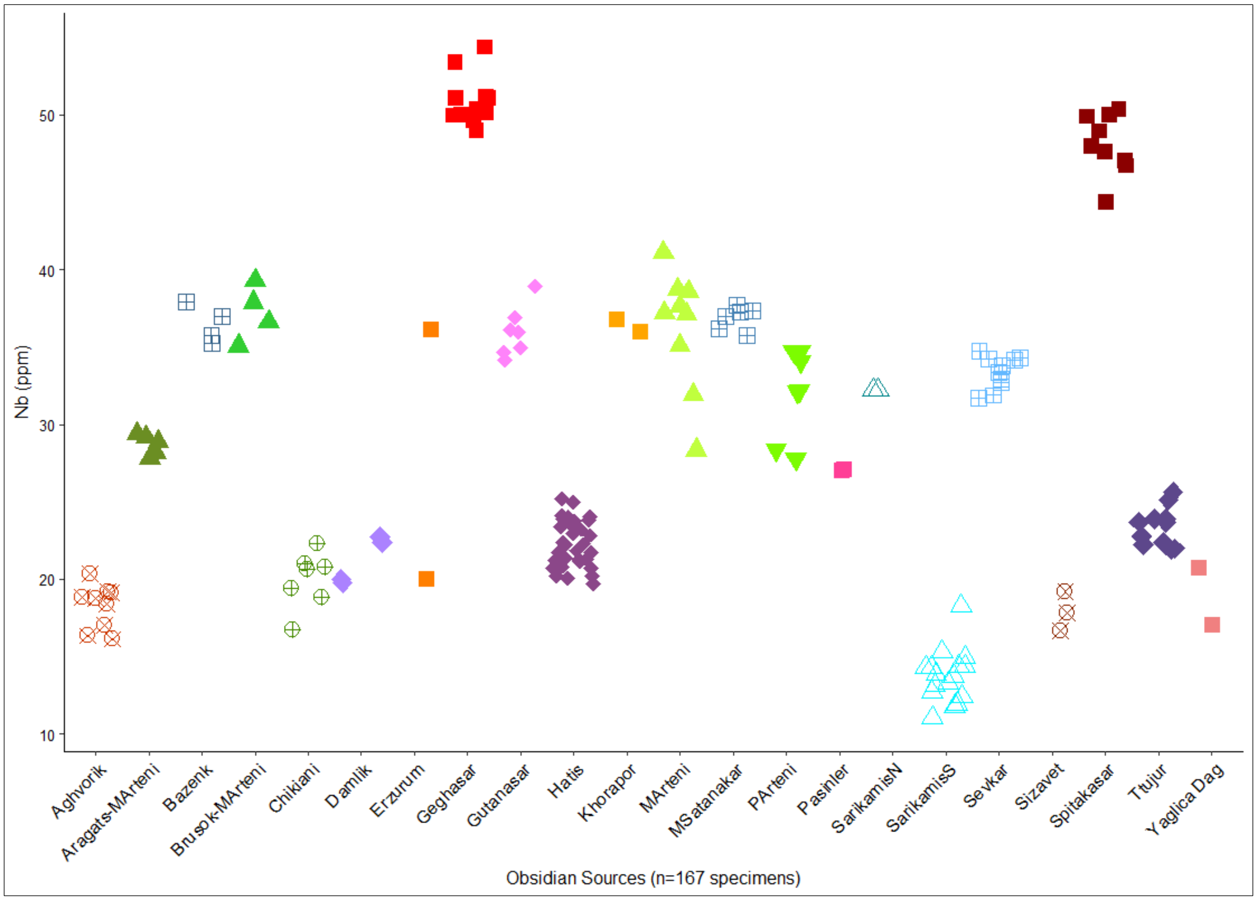

Figure A3.10 – Scatterplot of Nb (ppm) for all specimens analyzed (n=167).

Appendix 4: Bivariate Scatter Plots of Geological Specimens and Masis Blur Artifacts

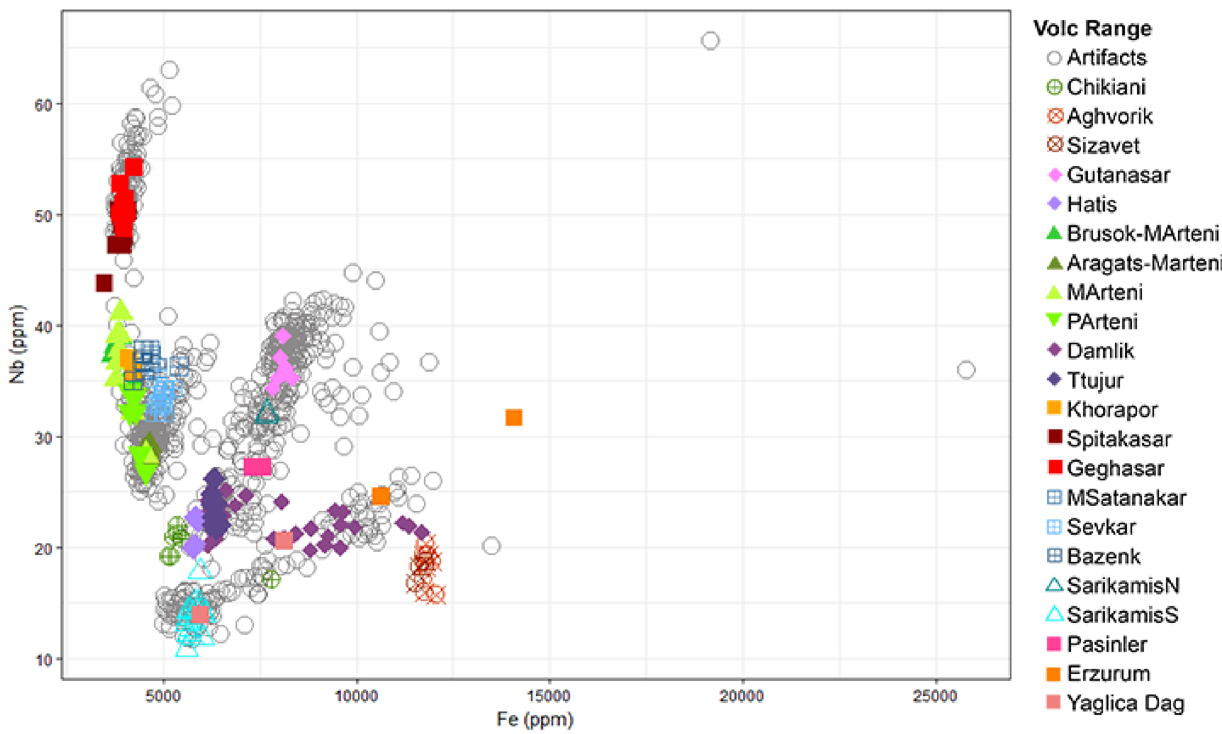

Figure A4.1 Bivariate scatterplot of Fe and Nb for all specimens analyzed (n=167).

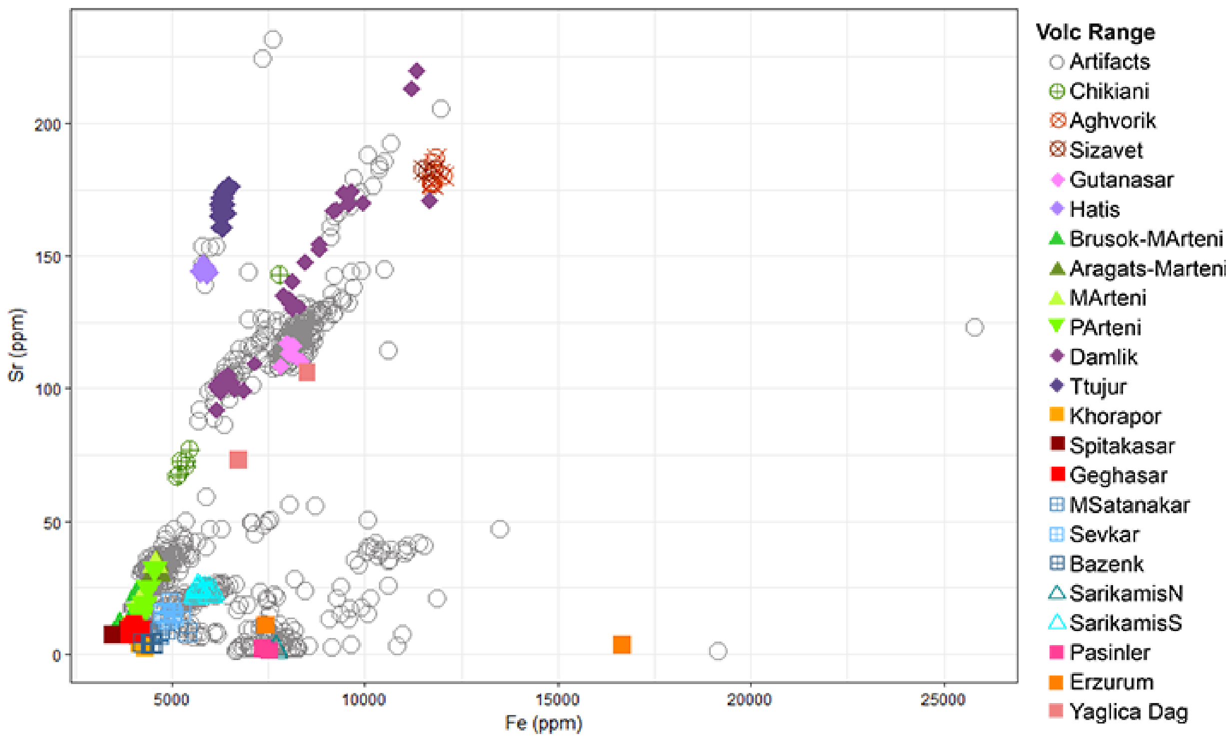

Figure A4.2 Bivariate scatterplot of Fe and Sr for all specimens analyzed (n=167).

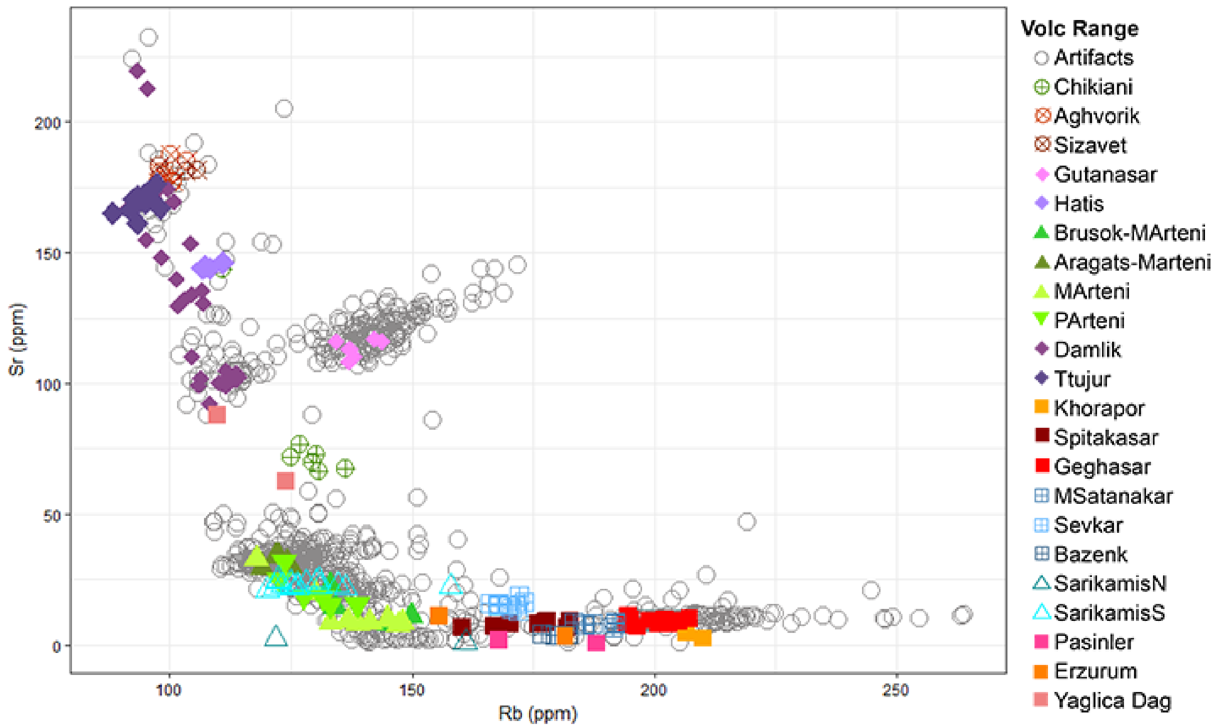

Figure A4.3 Bivariate scatterplot of Rb and Sr for all specimens analyzed (n=167).

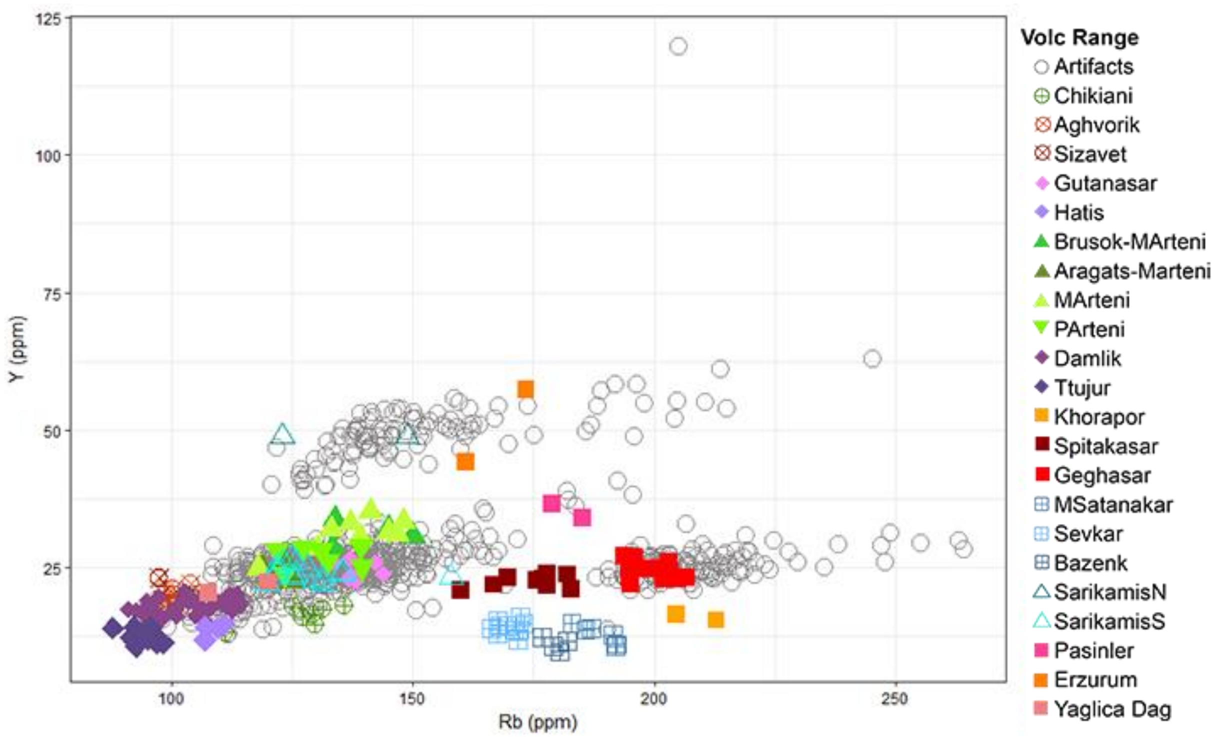

Figure A4.4 Bivariate scatterplot of Rb and Y for all specimens analyzed (n=167).

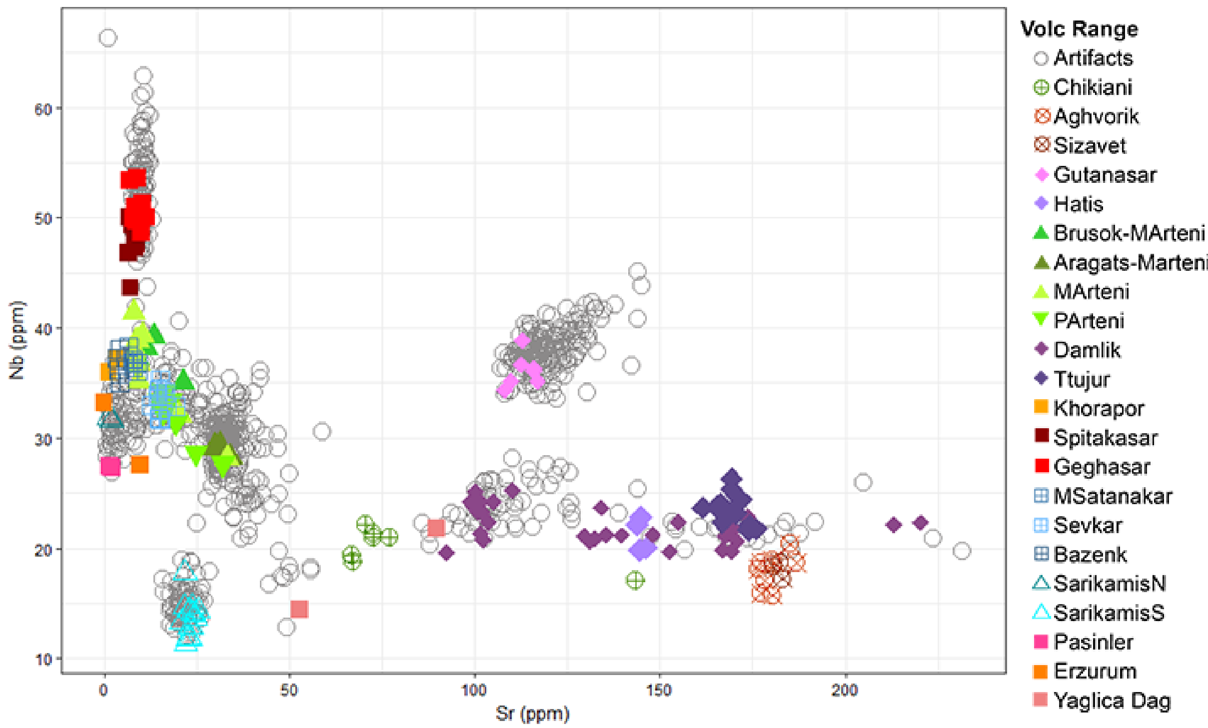

Figure A4.5 Bivariate scatterplot of Sr and Nb for all specimens analyzed (n=167).

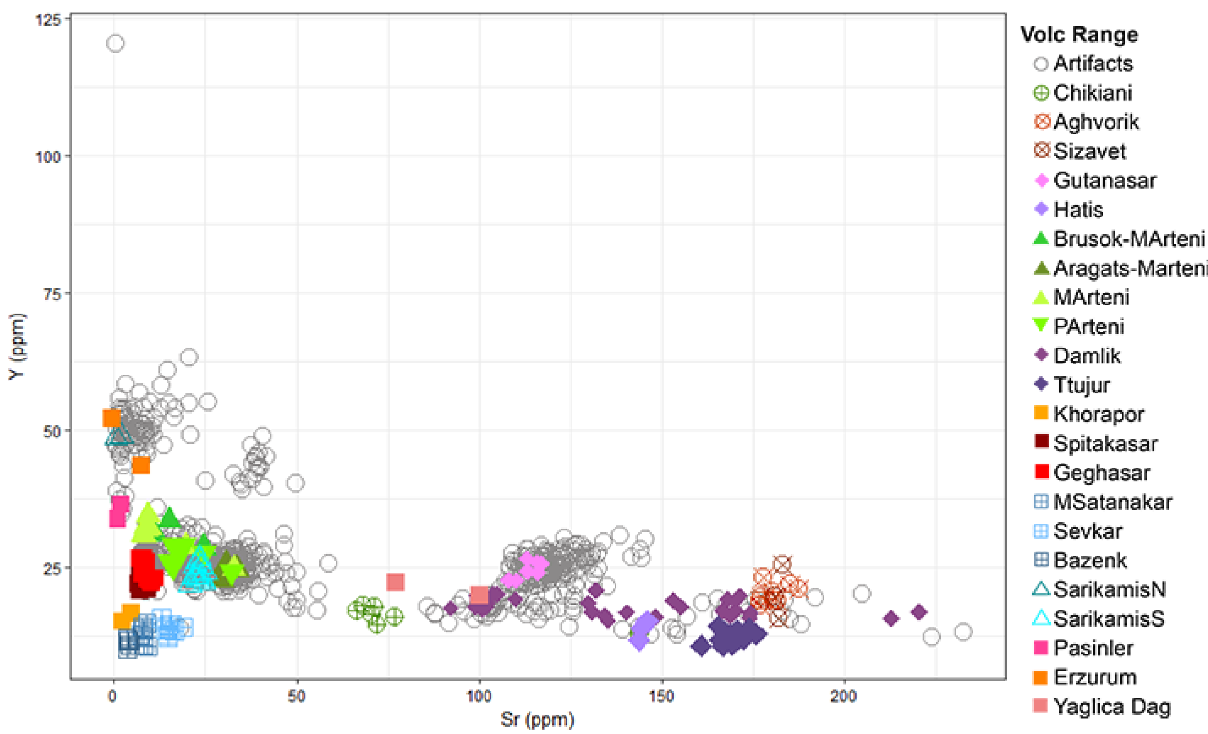

Figure A4.6 Bivariate scatterplot of Sr and Y for all specimens analyzed (n=167).

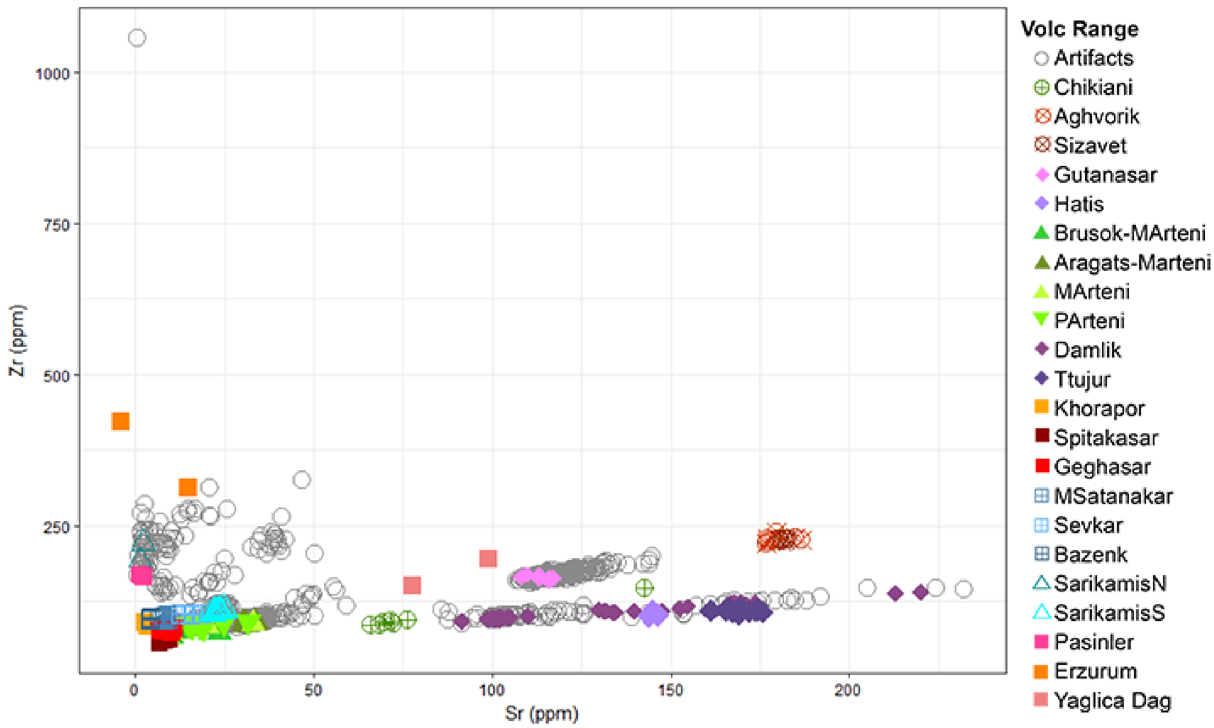

Figure A4.7 Bivariate scatterplot of Sr and Zr for all specimens analyzed (n=167).

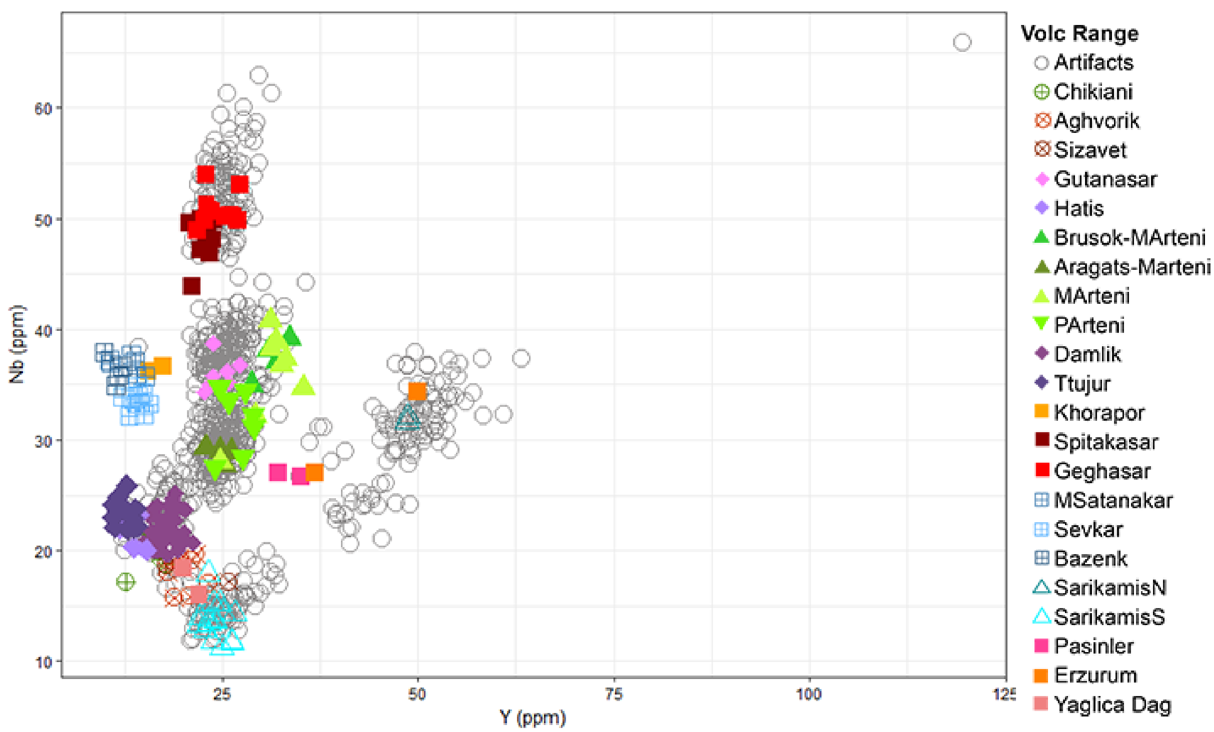

Figure A4.8 Bivariate scatterplot of Y and Nb for all specimens analyzed (n=167).

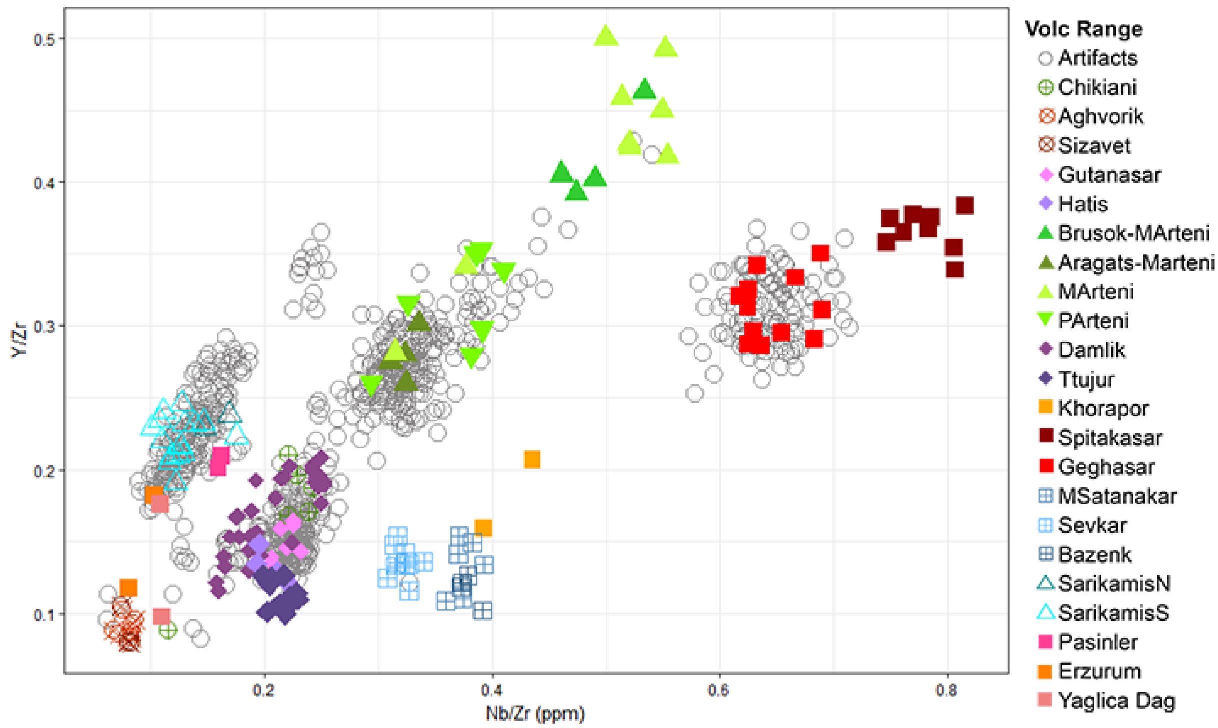

Figure A4.9 Bivariate scatterplot of Nb and Y ratioed to Zr for all specimens analyzed (n=167).

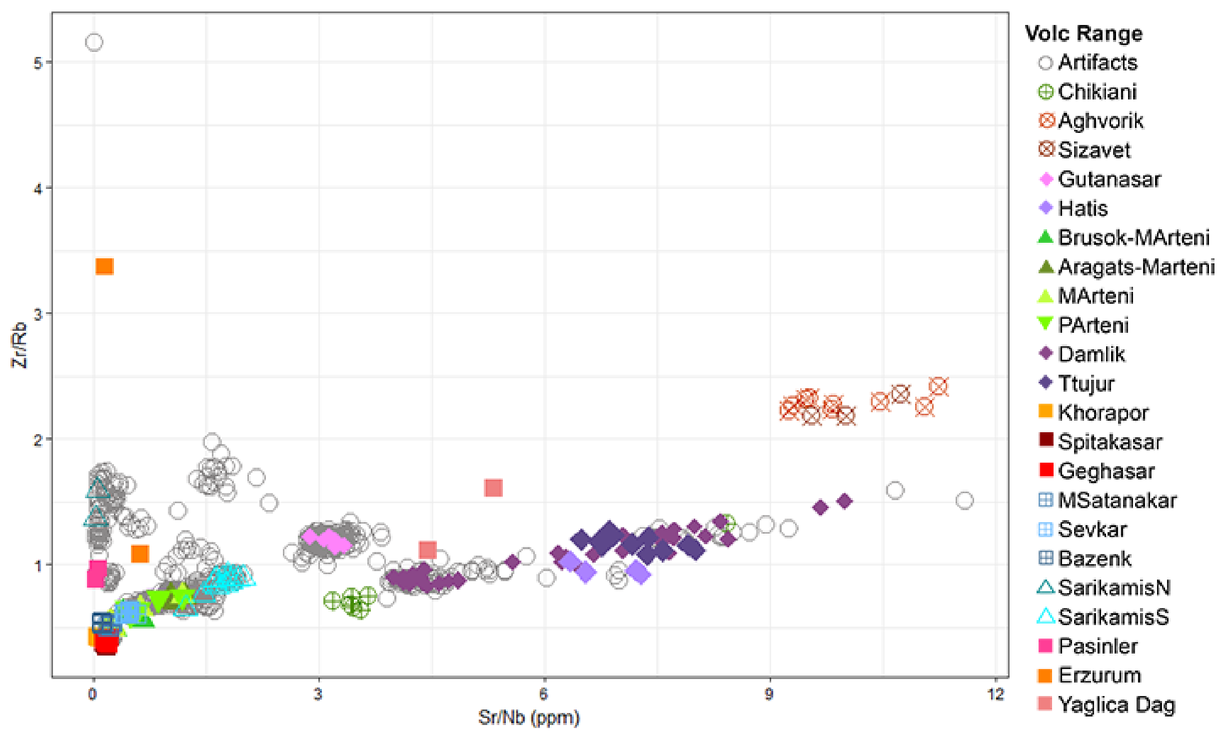

Figure A4.10 Bivariate scatterplot of Sr/Nb and Zr/Rb for all specimens analyzed (n=167).

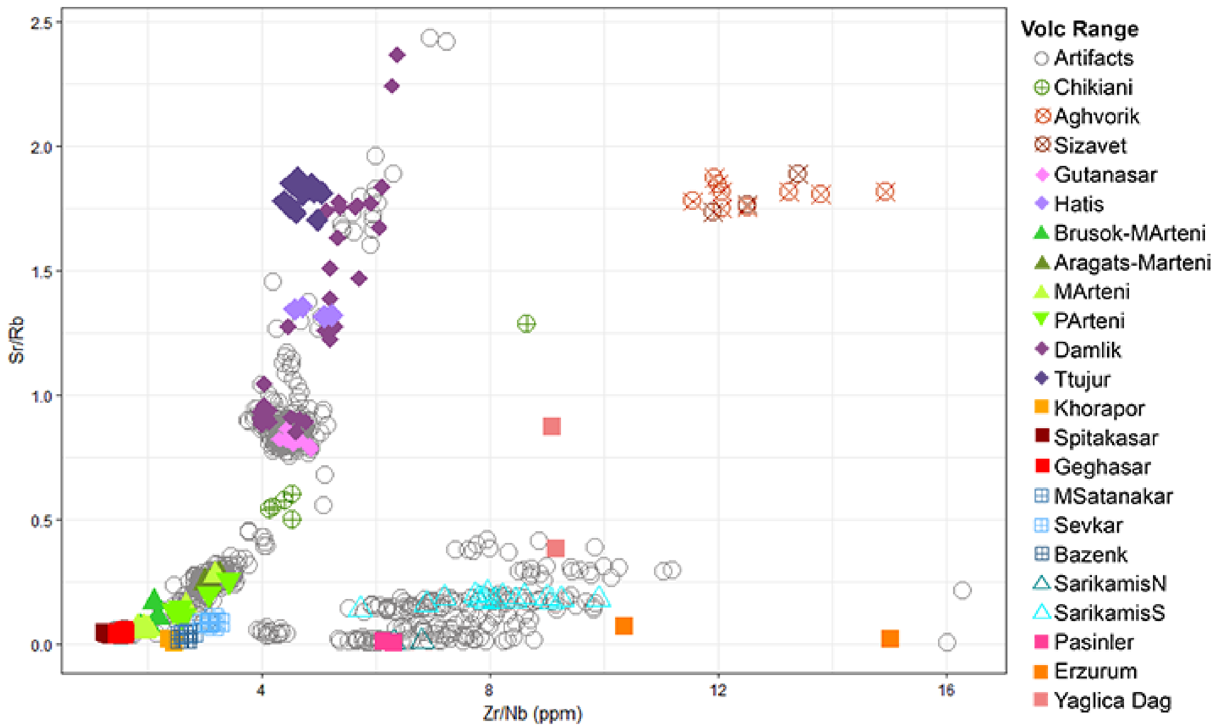

Figure A4.11 Bivariate scatterplot of Zr/Nb and Sr/Rb for all specimens analyzed (n=167).

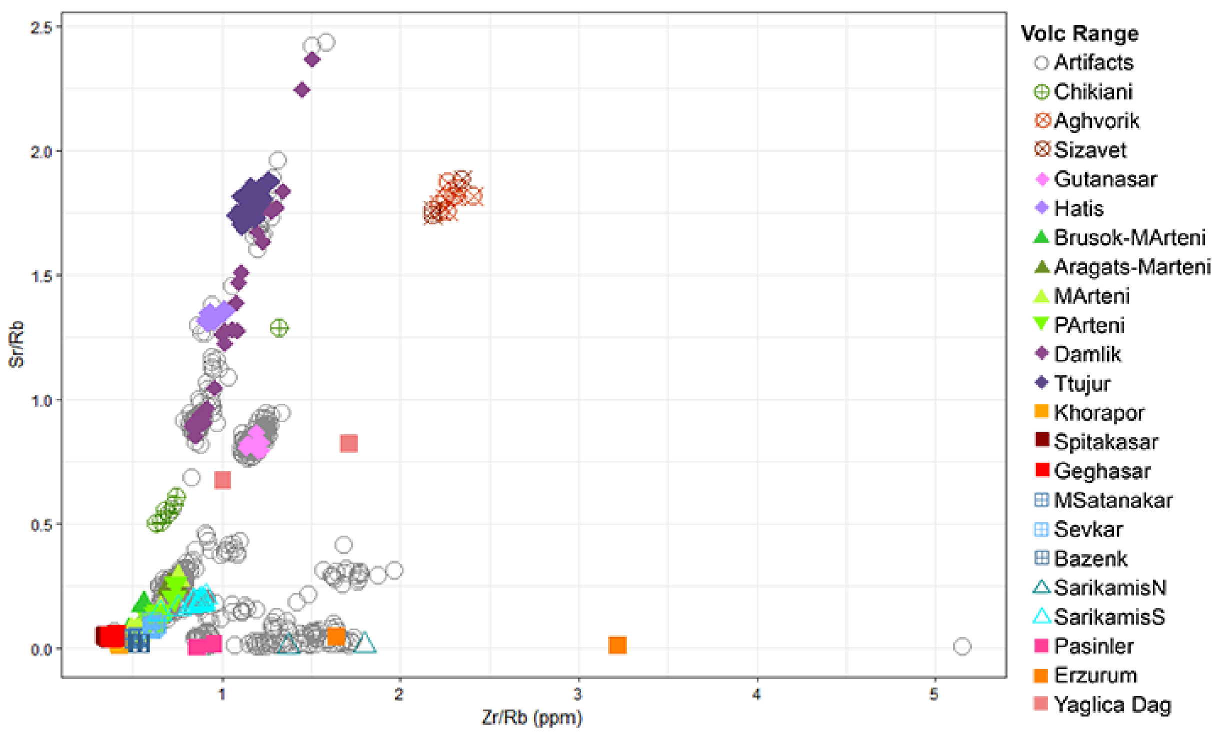

Figure A4.12 Bivariate scatterplot of Zr and Sr ratioed to Rb for all specimens analyzed (n=167).

Appendix 5: MD probabilities for Masis Blur Artifacts and the Attribution of Artifacts to a Source

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
1	10.90	0.00	0.00	0.00	12.78	10.43	0.00	0.00	Fe Sr Y Zr	M.Arteni	Geghasar
1	16.03	0.01	0.00	0.00	0.00	3.38	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
2	84.42	0.00	0.00	0.00	5.40	15.35	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
2	91.89	0.01	0.00	0.00	0.00	4.22	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
3	0.00	0.01	0.00	0.00	24.38	11.78	0.00	0.00	Fe Sr Y Zr	M.Arteni	P.Arteni
3	0.00	0.07	0.00	0.00	69.00	78.79	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
4	0.01	0.01	0.00	0.00	42.79	22.64	0.00	0.00	Fe Sr Y Zr	M.Arteni	M.Arteni
4	0.00	0.06	0.00	0.00	35.61	38.20	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
5	92.53	0.00	0.00	0.00	0.41	9.98	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
5	23.91	0.01	0.00	0.00	0.00	2.58	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
6	0.01	0.01	0.00	0.00	68.52	69.97	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
6	0.00	0.05	0.00	0.00	90.60	63.46	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
7	0.00	0.01	0.00	0.00	8.41	8.89	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
7	0.00	0.06	0.00	0.00	58.74	25.35	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
8	0.00	90.28	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
8	0.00	59.85	0.00	0.00	0.00	0.56	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
9	0.00	8.74	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
9	0.00	17.45	0.00	0.00	0.00	0.45	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Meydan Dag
10	0.00	0.02	0.00	0.00	0.00	0.19	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
11	0.00	0.04	0.18	24.22	0.00	0.18	0.00	0.00	Fe Sr Y Zr	Hatis-2	Hatis-2
11	0.00	0.61	0.53	25.42	0.43	6.41	0.00	0.00	Rb Sr Y Zr Nb	Hatis-2	
12	23.57	0.00	0.00	0.00	3.30	6.81	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
12	30.51	0.01	0.00	0.00	0.00	4.67	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
13	0.00	5.03	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
13	0.00	6.94	0.00	0.00	0.00	0.56	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
14	0.00	0.01	0.00	0.00	4.34	9.55	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
14	0.00	0.06	0.00	0.00	69.13	20.91	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
15	0.00	0.01	0.00	0.00	6.33	12.49	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
15	0.00	0.06	0.00	0.00	65.30	50.74	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
16	0.30	0.00	0.00	0.00	28.68	88.28	0.00	0.00	Fe Sr Y Zr	P.Arteni	P.Arteni
16	0.00	0.02	0.00	0.00	52.25	91.32	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
17	0.00	0.13	0.00	25.78	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Hatis-2	Hatis-2
17	0.00	0.35	0.00	3.40	2.79	7.14	0.00	0.09	Rb Sr Y Zr Nb	P.Arteni	
18	0.00	0.06	17.09	10.29	0.00	0.26	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
18	0.00	0.76	14.89	28.51	5.99	15.20	0.00	0.00	Rb Sr Y Zr Nb	Hatis-2	
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Pasinler
19	0.00	0.00	0.00	0.00	0.00	0.28	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
20	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
21	0.00	72.21	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
21	0.00	70.55	0.00	0.00	0.00	0.60	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
22	24.36	0.00	0.00	0.00	0.01	4.68	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
22	18.28	0.01	0.00	0.00	0.00	2.77	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
23	0.02	0.01	0.00	0.00	43.68	35.65	0.00	0.00	Fe Sr Y Zr	M.Arteni	M.Arteni
23	0.00	0.05	0.00	0.00	78.45	63.32	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
24	0.02	0.01	0.00	0.00	15.09	14.76	0.00	0.00	Fe Sr Y Zr	M.Arteni	M.Arteni
24	0.00	0.05	0.00	0.00	30.92	32.54	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
25	0.00	0.01	0.00	0.00	48.28	18.40	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
25	0.00	0.06	0.00	0.00	54.18	22.66	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
26	0.01	0.01	0.00	0.00	76.16	58.78	0.00	0.00	Fe Sr Y Zr	M.Arteni	M.Arteni
26	0.00	0.05	0.00	0.00	81.11	64.57	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
27	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
28	0.00	37.03	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
28	0.00	20.07	0.00	0.00	0.00	0.70	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
29	0.01	0.01	0.00	0.00	58.10	40.45	0.00	0.00	Fe Sr Y Zr	M.Arteni	M.Arteni
29	0.00	0.06	0.00	0.00	57.98	44.04	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
30	0.00	3.17	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
30	0.00	4.96	0.00	0.00	0.00	0.50	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
31	0.02	0.01	0.00	0.00	20.21	46.68	0.00	0.00	Fe Sr Y Zr	P.Arteni	P.Arteni
31	0.00	0.05	0.00	0.00	55.78	52.12	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
32	0.00	0.01	0.00	0.00	18.24	11.00	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
32	0.00	0.05	0.00	0.00	44.47	16.39	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
33	0.01	0.01	0.00	0.00	30.71	33.15	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
33	0.00	0.07	0.00	0.00	41.84	33.15	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
34	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
35	0.01	0.01	0.00	0.00	83.39	77.08	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
35	0.00	0.05	0.00	0.00	58.80	42.67	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
36	0.00	65.13	0.00	0.00	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
36	0.00	66.51	0.00	0.00	0.00	0.66	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
37	0.01	0.01	0.00	0.00	7.45	10.71	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
37	0.00	0.08	0.00	0.00	3.44	21.03	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
38	0.01	0.01	0.00	0.00	43.53	53.21	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
38	0.00	0.05	0.00	0.00	72.02	62.42	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
39	0.00	0.01	0.00	0.00	0.06	1.01	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
39	0.00	0.07	0.00	0.00	4.00	5.06	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
40	0.00	59.72	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
40	0.00	69.81	0.00	0.00	0.00	0.56	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
41	0.01	0.01	0.00	0.00	75.54	71.76	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
41	0.00	0.05	0.00	0.00	87.35	82.07	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
42	0.01	0.01	0.00	0.00	52.67	25.25	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
42	0.00	0.05	0.00	0.00	41.89	58.66	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
43	0.00	0.01	0.00	0.00	0.02	1.09	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
43	0.00	0.06	0.00	0.00	0.19	3.48	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
44	0.00	0.01	0.00	0.00	0.01	0.85	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
44	0.00	0.08	0.00	0.00	8.63	5.57	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
45	0.00	0.02	0.00	0.00	21.65	6.32	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
45	0.00	0.12	0.00	0.00	5.48	21.60	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
46	0.02	0.01	0.00	0.00	18.33	49.06	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
46	0.00	0.05	0.00	0.00	36.47	51.73	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
47	0.00	30.27	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
47	0.00	37.78	0.00	0.00	0.00	0.57	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
48	0.00	0.08	0.00	41.33	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Hatis-2	Hatis-2
48	0.00	0.26	0.00	55.25	0.33	12.07	0.00	0.04	Rb Sr Y Zr Nb	Hatis-2	
49	0.00	37.79	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
49	0.00	55.51	0.00	0.00	0.00	0.53	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
50	0.01	0.01	0.00	0.00	76.67	68.31	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
50	0.00	0.05	0.00	0.00	53.33	72.99	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
51	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
52	62.35	0.00	0.00	0.00	0.19	11.91	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
52	99.79	0.01	0.00	0.00	0.00	4.66	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
53	0.01	0.01	0.00	0.00	29.02	56.27	0.00	0.00	Fe Sr Y Zr	P.Arteni	P.Arteni
53	0.00	0.06	0.00	0.00	73.66	77.46	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
54	54.92	0.00	0.00	0.00	5.40	7.44	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
54	43.01	0.01	0.00	0.00	0.00	3.18	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
55	0.00	0.01	0.00	0.00	4.39	4.31	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni?
55	0.00	0.07	0.00	0.00	13.43	16.30	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
56	75.85	0.00	0.00	0.00	7.90	14.43	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
56	83.12	0.01	0.00	0.00	0.00	3.97	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
57	0.00	0.01	0.00	0.00	0.02	2.20	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
57	0.00	0.05	0.00	0.00	75.86	86.81	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
58	23.40	0.00	0.00	0.00	0.47	8.99	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
58	4.59	0.01	0.00	0.00	0.00	7.66	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
59	0.01	0.00	0.00	0.00	42.78	17.63	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
59	0.00	0.04	0.00	0.00	59.13	28.67	0.01	0.00	Rb Sr Y Zr Nb	M.Arteni	
60	0.00	62.64	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
60	0.00	61.48	0.00	0.00	0.00	0.59	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
61	0.00	30.50	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
61	0.00	41.75	0.00	0.00	0.00	0.47	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
62	0.00	72.76	0.00	0.00	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
62	0.00	56.09	0.00	0.00	0.00	0.65	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
63	0.02	0.01	0.00	0.00	47.03	40.59	0.00	0.00	Fe Sr Y Zr	M.Arteni	P.Arteni
63	0.00	0.05	0.00	0.00	20.78	18.05	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
64	0.00	3.38	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
64	0.00	8.82	0.00	0.00	0.00	0.39	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
65	0.00	39.00	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
65	0.00	32.94	0.00	0.00	0.00	0.61	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
66	12.95	0.00	0.00	0.00	11.30	8.49	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
66	6.91	0.01	0.00	0.00	0.00	2.73	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
67	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	P.Arteni	none
67	0.00	0.01	0.00	0.00	0.00	0.62	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
68	0.01	0.01	0.00	0.00	85.52	73.08	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
68	0.00	0.05	0.00	0.00	78.79	86.66	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
69	0.00	31.57	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
69	0.00	45.83	0.00	0.00	0.00	0.54	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
70	0.01	0.01	0.00	0.00	74.12	78.66	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
70	0.00	0.05	0.00	0.00	62.13	32.47	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
71	0.01	0.01	0.00	0.00	51.20	26.73	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
71	0.00	0.06	0.00	0.00	69.35	47.55	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
72	26.40	0.00	0.00	0.00	11.21	15.73	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
72	3.33	0.01	0.00	0.00	0.00	1.82	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
73	0.02	0.01	0.00	0.00	52.84	38.53	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
73	0.00	0.05	0.00	0.00	70.12	47.96	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
74	31.96	0.00	0.00	0.00	0.03	4.78	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
74	84.77	0.01	0.00	0.00	0.00	3.48	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
75	0.00	19.26	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
75	0.00	32.00	0.00	0.00	0.00	0.48	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
76	0.00	0.14	0.00	45.12	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Hatis-2	Hatis-2

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
76	0.00	0.36	0.00	33.42	2.51	12.70	0.00	0.65	Rb Sr Y Zr Nb	Hatis-2	
77	0.00	6.83	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
77	0.00	4.58	0.00	0.00	0.00	0.58	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
78	0.01	0.00	0.00	0.00	0.18	1.37	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
78	0.00	0.03	0.00	0.00	0.00	0.93	0.06	0.00	Rb Sr Y Zr Nb	P.Arteni	
79	0.00	45.16	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
79	0.00	35.85	0.00	0.00	0.00	0.57	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
80	19.39	0.00	0.00	0.00	3.25	5.46	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
80	81.14	0.01	0.00	0.00	0.00	4.14	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
81	0.01	0.01	0.00	0.00	56.24	47.91	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
81	0.00	0.06	0.00	0.00	75.65	87.92	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
82	0.60	0.00	0.00	0.00	8.35	21.33	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
82	0.01	0.02	0.00	0.00	53.75	52.60	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
83	0.00	0.01	0.00	0.00	35.80	42.71	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
83	0.00	0.04	0.00	0.00	11.68	9.03	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
84	0.01	0.01	0.00	0.00	8.58	7.13	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
84	0.00	0.05	0.00	0.00	51.57	81.33	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
85	0.00	0.01	0.00	0.00	42.54	21.27	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
85	0.00	0.06	0.00	0.00	69.95	28.45	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
86	0.00	60.92	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
86	0.00	81.60	0.00	0.00	0.00	0.57	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
87	2.10	0.00	0.00	0.00	3.16	3.75	0.00	0.00	Fe Sr Y Zr	P.Arteni	Geghasar
87	2.04	0.01	0.00	0.00	0.00	1.74	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
88	0.00	70.30	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
88	0.00	82.59	0.00	0.00	0.00	0.56	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
89	0.03	0.00	0.00	0.00	28.09	82.76	0.00	0.00	Fe Sr Y Zr	P.Arteni	P.Arteni
89	0.00	0.04	0.00	0.00	58.69	53.18	0.01	0.00	Rb Sr Y Zr Nb	M.Arteni	
90	0.00	0.00	0.00	0.00	0.00	0.24	18.87	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
90	0.00	0.04	0.00	0.00	0.00	0.96	18.12	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
91	72.79	0.00	0.00	0.00	0.24	15.90	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
91	67.34	0.01	0.00	0.00	0.00	3.20	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
92	2.04	0.00	0.00	0.00	19.68	11.55	0.00	0.00	Fe Sr Y Zr	M.Arteni	Geghasar
92	2.72	0.01	0.00	0.00	0.00	1.77	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
93	0.00	8.02	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
93	0.00	8.48	0.00	0.00	0.00	0.55	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
94	0.00	7.22	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
94	0.00	14.57	0.00	0.00	0.00	0.45	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
95	0.01	0.01	0.00	0.00	71.06	74.67	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
95	0.00	0.06	0.00	0.00	81.57	49.91	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
96	45.91	0.00	0.00	0.00	0.07	12.93	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
96	85.40	0.01	0.00	0.00	0.00	5.11	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
97	0.00	0.01	0.00	0.00	26.46	22.55	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
97	0.00	0.05	0.00	0.00	79.74	34.33	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
98	0.01	0.00	0.00	0.00	0.02	0.73	0.02	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
98	0.00	0.03	0.00	0.00	0.00	0.63	0.86	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
99	93.01	0.00	0.00	0.00	3.57	13.78	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
99	75.66	0.01	0.00	0.00	0.00	5.40	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
100	28.17	0.00	0.00	0.00	0.04	4.07	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
100	39.10	0.01	0.00	0.00	0.00	6.99	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
101	0.01	0.01	0.00	0.00	48.90	51.69	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
101	0.00	0.05	0.00	0.00	43.72	32.04	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
102	0.00	0.01	0.00	0.00	3.17	3.28	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
102	0.00	0.06	0.00	0.00	29.93	17.09	0.01	0.00	Rb Sr Y Zr Nb	M.Arteni	
103	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
103	0.00	0.01	0.00	0.00	0.00	0.23	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
104	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
104	0.00	0.22	0.00	0.00	0.00	0.32	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
105	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
105	0.00	0.17	0.00	0.00	0.00	0.34	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
106	0.00	85.48	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
106	0.00	45.23	0.00	0.00	0.00	0.68	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
107	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	none
107	0.00	0.19	0.00	0.00	0.00	0.38	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
108	0.00	0.01	0.00	0.00	1.84	3.12	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
108	0.00	0.06	0.00	0.00	31.17	11.12	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
109	0.00	0.01	0.00	0.00	0.07	1.15	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
109	0.00	0.06	0.00	0.00	9.33	7.90	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
110	65.42	0.00	0.00	0.00	2.66	40.51	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
110	71.45	0.01	0.00	0.00	0.00	3.93	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
111	94.88	0.00	0.00	0.00	4.11	18.31	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
111	31.76	0.01	0.00	0.00	0.00	3.22	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
112	68.78	0.00	0.00	0.00	1.00	26.93	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
112	76.74	0.01	0.00	0.00	0.00	3.40	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
113	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
113	0.00	0.01	0.00	0.00	0.00	0.57	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
114	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
114	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
115	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
115	0.00	0.02	0.00	0.00	0.00	0.28	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
116	0.01	0.01	0.00	0.00	40.53	45.66	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
116	0.00	0.06	0.00	0.00	58.71	58.80	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
117	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
117	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
118	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
118	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
119	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
119	0.00	0.21	0.00	0.00	0.00	0.31	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
120	0.00	0.00	0.00	0.00	0.09	1.48	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
120	0.00	0.04	0.00	0.00	0.00	1.01	0.06	0.00	Rb Sr Y Zr Nb	P.Arteni	
121	0.01	0.01	0.00	0.00	78.34	58.36	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
121	0.00	0.05	0.00	0.00	85.10	53.84	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
122	0.00	0.01	0.00	0.00	0.00	0.12	10.13	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
122	0.00	0.05	0.00	0.00	0.00	0.73	4.46	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
123	0.01	0.00	0.00	0.00	0.11	1.08	0.01	0.00	Fe Sr Y Zr	P.Arteni	None
123	0.00	0.03	0.00	0.00	0.00	0.87	1.30	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
124	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
124	0.00	0.01	0.00	0.00	0.00	0.25	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
125	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
125	0.00	0.22	0.00	0.00	0.00	0.34	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
126	0.01	0.00	0.00	0.00	0.04	1.05	0.01	0.00	Fe Sr Y Zr	P.Arteni	None
126	0.00	0.03	0.00	0.00	0.00	0.65	0.06	0.00	Rb Sr Y Zr Nb	P.Arteni	
127	0.00	68.34	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
127	0.00	69.73	0.00	0.00	0.00	0.68	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
128	0.00	0.06	44.07	1.13	0.00	0.43	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
128	0.00	0.74	65.29	5.27	20.46	25.84	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
129	0.01	0.01	0.00	0.00	62.29	41.51	0.00	0.00	Fe Sr Y Zr	M.Arteni	M.Arteni
129	0.00	0.05	0.00	0.00	77.99	61.05	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
130	0.00	0.00	0.00	0.00	0.02	0.73	0.06	0.00	Fe Sr Y Zr	P.Arteni	None
130	0.00	0.03	0.00	0.00	0.00	1.04	1.05	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
131	0.00	0.00	0.00	0.00	0.01	0.31	28.70	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
131	0.00	0.05	0.00	0.00	0.00	0.57	37.56	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
132	0.00	0.01	0.00	0.00	17.33	32.35	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
132	0.00	0.06	0.00	0.00	77.48	27.44	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
133	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
133	0.02	0.01	0.00	0.00	0.00	0.90	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
134	0.00	0.09	0.00	73.75	0.00	0.04	0.00	0.00	Fe Sr Y Zr	Hatis-2	Hatis-2
134	0.00	0.42	0.00	72.25	0.83	12.28	0.00	0.03	Rb Sr Y Zr Nb	Hatis-2	
135	0.00	0.04	0.00	0.00	0.00	0.51	0.00	0.05	Fe Sr Y Zr	P.Arteni	None
135	0.00	0.50	0.00	7.71	0.01	4.18	0.00	0.00	Rb Sr Y Zr Nb	Hatis-2	
136	0.00	0.11	0.00	37.62	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Hatis-2	Hatis-2
136	0.00	0.39	0.00	36.95	3.44	15.21	0.00	0.56	Rb Sr Y Zr Nb	Hatis-2	
137	0.00	72.55	0.00	0.00	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
137	0.00	88.20	0.00	0.00	0.00	0.69	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
138	0.00	0.08	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
138	0.00	0.48	0.00	0.00	0.00	2.92	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
139	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
139	0.00	0.01	0.00	0.00	0.00	0.20	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
140	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
140	0.00	0.21	0.00	0.00	0.00	0.24	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
141	0.00	0.12	0.00	79.86	0.00	0.04	0.00	0.00	Fe Sr Y Zr	Hatis-2	Hatis-2
141	0.00	0.47	0.00	92.62	3.15	17.87	0.00	0.04	Rb Sr Y Zr Nb	Hatis-2	
142	0.00	46.24	0.00	0.00	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
142	0.00	42.88	0.00	0.00	0.00	0.71	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
143	0.00	25.99	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
143	0.00	36.83	0.00	0.00	0.00	0.57	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
144	0.00	52.61	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
144	0.00	51.11	0.00	0.00	0.00	0.50	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
145	0.00	24.50	0.00	0.00	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
145	0.00	18.34	0.00	0.00	0.00	0.76	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
146	0.00	21.69	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
146	0.00	20.44	0.00	0.00	0.00	0.59	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
147	0.00	12.32	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
147	0.00	24.05	0.00	0.00	0.00	0.45	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
148	0.00	1.40	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
148	0.00	5.35	0.00	0.00	0.00	0.34	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
149	0.00	1.90	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
149	0.00	6.24	0.00	0.00	0.00	0.36	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
150	0.01	0.01	0.00	0.00	36.38	19.59	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
150	0.00	0.05	0.00	0.00	50.79	27.66	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
151	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
151	0.00	0.05	0.00	0.00	0.00	0.61	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
152	32.19	0.00	0.00	0.00	4.85	8.30	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
152	0.00	0.01	0.00	0.00	0.00	2.14	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
153	0.00	57.52	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
153	0.00	40.66	0.00	0.00	0.00	0.62	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
154	0.00	94.76	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
154	0.00	97.62	0.00	0.00	0.00	0.67	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
155	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
155	0.00	0.01	0.00	0.00	0.00	0.18	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
156	0.00	36.29	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
156	0.00	40.85	0.00	0.00	0.00	0.57	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
157	0.01	0.00	0.00	0.00	3.87	2.45	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
157	0.00	0.03	0.00	0.00	7.72	10.78	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
158	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
158	0.00	0.01	0.00	0.00	0.00	0.50	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
159	0.00	0.01	0.00	0.00	0.00	0.16	71.12	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
159	0.00	0.06	0.00	0.00	0.00	0.84	69.10	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
160	0.02	0.01	0.00	0.00	38.77	42.55	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
160	0.00	0.05	0.00	0.00	62.51	54.87	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
161	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Pasinler
161	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
162	0.00	0.01	0.00	0.00	23.42	33.30	0.00	0.00	Fe Sr Y Zr	P.Arteni	P.Arteni
162	0.00	0.06	0.00	0.00	18.30	55.87	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
163	0.00	0.01	0.00	0.00	3.62	4.66	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
163	0.00	0.06	0.00	0.00	17.90	9.11	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
164	0.00	0.01	0.00	0.00	0.07	1.51	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
164	0.00	0.06	0.00	0.00	1.43	5.62	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
165	0.00	0.01	0.00	0.00	5.94	6.77	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
165	0.00	0.06	0.00	0.00	38.85	19.72	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
166	0.00	0.08	0.00	0.00	0.00	0.40	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
166	0.00	0.52	0.00	0.00	0.00	6.66	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
167	0.00	3.25	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
167	0.00	5.63	0.00	0.00	0.00	0.47	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
168	0.00	18.64	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
168	0.00	25.64	0.00	0.00	0.00	0.51	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
169	0.00	0.01	0.00	0.00	0.00	0.07	1.43	0.00	Fe Sr Y Zr	Sarikamis-2	None
169	0.00	0.06	0.00	0.00	0.00	0.87	5.13	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
170	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
170	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
171	0.00	70.54	0.00	0.00	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
171	0.00	65.63	0.00	0.00	0.00	0.70	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
172	0.01	0.01	0.00	0.00	48.92	23.03	0.00	0.00	Fe Sr Y Zr	M.Arteni	M.Arteni
172	0.00	0.05	0.00	0.00	62.19	47.93	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
173	0.01	0.01	0.00	0.00	83.22	69.94	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
173	0.00	0.05	0.00	0.00	64.73	33.28	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
174	0.01	0.01	0.00	0.00	56.52	41.54	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
174	0.00	0.05	0.00	0.00	68.20	75.98	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
175	0.01	0.01	0.00	0.00	52.23	38.26	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
175	0.00	0.06	0.00	0.00	42.39	63.66	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
176	0.02	0.01	0.00	0.00	5.30	13.41	0.00	0.00	Fe Sr Y Zr	P.Arteni	P.Arteni
176	0.00	0.06	0.00	0.00	44.74	33.63	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
177	0.01	0.01	0.00	0.00	68.56	46.56	0.00	0.00	Fe Sr Y Zr	M.Arteni	M.Arteni
177	0.00	0.06	0.00	0.00	79.43	31.99	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
178	0.00	0.01	0.00	0.00	9.11	7.66	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
178	0.00	0.05	0.00	0.00	45.11	31.40	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
179	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
179	0.00	0.19	0.00	0.00	0.00	0.34	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
180	0.00	0.01	0.00	0.00	23.58	11.01	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
180	0.00	0.05	0.00	0.00	0.00	42.16	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
181	1.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Geghasar
181	0.53	0.01	0.00	0.00	0.00	0.00	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
182	1.43	0.00	0.00	0.00	14.87	8.21	0.00	0.00	Fe Sr Y Zr	M.Arteni	Geghasar
182	0.81	0.01	0.00	0.00	0.00	1.44	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
183	0.00	0.01	0.00	0.00	3.54	3.88	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
183	0.00	0.06	0.00	0.00	27.46	12.21	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
184	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
184	0.00	0.23	0.00	0.00	0.00	0.35	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
185	0.00	0.04	0.00	0.00	0.00	0.06	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
185	0.00	0.37	0.00	0.00	0.00	0.95	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
186	0.00	0.03	0.00	0.00	0.00	0.06	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
186	0.00	0.26	0.00	0.00	0.00	2.08	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
187	0.00	38.09	0.00	0.00	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
187	0.00	75.61	0.00	0.00	0.00	0.56	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
188	0.00	10.24	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
188	0.00	16.86	0.00	0.00	0.00	0.47	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
189	12.09	0.00	0.00	0.00	39.05	41.12	0.00	0.00	Fe Sr Y Zr	P.Arteni	Geghasar
189	20.71	0.01	0.00	0.00	0.00	3.10	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
190	0.00	0.01	0.00	0.00	63.17	70.64	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
190	0.00	0.05	0.00	0.00	58.50	83.06	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
191	28.73	0.00	0.00	0.00	0.03	8.54	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
191	34.91	0.01	0.00	0.00	0.00	3.56	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
192	0.00	0.05	2.20	9.76	0.00	0.15	0.00	0.00	Fe Sr Y Zr	Hatis-2	Hatis-2
192	0.00	0.80	11.45	22.93	3.86	15.56	0.00	0.00	Rb Sr Y Zr Nb	Hatis-2	
193	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
193	0.00	0.01	0.00	0.00	0.00	0.60	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
194	0.13	0.00	0.00	0.00	76.54	95.23	0.00	0.00	Fe Sr Y Zr	P.Arteni	P.Arteni
194	0.00	0.02	0.00	0.00	85.89	95.02	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
195	0.00	16.19	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
195	0.00	30.87	0.00	0.00	0.00	0.49	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
196	0.01	0.00	0.00	0.00	5.52	7.81	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
196	0.00	0.04	0.00	0.00	24.68	14.28	0.01	0.00	Rb Sr Y Zr Nb	M.Arteni	
197	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
197	0.00	0.01	0.00	0.00	0.00	0.22	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
198	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
198	0.00	0.01	0.00	0.00	0.00	0.50	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
199	40.10	0.00	0.00	0.00	0.01	2.73	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
199	27.13	0.01	0.00	0.00	0.00	4.30	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
200	0.00	2.22	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
200	0.00	5.42	0.00	0.00	0.00	0.40	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
201	0.00	0.05	63.93	1.35	0.00	0.48	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
201	0.00	0.60	41.43	2.05	6.39	12.69	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
202	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Pasinler
202	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
203	0.01	0.01	0.00	0.00	81.38	82.18	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
203	0.00	0.05	0.00	0.00	91.70	60.71	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
204	0.01	0.01	0.00	0.00	35.22	14.52	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
204	0.00	0.05	0.00	0.00	34.55	42.79	0.01	0.00	Rb Sr Y Zr Nb	P.Arteni	
205	0.00	0.01	0.00	0.00	0.34	2.24	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
205	0.00	0.08	0.00	0.00	35.40	11.34	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
206	0.00	0.01	0.00	0.00	9.02	15.87	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
206	0.00	0.05	0.00	0.00	54.31	19.27	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
207	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
207	0.00	0.01	0.00	0.00	0.00	0.28	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
208	0.01	0.01	0.00	0.00	30.06	52.44	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
208	0.00	0.06	0.00	0.00	36.95	39.39	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
209	0.15	0.00	0.00	0.00	92.13	38.70	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
209	0.00	0.02	0.00	0.00	70.23	52.81	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
210	0.00	0.01	0.00	0.00	55.64	32.06	0.00	0.00	Fe Sr Y Zr	M.Arteni	M.Arteni
210	0.00	0.06	0.00	0.00	68.01	21.61	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
211	0.01	0.01	0.00	0.00	57.31	41.56	0.00	0.00	Fe Sr Y Zr	M.Arteni	M.Arteni
211	0.00	0.05	0.00	0.00	63.79	31.38	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
212	0.00	0.01	0.00	0.00	51.91	30.27	0.00	0.00	Fe Sr Y Zr	M.Arteni	M.Arteni
212	0.00	0.07	0.00	0.00	30.94	36.45	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
213	0.03	0.01	0.00	0.00	7.94	12.67	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
213	0.00	0.05	0.00	0.00	41.33	32.93	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
214	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
214	0.00	0.19	0.00	0.00	0.00	0.32	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
215	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
215	0.00	0.20	0.00	0.00	0.00	0.31	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
216	0.00	0.08	0.00	0.00	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
216	0.00	0.50	0.00	0.00	0.00	2.56	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
217	0.00	0.00	0.00	0.00	0.01	0.62	0.02	0.00	Fe Sr Y Zr	P.Arteni	None
217	0.00	0.03	0.00	0.00	0.00	0.73	0.73	0.00	Rb Sr Y Zr Nb	P.Arteni	
218	0.01	0.01	0.00	0.00	43.65	41.72	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
218	0.00	0.05	0.00	0.00	84.26	40.88	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
219	0.01	0.01	0.00	0.00	21.21	17.41	0.00	0.00	Fe Sr Y Zr	M.Arteni	P.Arteni
219	0.00	0.05	0.00	0.00	49.06	65.42	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
220	20.25	0.00	0.00	0.00	0.11	4.84	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
220	15.25	0.01	0.00	0.00	0.00	3.12	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
221	32.60	0.00	0.00	0.00	0.57	6.44	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
221	28.06	0.01	0.00	0.00	0.00	3.07	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
222	0.00	0.00	0.00	0.00	0.00	0.28	27.71	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
222	0.00	0.04	0.00	0.00	0.00	0.99	40.70	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
223	0.01	0.00	0.00	0.00	0.38	1.58	0.02	0.00	Fe Sr Y Zr	P.Arteni	None
223	0.00	0.04	0.00	0.00	0.00	1.57	1.15	0.00	Rb Sr Y Zr Nb	P.Arteni	
224	54.95	0.00	0.00	0.00	3.89	4.55	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
224	48.10	0.01	0.00	0.00	0.00	4.55	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
225	0.00	0.00	0.00	0.00	0.07	0.69	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
225	0.01	0.03	0.00	0.00	0.53	3.43	0.01	0.00	Rb Sr Y Zr Nb	P.Arteni	
226	7.35	0.00	0.00	0.00	9.73	7.66	0.00	0.00	Fe Sr Y Zr	M.Arteni	Geghasar
226	4.18	0.01	0.00	0.00	0.00	2.10	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
227	62.45	0.00	0.00	0.00	2.35	21.02	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
227	46.18	0.01	0.00	0.00	0.00	3.68	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
228	42.98	0.00	0.00	0.00	5.04	35.45	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
228	55.99	0.01	0.00	0.00	0.00	3.59	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
229	6.55	0.00	0.00	0.00	13.13	11.76	0.00	0.00	Fe Sr Y Zr	M.Arteni	Geghasar

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
229	6.48	0.01	0.00	0.00	0.00	2.07	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
230	0.00	16.83	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
230	0.00	30.53	0.00	0.00	0.00	0.49	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
231	0.00	0.05	0.00	0.00	0.00	0.23	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
231	0.00	0.21	0.00	0.00	0.87	2.83	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
232	0.01	0.01	0.00	0.00	1.57	23.73	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
232	0.00	0.08	0.00	0.00	43.60	57.34	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
233	0.01	0.01	0.00	0.00	77.59	83.82	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
233	0.00	0.05	0.00	0.00	81.86	56.46	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
234	0.00	0.01	0.00	0.00	0.00	0.08	4.51	0.00	Fe Sr Y Zr	Sarikamis-2	None
234	0.00	0.06	0.00	0.00	0.00	1.06	1.65	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
235	48.99	0.00	0.00	0.00	1.53	42.27	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
235	21.17	0.01	0.00	0.00	0.00	3.19	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
236	24.16	0.00	0.00	0.00	0.73	11.29	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
236	64.89	0.01	0.00	0.00	0.00	4.58	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
237	0.00	81.77	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
237	0.00	97.50	0.00	0.00	0.00	0.61	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
238	0.00	0.00	0.00	0.00	0.00	0.23	4.49	0.00	Fe Sr Y Zr	Sarikamis-2	None
238	0.00	0.04	0.00	0.00	0.00	1.08	11.79	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
239	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
239	0.00	0.01	0.00	0.00	0.00	0.27	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
240	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	Meydan Dag
240	0.00	0.03	0.00	0.00	0.00	0.19	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
241	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
241	0.00	0.01	0.00	0.00	0.00	0.25	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
242	0.05	0.00	0.00	0.00	0.02	0.54	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
242	0.08	0.01	0.00	0.00	0.00	1.15	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
243	0.00	0.01	0.00	0.00	12.97	18.48	0.00	0.00	Fe Sr Y Zr	P.Arteni	M.Arteni
243	0.00	0.06	0.00	0.00	48.65	44.01	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
244	0.00	73.88	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
244	0.00	55.28	0.00	0.00	0.00	0.54	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
245	0.01	0.01	0.00	0.00	57.74	61.75	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
245	0.00	0.06	0.00	0.00	69.06	65.53	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
246	0.00	0.02	0.00	0.00	0.35	1.85	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
246	0.00	0.15	0.00	0.00	28.21	30.91	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
247	93.08	0.00	0.00	0.00	0.65	10.12	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
247	99.07	0.01	0.00	0.00	0.00	4.31	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
248	0.00	70.72	0.00	0.00	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
248	0.00	21.64	0.00	0.00	0.00	0.74	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
249	0.01	0.01	0.00	0.00	76.86	60.88	0.00	0.00	Fe Sr Y Zr	M.Arteni	M.Arteni
249	0.00	0.06	0.00	0.00	89.13	88.10	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
250	0.00	0.00	0.00	0.00	0.00	0.25	27.01	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
250	0.00	0.05	0.00	0.00	0.00	0.95	29.31	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
251	0.00	0.01	0.00	0.00	66.11	39.15	0.00	0.00	Fe Sr Y Zr	M.Arteni	M.Arteni
251	0.00	0.07	0.00	0.00	55.78	47.95	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
252	0.00	0.01	0.00	0.00	0.00	0.07	1.28	0.00	Fe Sr Y Zr	Sarikamis-2	None
252	0.00	0.06	0.00	0.00	0.00	1.19	4.41	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
253	1.84	0.00	0.00	0.00	8.89	6.26	0.00	0.00	Fe Sr Y Zr	M.Arteni	Geghasar
253	0.62	0.01	0.00	0.00	0.00	1.44	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
254	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	Meydan Dag
254	0.00	0.06	0.00	0.00	0.00	0.17	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
255	0.02	0.01	0.00	0.00	21.24	16.61	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
255	0.00	0.05	0.00	0.00	21.07	19.08	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
256	0.01	0.01	0.00	0.00	54.35	38.18	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
256	0.00	0.06	0.00	0.00	53.45	36.80	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
257	0.00	0.01	0.00	0.00	0.00	0.28	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
257	0.01	0.07	0.00	0.00	0.03	2.27	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
258	33.73	0.00	0.00	0.00	11.47	10.43	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
258	13.67	0.01	0.00	0.00	0.00	2.24	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
259	87.33	0.00	0.00	0.00	4.34	19.44	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
259	31.97	0.01	0.00	0.00	0.00	5.71	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
260	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
260	0.00	0.17	0.00	0.00	0.00	0.35	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
261	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	Bingöl B
261	0.00	0.21	0.00	0.00	0.00	0.22	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
262	0.01	0.01	0.00	0.00	81.31	43.30	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
262	0.00	0.05	0.00	0.00	80.52	66.79	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
263	0.00	68.34	0.00	0.00	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
263	0.00	90.92	0.00	0.00	0.00	0.61	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
264	0.00	19.89	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
264	0.00	13.99	0.00	0.00	0.00	0.60	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
265	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
265	0.00	0.02	0.00	0.00	0.00	0.29	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
266	0.00	34.33	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
266	0.00	25.06	0.00	0.00	0.00	0.65	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
267	0.00	95.92	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
267	0.00	91.20	0.00	0.00	0.00	0.64	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
268	0.03	0.01	0.00	0.00	1.49	8.09	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
268	0.00	0.05	0.00	0.00	42.74	24.68	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
269	0.00	0.01	0.00	0.00	0.00	0.14	27.16	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
269	0.00	0.05	0.00	0.00	0.00	0.76	31.47	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
270	0.00	0.00	0.00	0.00	0.00	0.17	36.78	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
270	0.00	0.05	0.00	0.00	0.00	0.91	39.89	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
271	0.01	0.00	0.00	0.00	0.01	0.86	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
271	0.00	0.03	0.00	0.00	0.00	0.89	0.05	0.00	Rb Sr Y Zr Nb	P.Arteni	
272	0.00	48.30	0.00	0.00	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
272	0.00	56.70	0.00	0.00	0.00	0.63	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
273	45.09	0.00	0.00	0.00	2.87	48.76	0.00	0.00	Fe Sr Y Zr	P.Arteni	Geghasar
273	54.55	0.01	0.00	0.00	0.00	3.53	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
274	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
274	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
275	0.00	0.11	0.00	46.94	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Hatis-2	Hatis-2
275	0.00	0.34	0.00	72.40	1.14	14.30	0.00	1.70	Rb Sr Y Zr Nb	Hatis-2	
276	0.00	10.17	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
276	0.00	8.95	0.00	0.00	0.00	0.54	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
277	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
277	0.00	0.03	0.00	0.00	0.00	0.67	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
278	0.00	0.01	0.00	0.00	48.14	18.46	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
278	0.00	0.06	0.00	0.00	27.79	13.61	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
279	0.00	0.01	0.00	0.00	49.96	20.94	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
279	0.00	0.07	0.00	0.00	56.13	42.76	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
280	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
280	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
281	0.00	48.28	0.00	0.00	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
281	0.00	45.91	0.00	0.00	0.00	0.71	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
282	4.14	0.00	0.00	0.00	7.81	9.92	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
282	0.47	0.01	0.00	0.00	0.00	1.39	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
283	0.00	0.01	0.00	0.00	0.64	2.75	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
283	0.00	0.06	0.00	0.00	24.36	9.33	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
284	0.00	43.25	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
284	0.00	57.76	0.00	0.00	0.00	0.58	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
285	0.00	0.00	0.00	0.00	0.02	0.69	0.07	0.00	Fe Sr Y Zr	P.Arteni	None
285	0.00	0.03	0.00	0.00	0.00	0.72	0.63	0.00	Rb Sr Y Zr Nb	P.Arteni	
286	0.00	0.02	1.32	0.36	0.01	0.31	0.00	0.00	Fe Sr Y Zr	Hatis-1	None
286	0.00	0.34	3.17	0.52	0.04	2.61	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
287	0.00	0.06	10.69	0.75	0.00	0.40	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
287	0.00	0.71	16.95	2.08	1.91	12.40	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
288	0.00	0.00	0.00	0.00	0.01	0.48	0.27	0.00	Fe Sr Y Zr	P.Arteni	None
288	0.00	0.03	0.00	0.00	0.00	0.77	1.85	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
289	0.00	0.01	0.00	0.00	0.00	0.17	84.92	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
289	0.00	0.07	0.00	0.00	0.00	0.52	72.57	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
290	0.70	0.00	0.00	0.00	6.91	71.35	0.00	0.00	Fe Sr Y Zr	P.Arteni	P.Arteni
290	0.00	0.02	0.00	0.00	36.12	56.26	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
291	0.00	0.01	0.00	0.00	0.35	3.28	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
291	0.00	0.04	0.00	0.00	9.38	7.87	0.01	0.00	Rb Sr Y Zr Nb	M.Arteni	
292	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
292	0.00	0.01	0.00	0.00	0.00	0.24	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
293	0.00	0.01	0.00	0.00	1.36	2.07	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
293	0.00	0.06	0.00	0.00	1.24	5.49	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
294	0.00	0.01	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
294	0.00	0.06	0.00	0.00	0.00	0.71	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
295	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
295	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
296	0.01	0.01	0.00	0.00	82.00	75.28	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
296	0.00	0.05	0.00	0.00	84.13	91.46	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
297	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
297	0.00	0.01	0.00	0.00	0.00	0.49	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
298	62.02	0.00	0.00	0.00	0.20	12.08	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
298	79.37	0.01	0.00	0.00	0.00	6.45	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
299	11.99	0.00	0.00	0.00	10.33	8.40	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
299	11.48	0.01	0.00	0.00	0.00	2.54	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
300	64.09	0.00	0.00	0.00	0.46	27.93	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
300	70.25	0.01	0.00	0.00	0.00	4.34	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
301	0.01	0.01	0.00	0.00	66.83	32.80	0.00	0.00	Fe Sr Y Zr	M.Arteni	M.Arteni
301	0.00	0.05	0.00	0.00	45.50	22.79	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
302	0.00	97.09	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
302	0.00	70.86	0.00	0.00	0.00	0.57	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
303	0.00	10.62	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
303	0.00	25.90	0.00	0.00	0.00	0.52	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
304	44.85	0.00	0.00	0.00	2.09	13.44	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
304	68.55	0.01	0.00	0.00	0.00	4.09	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
305	0.02	0.00	0.00	0.00	65.86	39.25	0.00	0.00	Fe Sr Y Zr	M.Arteni	M.Arteni
305	0.00	0.04	0.00	0.00	40.82	31.22	0.02	0.00	Rb Sr Y Zr Nb	M.Arteni	

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
306	49.11	0.00	0.00	0.00	0.08	5.29	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
306	71.38	0.01	0.00	0.00	0.00	3.51	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
307	0.00	4.63	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
307	0.00	11.00	0.00	0.00	0.00	0.42	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
308	0.00	17.24	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
308	0.00	33.21	0.00	0.00	0.00	0.50	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
309	0.00	0.04	0.00	0.00	0.00	0.05	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
309	0.00	0.31	0.00	0.00	0.00	3.60	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
310	0.01	0.01	0.00	0.00	59.89	21.43	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
310	0.00	0.05	0.00	0.00	72.91	41.80	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
311	0.01	0.01	0.00	0.00	18.73	10.43	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
311	0.00	0.04	0.00	0.00	31.77	18.11	0.01	0.00	Rb Sr Y Zr Nb	M.Arteni	
312	50.65	0.00	0.00	0.00	4.04	42.35	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
312	45.50	0.01	0.00	0.00	0.00	4.88	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
313	0.01	0.01	0.00	0.00	36.32	18.65	0.00	0.00	Fe Sr Y Zr	M.Arteni	P.Arteni
313	0.00	0.05	0.00	0.00	17.21	28.69	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
314	0.00	0.01	0.00	0.00	14.63	25.56	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
314	0.00	0.06	0.00	0.00	26.91	54.53	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
315	1.76	0.00	0.00	0.00	70.29	36.36	0.00	0.00	Fe Sr Y Zr	M.Arteni	Geghasar
315	4.78	0.01	0.00	0.00	0.00	2.26	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
316	0.00	0.01	0.00	0.00	0.00	0.07	0.54	0.00	Fe Sr Y Zr	Sarikamis-2	None
316	0.00	0.06	0.00	0.00	0.00	1.04	0.34	0.00	Rb Sr Y Zr Nb	P.Arteni	
317	0.00	0.00	0.00	0.00	0.00	0.34	5.44	0.00	Fe Sr Y Zr	Sarikamis-2	None
317	0.00	0.04	0.00	0.00	0.00	0.84	18.25	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
318	0.00	0.01	0.00	0.00	8.52	5.04	0.00	0.00	Fe Sr Y Zr	M.Arteni	None
318	0.00	0.05	0.00	0.00	2.88	11.08	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
319	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
319	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
320	0.01	0.01	0.00	0.00	58.92	50.14	0.00	0.00	Fe Sr Y Zr	M.Arteni	M.Arteni
320	0.00	0.05	0.00	0.00	80.66	28.88	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
321	0.00	0.01	0.00	0.00	0.00	0.47	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
321	0.00	0.06	0.00	0.00	0.76	2.91	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
322	0.00	0.01	0.00	0.00	0.02	0.93	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
322	0.00	0.07	0.00	0.00	1.49	4.69	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
323	0.00	0.00	0.00	0.00	0.00	0.13	51.02	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
323	0.00	0.05	0.00	0.00	0.00	0.76	38.17	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
324	0.00	0.03	0.00	0.00	0.00	0.16	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
324	0.00	0.16	0.00	0.00	1.06	4.56	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
325	0.00	0.00	0.00	0.00	0.00	0.10	1.87	0.00	Fe Sr Y Zr	Sarikamis-2	None
325	0.00	0.05	0.00	0.00	0.00	0.78	4.63	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
326	0.08	0.00	0.00	0.00	4.48	8.41	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
326	0.00	0.04	0.00	0.00	19.16	26.45	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
327	0.00	0.01	0.00	0.00	31.22	11.15	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
327	0.00	0.06	0.00	0.00	40.51	23.94	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
328	0.00	0.00	0.00	0.00	0.00	0.23	53.46	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
328	0.00	0.05	0.00	0.00	0.00	1.32	70.86	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
329	0.00	1.45	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
329	0.00	5.09	0.00	0.00	0.00	0.33	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
330	0.00	85.36	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
330	0.00	92.16	0.00	0.00	0.00	0.63	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
331	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	None

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
331	0.00	0.08	0.00	0.00	0.00	0.67	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
332	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
332	0.00	0.04	0.00	0.00	0.00	0.90	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
333	31.76	0.00	0.00	0.00	0.09	6.17	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
333	55.83	0.01	0.00	0.00	0.00	5.81	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
334	0.00	41.23	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
334	0.00	67.56	0.00	0.00	0.00	0.60	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
335	0.01	0.01	0.00	0.00	60.58	59.18	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
335	0.00	0.05	0.00	0.00	64.00	72.45	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
336	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
336	0.00	0.03	0.00	0.00	0.00	0.28	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
337	0.00	0.01	0.00	0.00	13.91	8.70	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
337	0.00	0.05	0.00	0.00	38.51	18.52	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
338	0.00	91.18	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
338	0.00	98.24	0.00	0.00	0.00	0.62	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
339	0.02	0.01	0.00	0.00	10.37	12.36	0.00	0.00	Fe Sr Y Zr	P.Arteni	P.Arteni
339	0.00	0.06	0.00	0.00	62.36	35.96	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
340	0.00	0.01	0.00	0.00	0.00	0.12	22.62	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
340	0.00	0.06	0.00	0.00	0.00	1.13	42.79	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
341	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
341	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
342	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
342	0.00	0.07	0.00	0.00	0.00	0.61	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
343	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
343	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
344	0.00	0.00	0.00	0.00	0.00	0.40	0.39	0.00	Fe Sr Y Zr	P.Arteni	None
344	0.00	0.03	0.00	0.00	0.00	0.96	3.60	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
345	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
345	0.00	0.01	0.00	0.00	0.00	0.19	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
346	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
346	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
347	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
347	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
348	0.17	0.00	0.00	0.00	9.76	22.39	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
348	0.00	0.02	0.00	0.00	86.64	93.81	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
349	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
349	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
350	5.70	0.00	0.00	0.00	2.44	6.61	0.00	0.00	Fe Sr Y Zr	P.Arteni	Geghasar
350	4.96	0.01	0.00	0.00	0.00	1.96	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
351	0.00	11.93	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
351	0.00	26.33	0.00	0.00	0.00	0.52	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
352	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
352	0.00	0.02	0.00	0.00	0.00	0.30	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
353	0.00	0.04	6.01	0.20	0.03	0.58	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
353	0.00	0.53	8.96	5.93	0.21	5.88	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
354	0.00	49.32	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
354	0.00	48.46	0.00	0.00	0.00	0.56	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
355	0.00	32.24	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
355	0.00	51.19	0.00	0.00	0.00	0.51	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
356	0.00	44.59	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
356	0.00	58.77	0.00	0.00	0.00	0.53	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
357	0.00	0.01	0.00	0.00	19.68	15.19	0.00	0.00	Fe Sr Y Zr	M.Arteni	None
357	0.00	0.05	0.00	0.00	61.57	86.99	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
358	0.01	0.01	0.00	0.00	27.15	40.40	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
358	0.00	0.06	0.00	0.00	40.73	46.40	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
359	0.00	9.46	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
359	0.00	12.82	0.00	0.00	0.00	0.54	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
360	0.00	8.77	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
360	0.00	15.13	0.00	0.00	0.00	0.54	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
361	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
361	0.00	0.01	0.00	0.00	0.00	0.38	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
362	0.00	0.01	0.00	0.00	0.00	0.08	1.31	0.00	Fe Sr Y Zr	Sarikamis-2	None
362	0.00	0.07	0.00	0.00	0.00	1.08	2.97	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
363	35.59	0.00	0.00	0.00	0.03	3.80	0.00	0.00	Fe Sr Y Zr	Geghasar	None
363	98.99	0.01	0.00	0.00	0.00	4.43	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
364	0.00	98.72	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
364	0.00	46.75	0.00	0.00	0.00	0.54	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
365	0.00	0.06	1.18	10.62	0.00	0.20	0.00	0.00	Fe Sr Y Zr	Hatis-2	None
365	0.00	0.72	0.37	0.14	0.04	4.73	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
366	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
366	0.00	0.01	0.00	0.00	0.00	0.52	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
367	0.00	3.68	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
367	0.00	6.76	0.00	0.00	0.00	0.45	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
368	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
368	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
369	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
369	0.00	0.22	0.00	0.00	0.00	0.41	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
370	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Bingöl A
370	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
371	0.00	83.36	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
371	0.00	90.49	0.00	0.00	0.00	0.61	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
372	0.00	2.49	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
372	0.00	7.97	0.00	0.00	0.00	0.36	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
373	0.00	13.60	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
373	0.00	13.92	0.00	0.00	0.00	0.51	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
374	0.00	97.63	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
374	0.00	86.71	0.00	0.00	0.00	0.65	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
375	0.00	0.07	0.53	15.17	0.00	0.14	0.00	0.00	Fe Sr Y Zr	Hatis-2	None
375	0.00	0.86	0.69	37.61	13.40	19.37	0.00	0.00	Rb Sr Y Zr Nb	Hatis-2	
376	0.00	0.12	0.00	58.16	0.00	0.04	0.00	0.00	Fe Sr Y Zr	Hatis-2	Hatis-2
376	0.00	0.39	0.00	64.10	0.94	13.67	0.00	1.32	Rb Sr Y Zr Nb	Hatis-2	
377	44.61	0.00	0.00	0.00	2.22	19.96	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
377	72.84	0.01	0.00	0.00	0.00	4.11	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
378	28.00	0.00	0.00	0.00	4.14	14.18	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
378	16.39	0.01	0.00	0.00	0.00	2.05	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
379	0.01	0.01	0.00	0.00	65.17	58.45	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
379	0.00	0.05	0.00	0.00	85.04	60.51	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
380	89.51	0.00	0.00	0.00	3.33	13.21	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
380	60.86	0.01	0.00	0.00	0.00	5.65	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
381	0.00	0.01	0.00	0.00	61.09	36.60	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni?
381	0.00	0.06	0.00	0.00	12.34	10.08	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
382	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
382	0.00	0.01	0.00	0.00	0.00	0.19	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
383	0.02	0.01	0.00	0.00	40.54	39.55	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
383	0.00	0.05	0.00	0.00	36.97	33.12	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
384	0.01	0.00	0.00	0.00	0.24	1.43	0.01	0.00	Fe Sr Y Zr	P.Arteni	None
384	0.00	0.04	0.00	0.00	0.00	0.77	0.07	0.00	Rb Sr Y Zr Nb	P.Arteni	
385	0.00	53.16	0.00	0.00	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
385	0.00	59.00	0.00	0.00	0.00	0.69	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
386	0.01	0.01	0.00	0.00	88.64	83.07	0.00	0.00	Fe Sr Y Zr	M.Arteni	P.Arteni
386	0.00	0.05	0.00	0.00	67.58	83.53	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
387	82.22	0.00	0.00	0.00	3.46	11.39	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
387	14.36	0.01	0.00	0.00	0.00	4.39	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
388	0.00	67.04	0.00	0.00	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
388	0.00	51.00	0.00	0.00	0.00	0.70	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
389	0.01	0.01	0.00	0.00	64.22	37.34	0.00	0.00	Fe Sr Y Zr	M.Arteni	M.Arteni
389	0.00	0.05	0.00	0.00	82.42	71.19	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
390	0.08	0.01	0.00	0.00	0.03	1.61	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
390	0.00	0.05	0.00	0.00	5.41	9.19	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
391	0.00	31.36	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
391	0.00	33.61	0.00	0.00	0.00	0.55	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
392	83.53	0.00	0.00	0.00	4.38	27.90	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
392	89.21	0.01	0.00	0.00	0.00	6.26	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
393	0.00	28.59	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
393	0.00	38.84	0.00	0.00	0.00	0.47	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
394	0.00	65.35	0.00	0.00	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
394	0.00	60.59	0.00	0.00	0.00	0.73	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
395	0.01	0.01	0.00	0.00	72.11	51.85	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
395	0.00	0.05	0.00	0.00	67.15	61.84	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
396	0.00	57.26	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
396	0.00	66.04	0.00	0.00	0.00	0.69	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
397	0.00	58.93	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
397	0.00	43.27	0.00	0.00	0.00	0.61	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
398	0.62	0.00	0.00	0.00	0.77	6.11	0.00	0.00	Fe Sr Y Zr	P.Arteni	P.Arteni
398	0.00	0.02	0.00	0.00	47.79	19.31	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
399	0.00	12.61	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
399	0.00	27.66	0.00	0.00	0.00	0.44	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
400	0.00	0.06	0.00	0.00	0.00	0.13	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
400	0.00	0.14	0.00	0.10	0.01	7.25	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
401	0.00	0.13	0.00	42.09	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Hatis-2	Hatis-2
401	0.00	0.41	0.00	36.90	2.37	16.16	0.00	0.25	Rb Sr Y Zr Nb	Hatis-2	
402	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
402	0.00	0.06	0.00	0.00	0.00	0.59	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
403	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
403	0.00	0.01	0.00	0.00	0.00	0.24	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
404	69.31	0.00	0.00	0.00	0.15	5.73	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
404	48.10	0.01	0.00	0.00	0.00	3.43	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
405	0.18	0.00	0.00	0.00	5.84	12.34	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
405	0.00	0.03	0.00	0.00	32.94	39.47	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
406	55.19	0.00	0.00	0.00	5.55	7.46	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
406	86.64	0.01	0.00	0.00	0.00	6.03	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
407	0.00	13.21	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
407	0.00	7.85	0.00	0.00	0.00	0.65	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
408	15.04	0.00	0.00	0.00	12.09	19.82	0.00	0.00	Fe Sr Y Zr	P.Arteni	Geghasar
408	13.69	0.01	0.00	0.00	0.00	2.25	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
409	5.00	0.00	0.00	0.00	1.52	2.56	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
409	1.04	0.01	0.00	0.00	0.00	2.02	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
410	0.00	0.01	0.00	0.00	0.00	0.09	8.95	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
410	0.00	0.06	0.00	0.00	0.00	0.97	30.75	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
411	0.00	35.56	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
411	0.00	50.23	0.00	0.00	0.00	0.53	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
412	33.83	0.00	0.00	0.00	12.33	32.42	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
412	48.43	0.01	0.00	0.00	0.00	3.75	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
413	0.18	0.00	0.00	0.00	38.31	34.31	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
413	0.00	0.02	0.00	0.00	43.80	34.37	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
414	0.12	0.00	0.00	0.00	45.15	18.44	0.00	0.00	Fe Sr Y Zr	M.Arteni	None
414	0.02	0.02	0.00	0.00	5.94	17.27	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
415	0.00	21.81	0.00	0.00	0.00	0.04	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
415	0.00	39.65	0.00	0.00	0.00	0.93	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
416	0.00	37.66	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
416	0.00	40.36	0.00	0.00	0.00	0.54	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
417	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
417	0.00	0.04	0.00	0.00	0.00	0.14	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
418	39.76	0.00	0.00	0.00	2.43	5.41	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
418	29.22	0.01	0.00	0.00	0.00	2.61	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
419	0.14	0.00	0.00	0.00	75.20	33.24	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
419	0.00	0.02	0.00	0.00	99.67	69.15	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
420	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
420	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
421	0.00	0.00	0.00	0.00	0.00	0.12	7.43	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
421	0.00	0.05	0.00	0.00	0.00	0.69	0.85	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
422	0.00	0.06	0.64	33.68	0.00	0.16	0.00	0.00	Fe Sr Y Zr	Hatis-2	Hatis-2
422	0.00	0.75	1.68	38.41	2.29	12.26	0.00	0.00	Rb Sr Y Zr Nb	Hatis-2	
423	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
423	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
424	63.02	0.00	0.00	0.00	0.50	3.11	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
424	16.65	0.01	0.00	0.00	0.00	1.98	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
425	28.57	0.00	0.00	0.00	4.45	5.14	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
425	44.98	0.01	0.00	0.00	0.00	3.11	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
426	16.96	0.00	0.00	0.00	5.43	27.11	0.00	0.00	Fe Sr Y Zr	P.Arteni	Geghasar
426	8.48	0.01	0.00	0.00	0.00	2.00	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
427	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
427	0.00	0.02	0.00	0.00	0.00	0.21	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
428	0.00	10.60	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
428	0.00	21.21	0.00	0.00	0.00	0.59	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
429	0.00	0.04	0.00	0.00	0.00	0.07	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
429	0.00	0.33	0.00	0.00	0.00	2.55	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
430	0.00	31.00	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
430	0.00	43.89	0.00	0.00	0.00	0.60	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
431	0.00	28.54	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
431	0.00	42.84	0.00	0.00	0.00	0.65	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
432	0.00	32.76	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
432	0.00	31.94	0.00	0.00	0.00	0.57	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
433	0.00	57.78	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
433	0.00	74.48	0.00	0.00	0.00	0.63	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
434	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
434	0.00	0.04	0.00	0.00	0.00	0.77	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
435	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
435	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
436	0.00	28.72	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
436	0.00	40.17	0.00	0.00	0.00	0.48	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
437	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
437	0.00	0.19	0.00	0.00	0.00	0.42	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
438	0.00	73.32	0.00	0.00	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
438	0.00	91.09	0.00	0.00	0.00	0.64	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
439	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
439	0.00	0.01	0.00	0.00	0.00	0.56	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
440	0.00	65.49	0.00	0.00	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
440	0.00	50.81	0.00	0.00	0.00	0.71	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
441	0.00	0.01	0.00	0.00	46.67	22.46	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
441	0.00	0.06	0.00	0.00	32.47	18.84	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
442	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
442	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
443	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
443	0.00	0.02	0.00	0.00	0.00	0.52	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
444	0.12	0.00	0.00	0.00	92.85	97.81	0.00	0.00	Fe Sr Y Zr	P.Arteni	P.Arteni
444	0.01	0.02	0.00	0.00	38.88	32.52	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
445	0.00	0.01	0.00	0.00	0.01	0.77	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
445	0.00	0.06	0.00	0.00	0.24	4.59	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
446	60.40	0.00	0.00	0.00	0.70	8.63	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
446	75.07	0.01	0.00	0.00	0.00	7.97	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
447	0.00	0.04	0.65	23.60	0.00	0.16	0.00	0.00	Fe Sr Y Zr	Hatis-2	Hatis-2
447	0.00	0.62	6.03	17.51	0.76	8.05	0.00	0.00	Rb Sr Y Zr Nb	Hatis-2	
448	18.19	0.00	0.00	0.00	1.70	3.26	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
448	24.89	0.01	0.00	0.00	0.00	4.43	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
449	35.33	0.00	0.00	0.00	2.99	6.69	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
449	53.96	0.01	0.00	0.00	0.00	3.47	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
450	0.58	0.00	0.00	0.00	84.22	16.32	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
450	0.01	0.01	0.00	0.00	77.10	47.23	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
451	0.01	0.01	0.00	0.00	47.48	57.77	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
451	0.00	0.06	0.00	0.00	71.82	52.69	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
452	0.00	0.01	0.00	0.00	0.00	0.35	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
452	0.00	0.07	0.00	0.00	0.46	2.74	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
453	0.00	0.05	0.00	0.03	0.00	0.21	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
453	0.00	0.47	0.00	5.72	0.01	4.34	0.00	0.00	Rb Sr Y Zr Nb	Hatis-2	
454	0.00	0.04	1.67	0.76	0.00	0.18	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
454	0.00	0.58	19.29	2.25	1.07	8.28	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
455	61.64	0.00	0.00	0.00	0.24	2.73	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
455	56.58	0.01	0.00	0.00	0.00	2.47	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
456	4.11	0.00	0.00	0.00	57.25	30.36	0.00	0.00	Fe Sr Y Zr	M.Arteni	Geghasar
456	2.28	0.01	0.00	0.00	0.00	1.81	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
457	7.18	0.00	0.00	0.00	0.44	4.48	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
457	12.97	0.01	0.00	0.00	0.00	3.65	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
458	0.03	0.00	0.00	0.00	0.00	0.40	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
458	0.04	0.01	0.00	0.00	0.00	1.04	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
459	0.01	0.01	0.00	0.00	85.00	46.77	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
459	0.00	0.05	0.00	0.00	92.32	57.81	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
460	0.00	0.01	0.00	0.00	4.99	3.32	0.00	0.00	Fe Sr Y Zr	M.Arteni	None
460	0.00	0.06	0.00	0.00	1.19	7.79	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
461	54.64	0.00	0.00	0.00	0.04	4.04	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
461	95.57	0.01	0.00	0.00	0.00	3.30	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
462	0.33	0.00	0.00	0.00	11.27	29.20	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
462	0.00	0.02	0.00	0.00	69.57	83.53	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
463	0.02	0.00	0.00	0.00	75.12	54.53	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
463	0.00	0.03	0.00	0.00	86.79	57.59	0.01	0.00	Rb Sr Y Zr Nb	M.Arteni	
464	80.75	0.00	0.00	0.00	0.93	16.06	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
464	78.36	0.01	0.00	0.00	0.00	6.05	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
465	10.13	0.00	0.00	0.00	4.75	52.74	0.00	0.00	Fe Sr Y Zr	P.Arteni	Geghasar
465	13.73	0.01	0.00	0.00	0.00	2.25	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
466	0.00	44.12	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
466	0.00	69.84	0.00	0.00	0.00	0.70	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
467	0.00	1.69	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
467	0.00	6.54	0.00	0.00	0.00	0.38	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
468	7.03	0.00	0.00	0.00	0.00	2.74	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
468	31.67	0.01	0.00	0.00	0.00	4.58	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
469	0.00	0.09	0.00	27.42	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Hatis-2	Hatis-2
469	0.00	0.35	0.00	25.68	1.52	13.79	0.00	0.61	Rb Sr Y Zr Nb	Hatis-2	
470	0.00	25.56	0.00	0.00	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
470	0.00	18.86	0.00	0.00	0.00	0.70	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
471	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
471	0.00	0.02	0.00	0.00	0.00	0.29	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
472	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
472	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
473	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
473	0.00	0.02	0.00	0.00	0.00	0.33	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
474	81.48	0.00	0.00	0.00	1.06	8.05	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
474	93.62	0.01	0.00	0.00	0.00	5.57	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
475	0.01	0.01	0.00	0.00	52.12	44.27	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
475	0.00	0.05	0.00	0.00	66.90	61.42	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
476	0.00	86.17	0.00	0.00	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
476	0.00	76.77	0.00	0.00	0.00	0.65	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
477	0.00	69.01	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
477	0.00	91.14	0.00	0.00	0.00	0.59	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
478	11.21	0.00	0.00	0.00	0.01	3.89	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
478	45.97	0.01	0.00	0.00	0.00	6.58	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
479	0.00	4.06	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
479	0.00	7.43	0.00	0.00	0.00	0.44	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
480	0.04	0.01	0.00	0.00	3.31	25.97	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
480	0.00	0.05	0.00	0.00	8.76	29.54	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
481	0.13	0.00	0.00	0.00	9.35	21.48	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
481	0.00	0.03	0.00	0.00	25.44	36.91	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
482	0.00	0.06	0.00	0.00	0.00	0.17	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
482	0.00	0.13	0.00	0.03	0.00	5.14	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
483	0.01	0.01	0.00	0.00	75.71	55.51	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
483	0.00	0.06	0.00	0.00	72.73	71.13	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
484	0.02	0.00	0.00	0.00	32.36	18.50	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
484	0.00	0.03	0.00	0.00	59.14	58.79	0.01	0.00	Rb Sr Y Zr Nb	M.Arteni	
485	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
485	0.00	0.01	0.00	0.00	0.00	0.41	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
486	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Erzurum
486	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
487	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
487	0.00	0.01	0.00	0.00	0.00	0.23	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
488	0.00	0.05	4.15	10.36	0.00	0.23	0.00	0.00	Fe Sr Y Zr	Hatis-2	Hatis-2
488	0.00	0.74	4.15	40.95	6.33	14.41	0.00	0.00	Rb Sr Y Zr Nb	Hatis-2	
489	0.00	0.07	22.08	5.45	0.00	0.20	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-2
489	0.00	0.78	3.73	0.16	1.85	5.35	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
490	0.00	1.35	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
490	0.00	2.82	0.00	0.00	0.00	0.41	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
491	0.01	0.01	0.00	0.00	66.67	25.97	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
491	0.00	0.05	0.00	0.00	77.35	50.55	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
492	0.00	0.01	0.00	0.00	42.19	21.39	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
492	0.00	0.11	0.00	0.00	17.75	45.28	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
493	0.00	0.06	0.30	0.60	0.00	0.24	0.00	0.00	Fe Sr Y Zr	Hatis-2	None
493	0.00	0.75	0.33	31.59	5.21	13.44	0.00	0.00	Rb Sr Y Zr Nb	Hatis-2	
494	17.80	0.00	0.00	0.00	1.95	8.30	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
494	26.13	0.01	0.00	0.00	0.00	2.55	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
495	0.00	51.78	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
495	0.00	75.94	0.00	0.00	0.00	0.54	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
496	0.00	6.63	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
496	0.00	14.81	0.00	0.00	0.00	0.42	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
497	0.00	0.04	0.00	0.00	0.01	0.44	0.00	0.09	Fe Sr Y Zr	P.Arteni	None
497	0.00	0.54	0.00	0.69	0.01	4.46	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
498	0.00	12.77	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
498	0.00	21.10	0.00	0.00	0.00	0.48	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
499	0.00	49.23	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
499	0.00	35.79	0.00	0.00	0.00	0.62	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
500	0.00	5.62	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
500	0.00	13.91	0.00	0.00	0.00	0.40	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
501	0.03	0.01	0.00	0.00	2.79	8.94	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
501	0.00	0.05	0.00	0.00	35.40	30.18	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
502	0.01	0.01	0.00	0.00	34.13	32.53	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
502	0.00	0.06	0.00	0.00	87.36	75.99	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
503	0.01	0.00	0.00	0.00	55.55	7.40	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
503	0.00	0.05	0.00	0.00	10.25	11.00	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
504	0.00	0.01	0.00	0.00	43.48	17.64	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
504	0.00	0.05	0.00	0.00	34.45	16.20	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
505	0.00	4.85	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
505	0.00	7.43	0.00	0.00	0.00	0.49	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
506	0.02	0.01	0.00	0.00	11.96	47.81	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
506	0.00	0.05	0.00	0.00	19.81	43.75	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
507	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
507	0.00	0.21	0.00	0.00	0.00	0.29	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
508	0.00	8.07	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
508	0.00	17.23	0.00	0.00	0.00	0.46	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
509	0.00	59.15	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
509	0.00	77.74	0.00	0.00	0.00	0.73	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
510	0.00	50.90	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
510	0.00	74.18	0.00	0.00	0.00	0.57	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
511	0.00	58.59	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
511	0.00	67.68	0.00	0.00	0.00	0.53	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
512	0.01	0.01	0.00	0.00	87.09	49.03	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
512	0.00	0.05	0.00	0.00	45.87	47.24	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
513	0.00	0.01	0.00	0.00	14.52	29.65	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
513	0.00	0.05	0.00	0.00	67.14	58.01	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
514	0.00	0.01	0.00	0.00	53.07	27.50	0.00	0.00	Fe Sr Y Zr	M.Arteni	M.Arteni
514	0.00	0.06	0.00	0.00	57.70	30.52	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
515	0.00	40.13	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
515	0.00	47.87	0.00	0.00	0.00	0.49	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
516	0.01	0.01	0.00	0.00	37.69	25.99	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
516	0.00	0.06	0.00	0.00	30.04	36.47	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
517	0.01	0.01	0.00	0.00	55.99	61.12	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
517	0.00	0.05	0.00	0.00	89.74	62.86	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
518	0.01	0.01	0.00	0.00	63.40	56.79	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
518	0.00	0.05	0.00	0.00	76.66	39.64	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
519	0.00	36.78	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
519	0.00	22.50	0.00	0.00	0.00	0.59	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
520	0.00	0.06	0.01	0.00	0.05	0.71	0.00	0.00	Fe Sr Y Zr	P.Arteni	Hatis-1
520	0.00	0.62	0.01	0.00	0.07	16.09	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
521	0.00	0.01	0.00	0.00	0.85	2.87	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
521	0.00	0.06	0.00	0.00	19.70	9.32	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
522	0.00	34.66	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
522	0.00	34.13	0.00	0.00	0.00	0.54	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
523	82.18	0.00	0.00	0.00	2.58	6.58	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
523	93.42	0.01	0.00	0.00	0.00	3.55	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
524	0.00	24.24	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
524	0.00	20.89	0.00	0.00	0.00	0.54	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
525	27.52	0.00	0.00	0.00	8.58	5.14	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
525	32.00	0.01	0.00	0.00	0.00	4.53	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
526	0.00	0.01	0.00	0.00	44.19	41.75	0.00	0.00	Fe Sr Y Zr	M.Arteni	M.Arteni
526	0.00	0.05	0.00	0.00	69.13	37.93	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
527	0.00	27.63	0.00	0.00	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
527	0.00	21.79	0.00	0.00	0.00	0.74	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
528	0.00	0.12	0.00	63.28	0.00	0.04	0.00	0.00	Fe Sr Y Zr	Hatis-2	Hatis-2
528	0.00	0.47	0.00	82.89	4.53	18.10	0.00	0.06	Rb Sr Y Zr Nb	Hatis-2	
529	0.00	49.11	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
529	0.00	35.33	0.00	0.00	0.00	0.69	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
530	0.00	16.67	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
530	0.00	22.66	0.00	0.00	0.00	0.49	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
531	0.00	24.61	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
531	0.00	34.74	0.00	0.00	0.00	0.55	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
532	0.00	19.37	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
532	0.00	35.88	0.00	0.00	0.00	0.49	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
533	0.00	0.05	75.67	1.59	0.00	0.47	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
533	0.00	0.70	22.40	12.06	6.49	17.91	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
534	0.00	38.44	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
534	0.00	24.27	0.00	0.00	0.00	0.64	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
535	0.00	0.01	0.00	0.00	61.79	38.62	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
535	0.00	0.09	0.00	0.00	62.24	79.02	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
536	0.00	0.01	0.00	0.00	38.87	17.24	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
536	0.00	0.07	0.00	0.00	56.97	32.13	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
537	0.00	0.06	40.87	1.00	0.00	0.39	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
537	0.00	0.72	51.93	11.65	18.29	16.27	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
538	0.00	0.04	25.41	0.95	0.01	0.55	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-2
538	0.00	0.51	39.07	4.86	0.97	7.83	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
539	0.01	0.01	0.00	0.00	70.42	44.37	0.00	0.00	Fe Sr Y Zr	M.Arteni	M.Arteni
539	0.00	0.05	0.00	0.00	61.15	47.83	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
540	0.01	0.01	0.00	0.00	46.04	19.93	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
540	0.00	0.05	0.00	0.00	15.83	19.43	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
541	0.00	3.90	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
541	0.00	11.20	0.00	0.00	0.00	0.39	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
542	0.00	34.37	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
542	0.00	54.34	0.00	0.00	0.00	0.53	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
543	0.00	18.15	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
543	0.00	23.43	0.00	0.00	0.00	0.51	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
544	0.04	0.01	0.00	0.00	3.23	11.55	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
544	0.00	0.05	0.00	0.00	10.31	22.94	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
545	0.00	0.05	17.95	12.64	0.00	0.23	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
545	0.00	0.68	10.63	1.52	1.06	8.43	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
546	0.00	36.58	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
546	0.00	36.15	0.00	0.00	0.00	0.56	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
547	0.00	0.02	0.00	0.00	10.10	5.62	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
547	0.00	0.14	0.00	0.00	13.13	33.43	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
548	0.00	0.05	0.00	8.03	0.00	0.10	0.00	0.00	Fe Sr Y Zr	Hatis-2	Hatis-2
548	0.00	0.63	0.04	6.78	0.01	5.13	0.00	0.00	Rb Sr Y Zr Nb	Hatis-2	
549	0.22	0.00	0.00	0.00	93.95	85.78	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
549	0.00	0.02	0.00	0.00	49.33	22.71	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
550	7.33	0.00	0.00	0.00	42.33	37.21	0.00	0.00	Fe Sr Y Zr	M.Arteni	Geghasar
550	7.77	0.01	0.00	0.00	0.00	2.63	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
551	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
551	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
552	0.02	0.01	0.00	0.00	1.89	9.45	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
552	0.00	0.05	0.00	0.00	76.99	58.25	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
553	0.00	0.01	0.00	0.00	6.49	7.70	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
553	0.00	0.05	0.00	0.00	33.36	27.70	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
554	0.01	0.01	0.00	0.00	87.42	75.28	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
554	0.00	0.04	0.00	0.00	79.39	39.28	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
555	0.00	0.05	75.75	2.83	0.00	0.41	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
555	0.00	0.64	87.32	8.43	6.28	14.68	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
556	0.00	0.05	16.89	0.12	0.03	0.81	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
556	0.00	0.62	21.32	0.94	3.42	12.59	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
557	0.00	0.05	14.49	1.75	0.00	0.29	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
557	0.00	0.62	31.09	2.21	3.72	13.79	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
558	0.00	0.04	48.07	4.77	0.00	0.40	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
558	0.00	0.51	52.01	11.77	1.06	8.37	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
559	0.00	0.09	0.00	14.79	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Hatis-2	Hatis-2
559	0.00	0.28	0.00	50.98	0.80	14.05	0.00	0.12	Rb Sr Y Zr Nb	Hatis-2	
560	0.00	0.04	21.35	3.46	0.00	0.39	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
560	0.00	0.52	15.67	2.14	0.30	6.51	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
561	0.00	0.06	4.01	0.50	0.00	0.31	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
561	0.00	0.68	2.19	0.17	0.87	8.84	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
562	0.00	0.03	0.91	5.51	0.00	0.25	0.00	0.00	Fe Sr Y Zr	Hatis-2	Hatis-1
562	0.00	0.47	5.03	5.89	0.08	5.08	0.00	0.00	Rb Sr Y Zr Nb	Hatis-2	
563	0.00	0.06	54.15	0.54	0.00	0.55	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-2
563	0.00	0.63	33.64	1.35	3.98	10.22	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
564	0.00	0.06	2.05	0.16	0.00	0.40	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
564	0.00	0.69	3.25	0.31	12.23	22.27	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
565	0.00	0.00	0.00	0.00	0.00	0.33	0.44	0.00	Fe Sr Y Zr	Sarikamis-2	None
565	0.00	0.03	0.00	0.00	0.00	1.01	0.94	0.00	Rb Sr Y Zr Nb	P.Arteni	
566	0.00	0.01	0.00	0.00	9.68	5.68	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
566	0.00	0.08	0.00	0.00	48.23	36.05	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
567	0.00	0.01	0.00	0.00	1.65	3.95	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
567	0.00	0.05	0.00	0.00	44.32	14.51	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
568	0.04	0.00	0.00	0.00	58.78	57.08	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
568	0.00	0.03	0.00	0.00	53.58	40.20	0.02	0.00	Rb Sr Y Zr Nb	M.Arteni	
569	0.01	0.01	0.00	0.00	34.27	32.45	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
569	0.00	0.06	0.00	0.00	51.38	78.01	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
570	0.05	0.00	0.00	0.00	71.57	36.76	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
570	0.00	0.03	0.00	0.00	43.06	42.22	0.01	0.00	Rb Sr Y Zr Nb	M.Arteni	
571	0.01	0.01	0.00	0.00	13.86	19.92	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
571	0.00	0.07	0.00	0.00	14.08	48.36	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
572	0.00	0.01	0.00	0.00	2.15	8.56	0.00	0.00	Fe Sr Y Zr	P.Arteni	M.Arteni
572	0.00	0.05	0.00	0.00	73.30	44.03	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
573	0.01	0.01	0.00	0.00	75.02	58.26	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
573	0.00	0.05	0.00	0.00	80.04	74.14	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
574	0.01	0.01	0.00	0.00	58.69	34.37	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
574	0.00	0.05	0.00	0.00	75.29	63.28	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
575	25.45	0.00	0.00	0.00	0.02	6.07	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
575	55.90	0.01	0.00	0.00	0.00	4.82	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
576	0.01	0.01	0.00	0.00	54.54	71.21	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
576	0.00	0.05	0.00	0.00	46.20	23.09	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
577	0.00	0.01	0.00	0.00	36.96	30.26	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
577	0.00	0.06	0.00	0.00	78.92	82.19	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
578	0.00	0.00	0.00	0.00	0.00	0.08	6.36	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
578	0.00	0.05	0.00	0.00	0.00	1.17	8.53	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
579	0.00	0.01	0.00	0.00	30.90	13.67	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
579	0.00	0.06	0.00	0.00	56.88	26.17	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
580	0.00	0.01	0.00	0.00	11.22	14.14	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
580	0.00	0.05	0.00	0.00	65.27	19.15	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
581	0.00	0.01	0.00	0.00	30.80	11.40	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
581	0.00	0.05	0.00	0.00	57.82	24.33	0.01	0.00	Rb Sr Y Zr Nb	M.Arteni	
582	0.02	0.00	0.00	0.00	0.72	2.14	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
582	0.00	0.04	0.00	0.00	0.00	0.66	0.01	0.00	Rb Sr Y Zr Nb	P.Arteni	
583	0.01	0.01	0.00	0.00	60.77	55.42	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
583	0.00	0.06	0.00	0.00	70.97	28.75	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
584	0.00	0.00	0.00	0.00	0.00	0.32	0.74	0.00	Fe Sr Y Zr	Sarikamis-2	None
584	0.00	0.04	0.00	0.00	0.00	1.09	4.23	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
585	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
585	0.00	0.05	0.00	0.00	0.00	0.83	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
586	38.60	0.00	0.00	0.00	13.80	24.60	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
586	43.49	0.01	0.00	0.00	0.00	4.71	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
587	0.00	0.00	0.00	0.00	0.00	0.28	39.65	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
587	0.00	0.05	0.00	0.00	0.00	0.88	84.09	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
588	0.00	0.00	0.00	0.00	0.01	0.50	1.95	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
588	0.00	0.04	0.00	0.00	0.00	0.84	23.76	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
589	46.79	0.00	0.00	0.00	0.13	3.07	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
589	30.72	0.01	0.00	0.00	0.00	4.10	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
590	0.01	0.01	0.00	0.00	71.55	63.43	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
590	0.00	0.06	0.00	0.00	36.51	35.20	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
591	0.00	0.01	0.00	0.00	60.57	32.42	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
591	0.00	0.06	0.00	0.00	57.55	18.95	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
592	26.91	0.00	0.00	0.00	3.14	37.30	0.00	0.00	Fe Sr Y Zr	P.Arteni	Geghasar
592	3.94	0.01	0.00	0.00	0.00	1.75	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
593	41.85	0.00	0.00	0.00	0.29	32.10	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
593	25.60	0.01	0.00	0.00	0.00	4.63	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
594	0.00	26.86	0.00	0.00	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
594	0.00	41.10	0.00	0.00	0.00	0.66	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
595	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
595	0.00	0.17	0.00	0.00	0.00	0.34	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
596	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Pasinler
596	0.00	0.01	0.00	0.00	0.00	0.41	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
597	0.00	0.03	0.00	0.00	0.00	0.09	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
597	0.00	0.17	0.00	0.00	0.14	3.31	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
598	2.01	0.00	0.00	0.00	7.91	6.75	0.00	0.00	Fe Sr Y Zr	M.Arteni	None
598	0.61	0.01	0.00	0.00	0.00	1.44	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
599	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
599	0.00	0.01	0.00	0.00	0.00	0.22	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
600	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
600	0.00	0.01	0.00	0.00	0.00	0.20	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
601	0.00	95.66	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
601	0.00	76.52	0.00	0.00	0.00	0.55	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
602	0.03	0.01	0.00	0.00	6.94	5.16	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
602	0.00	0.05	0.00	0.00	43.76	21.37	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
603	0.00	0.01	0.00	0.00	37.36	38.59	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
603	0.00	0.07	0.00	0.00	59.65	58.18	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
604	0.01	0.01	0.00	0.00	87.63	53.86	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
604	0.00	0.04	0.00	0.00	88.71	41.04	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
605	0.00	0.00	0.00	0.00	0.00	0.28	0.26	0.00	Fe Sr Y Zr	P.Arteni	None
605	0.00	0.04	0.00	0.00	0.00	1.38	1.43	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
606	0.00	0.00	0.00	0.00	0.03	0.99	0.02	0.00	Fe Sr Y Zr	P.Arteni	None
606	0.00	0.04	0.00	0.00	0.00	1.00	0.26	0.00	Rb Sr Y Zr Nb	P.Arteni	
607	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
607	0.00	0.01	0.00	0.00	0.00	0.25	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
608	0.02	0.01	0.00	0.00	47.71	32.87	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
608	0.00	0.05	0.00	0.00	46.76	51.65	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
609	45.87	0.00	0.00	0.00	0.34	31.41	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
609	50.57	0.01	0.00	0.00	0.00	3.87	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
610	0.00	0.00	0.00	0.00	0.00	0.19	64.85	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
610	0.00	0.06	0.00	0.00	0.00	0.51	84.17	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
611	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
611	0.00	0.01	0.00	0.00	0.00	0.22	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
612	54.59	0.00	0.00	0.00	0.03	3.41	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
612	87.76	0.01	0.00	0.00	0.00	4.20	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
613	0.00	0.01	0.00	0.00	22.84	11.24	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
613	0.00	0.05	0.00	0.00	28.93	16.92	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
614	0.06	0.00	0.00	0.00	60.43	76.69	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
614	0.00	0.03	0.00	0.00	19.89	26.25	0.02	0.00	Rb Sr Y Zr Nb	P.Arteni	
615	0.00	0.00	0.00	0.00	0.01	0.61	0.08	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
615	0.00	0.04	0.00	0.00	0.00	0.96	0.53	0.00	Rb Sr Y Zr Nb	P.Arteni	
616	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
616	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
617	0.00	3.49	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
617	0.00	8.66	0.00	0.00	0.00	0.39	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
618	0.00	0.00	0.00	0.00	0.01	0.62	0.17	0.00	Fe Sr Y Zr	P.Arteni	None
618	0.00	0.04	0.00	0.00	0.00	0.83	0.49	0.00	Rb Sr Y Zr Nb	P.Arteni	
619	0.00	20.23	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
619	0.00	36.14	0.00	0.00	0.00	0.49	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
620	10.82	0.00	0.00	0.00	3.37	15.18	0.00	0.00	Fe Sr Y Zr	P.Arteni	Geghasar
620	3.51	0.01	0.00	0.00	0.00	1.79	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
621	0.03	0.01	0.00	0.00	3.08	11.24	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
621	0.00	0.05	0.00	0.00	25.69	18.87	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
622	56.22	0.00	0.00	0.00	3.81	12.54	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
622	14.39	0.01	0.00	0.00	0.00	3.26	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
623	0.00	0.01	0.00	0.00	41.54	25.20	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
623	0.00	0.05	0.00	0.00	23.02	17.20	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
624	0.00	0.00	0.00	0.00	0.00	0.25	1.34	0.00	Fe Sr Y Zr	Sarikamis-2	None
624	0.00	0.04	0.00	0.00	0.00	1.38	7.88	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
625	96.76	0.00	0.00	0.00	0.62	6.44	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
625	46.58	0.01	0.00	0.00	0.00	3.25	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
626	0.00	0.04	0.00	0.00	0.00	0.05	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
626	0.00	0.32	0.00	0.00	0.00	2.21	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
627	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
627	0.00	0.05	0.00	0.00	0.00	0.68	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
628	0.00	0.00	0.00	0.00	0.03	0.74	0.16	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
628	0.00	0.04	0.00	0.00	0.00	0.96	0.78	0.00	Rb Sr Y Zr Nb	P.Arteni	
629	0.00	0.01	0.00	0.00	0.00	0.12	23.40	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
629	0.00	0.06	0.00	0.00	0.00	0.88	25.26	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
630	0.00	0.00	0.00	0.00	0.00	0.22	10.72	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
630	0.00	0.04	0.00	0.00	0.00	0.80	3.95	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
631	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
631	0.00	0.01	0.00	0.00	0.00	0.24	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
632	0.01	0.01	0.00	0.00	53.06	67.45	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
632	0.00	0.05	0.00	0.00	46.37	39.15	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
633	0.00	0.01	0.00	0.00	0.00	0.07	0.17	0.00	Fe Sr Y Zr	Sarikamis-2	None
633	0.00	0.05	0.00	0.00	0.00	1.60	0.17	0.00	Rb Sr Y Zr Nb	P.Arteni	
634	0.00	0.00	0.00	0.00	0.00	0.11	15.66	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
634	0.00	0.04	0.00	0.00	0.00	2.42	2.85	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
635	0.00	83.50	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
635	0.00	82.27	0.00	0.00	0.00	0.56	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
636	0.00	0.00	0.00	0.00	0.01	0.77	0.02	0.00	Fe Sr Y Zr	P.Arteni	None
636	0.00	0.04	0.00	0.00	0.00	1.15	0.10	0.00	Rb Sr Y Zr Nb	P.Arteni	
637	0.00	0.00	0.00	0.00	0.00	0.20	74.66	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
637	0.00	0.05	0.00	0.00	0.00	0.91	73.48	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
638	0.00	0.00	0.00	0.00	0.00	0.07	0.08	0.00	Fe Sr Y Zr	Sarikamis-2	None
638	0.00	0.05	0.00	0.00	0.00	0.61	2.76	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
639	0.00	4.76	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
639	0.00	12.55	0.00	0.00	0.00	0.40	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
640	27.71	0.00	0.00	0.00	0.03	3.77	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
640	54.64	0.01	0.00	0.00	0.00	4.66	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
641	0.06	0.00	0.00	0.00	0.02	0.95	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
641	0.03	0.01	0.00	0.00	0.00	0.93	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
642	0.00	0.02	0.00	0.00	0.08	1.03	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
642	0.00	0.10	0.00	0.00	21.38	10.43	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
643	0.00	0.02	0.00	0.00	0.01	0.45	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
643	0.00	0.08	0.00	0.00	0.23	3.04	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
644	0.00	5.45	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
644	0.00	8.00	0.00	0.00	0.00	0.49	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
645	0.00	18.33	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
645	0.00	28.49	0.00	0.00	0.00	0.56	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
646	0.00	46.34	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
646	0.00	74.40	0.00	0.00	0.00	0.59	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
647	0.01	0.01	0.00	0.00	44.08	74.14	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
647	0.00	0.05	0.00	0.00	52.27	56.83	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
648	0.00	0.01	0.00	0.00	42.62	42.31	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
648	0.00	0.05	0.00	0.00	88.72	46.27	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
649	14.05	0.00	0.00	0.00	3.83	12.95	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
649	19.06	0.01	0.00	0.00	0.00	2.99	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
650	0.00	0.01	0.00	0.00	0.28	1.75	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
650	0.00	0.06	0.00	0.00	1.29	4.17	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
651	0.10	0.00	0.00	0.00	4.58	45.43	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
651	0.00	0.03	0.00	0.00	63.84	68.96	0.02	0.00	Rb Sr Y Zr Nb	P.Arteni	
652	0.05	0.00	0.00	0.00	70.29	47.93	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
652	0.00	0.03	0.00	0.00	81.27	83.11	0.01	0.00	Rb Sr Y Zr Nb	P.Arteni	
653	39.82	0.00	0.00	0.00	12.72	33.27	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
653	26.14	0.01	0.00	0.00	0.00	3.21	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
654	0.00	0.01	0.00	0.00	2.25	6.58	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
654	0.00	0.04	0.00	0.00	28.25	14.79	0.01	0.00	Rb Sr Y Zr Nb	M.Arteni	
655	0.01	0.01	0.00	0.00	33.47	51.73	0.00	0.00	Fe Sr Y Zr	P.Arteni	P.Arteni
655	0.00	0.05	0.00	0.00	64.35	74.39	0.01	0.00	Rb Sr Y Zr Nb	P.Arteni	
656	0.04	0.00	0.00	0.00	76.70	84.41	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
656	0.00	0.03	0.00	0.00	27.14	26.48	0.01	0.00	Rb Sr Y Zr Nb	M.Arteni	
657	0.01	0.01	0.00	0.00	76.93	68.59	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
657	0.00	0.06	0.00	0.00	80.51	31.50	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
658	0.00	69.24	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
658	0.00	52.16	0.00	0.00	0.00	0.51	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
659	0.00	8.44	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
659	0.00	18.19	0.00	0.00	0.00	0.42	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
660	0.00	0.01	0.00	0.00	5.62	8.04	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
660	0.00	0.06	0.00	0.00	69.03	23.52	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
661	0.00	0.01	0.00	0.00	0.32	3.08	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
661	0.00	0.06	0.00	0.00	5.34	5.01	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
662	29.28	0.00	0.00	0.00	19.81	42.15	0.00	0.00	Fe Sr Y Zr	P.Arteni	Geghasar
662	47.12	0.01	0.00	0.00	0.00	4.84	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
663	11.56	0.00	0.00	0.00	42.43	37.39	0.00	0.00	Fe Sr Y Zr	M.Arteni	Geghasar
663	10.91	0.01	0.00	0.00	0.00	2.56	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
664	0.01	0.01	0.00	0.00	29.03	14.08	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
664	0.00	0.05	0.00	0.00	4.45	11.76	0.01	0.00	Rb Sr Y Zr Nb	P.Arteni	
665	0.00	0.01	0.00	0.00	0.00	0.09	15.01	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
665	0.00	0.05	0.00	0.00	0.00	1.29	16.97	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
666	0.00	96.74	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
666	0.00	42.39	0.00	0.00	0.00	0.59	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
667	0.02	0.01	0.00	0.00	5.35	4.27	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
667	0.00	0.05	0.00	0.00	4.44	13.44	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
668	0.01	0.01	0.00	0.00	34.16	13.18	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
668	0.00	0.05	0.00	0.00	65.38	44.01	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
669	12.88	0.00	0.00	0.00	22.99	38.47	0.00	0.00	Fe Sr Y Zr	P.Arteni	P.Arteni
669	18.76	0.01	0.00	0.00	0.00	3.07	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
670	0.00	0.01	0.00	0.00	0.00	0.16	42.34	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
670	0.00	0.06	0.00	0.00	0.00	1.59	28.47	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
671	0.00	78.53	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
671	0.00	70.62	0.00	0.00	0.00	0.55	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
672	2.20	0.00	0.00	0.00	0.44	1.75	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
672	4.38	0.01	0.00	0.00	0.00	2.65	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
673	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
673	0.00	0.17	0.00	0.00	0.00	0.42	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
674	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
674	0.00	0.45	0.00	0.00	0.00	0.44	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
675	0.02	0.01	0.00	0.00	14.69	26.64	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
675	0.00	0.05	0.00	0.00	60.31	36.49	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
676	0.01	0.01	0.00	0.00	38.92	40.77	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
676	0.00	0.05	0.00	0.00	35.42	37.94	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
677	0.01	0.01	0.00	0.00	76.93	78.96	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
677	0.00	0.05	0.00	0.00	79.86	92.36	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
678	0.01	0.01	0.00	0.00	78.33	30.30	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
678	0.00	0.06	0.00	0.00	54.82	51.38	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
679	28.08	0.00	0.00	0.00	1.48	5.97	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
679	32.02	0.01	0.00	0.00	0.00	9.87	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
680	0.00	0.06	56.38	0.98	0.00	0.46	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
680	0.00	0.70	62.49	4.34	10.69	17.17	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
681	0.00	0.05	44.78	2.24	0.00	0.37	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
681	0.00	0.63	12.31	1.02	1.84	9.85	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
682	0.00	0.05	66.98	3.56	0.00	0.34	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
682	0.00	0.64	41.74	1.67	3.90	9.87	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
683	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
683	0.00	0.02	0.00	0.00	0.00	0.29	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
684	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	Meydan Dag
684	0.00	0.04	0.00	0.00	0.00	0.19	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
685	0.00	0.06	13.37	0.18	0.00	0.51	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
685	0.00	0.70	31.74	1.38	21.33	9.38	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
686	0.00	0.01	0.00	0.00	0.00	0.07	0.86	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
686	0.00	0.06	0.00	0.00	0.00	0.90	0.79	0.00	Rb Sr Y Zr Nb	P.Arteni	
687	0.00	0.06	55.04	0.65	0.00	0.52	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
687	0.00	0.64	37.88	1.80	3.63	10.67	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
688	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	P.Arteni	None

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
688	0.00	0.01	0.00	0.00	0.00	0.45	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
689	96.28	0.00	0.00	0.00	0.52	11.67	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
689	94.01	0.01	0.00	0.00	0.00	5.95	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
690	9.36	0.00	0.00	0.00	10.34	23.27	0.00	0.00	Fe Sr Y Zr	P.Arteni	Geghasar
690	3.66	0.01	0.00	0.00	0.00	1.92	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
691	0.00	0.12	0.00	66.91	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Hatis-2	Hatis-2
691	0.00	0.43	0.00	36.32	3.49	12.58	0.00	0.40	Rb Sr Y Zr Nb	Hatis-2	
692	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
692	0.00	0.20	0.00	0.00	0.00	0.32	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
693	0.00	4.43	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
693	0.00	9.95	0.00	0.00	0.00	0.44	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
694	0.00	0.78	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
694	0.00	2.74	0.00	0.00	0.00	0.33	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
695	0.00	0.13	0.00	0.19	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Hatis-2	None
695	0.00	0.42	0.00	0.00	0.05	1.83	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
696	0.00	0.01	0.00	0.00	2.39	3.11	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
696	0.00	0.06	0.00	0.00	10.86	7.21	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
697	0.00	0.01	0.00	0.00	19.75	11.44	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
697	0.00	0.07	0.00	0.00	65.52	22.09	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
698	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
698	0.00	0.01	0.00	0.00	0.00	0.30	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
699	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
699	0.02	0.02	0.00	0.00	0.16	2.61	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
700	0.00	0.06	48.71	7.24	0.00	0.27	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
700	0.00	0.78	36.87	16.91	9.59	19.66	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
701	0.04	0.00	0.00	0.00	71.75	71.60	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
701	0.00	0.03	0.00	0.00	97.27	96.57	0.01	0.00	Rb Sr Y Zr Nb	M.Arteni	
702	0.17	0.00	0.00	0.00	8.19	11.59	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
702	0.00	0.02	0.00	0.00	29.66	28.72	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
703	0.02	0.00	0.00	0.00	67.08	42.56	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
703	0.00	0.03	0.00	0.00	81.27	63.95	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
704	0.00	0.01	0.00	0.00	0.00	0.08	3.93	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
704	0.00	0.06	0.00	0.00	0.00	1.69	2.01	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
705	0.01	0.00	0.00	0.00	15.34	10.77	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
705	0.00	0.04	0.00	0.00	26.82	14.47	0.01	0.00	Rb Sr Y Zr Nb	M.Arteni	
706	0.21	0.00	0.00	0.00	3.56	7.17	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
706	0.21	0.01	0.00	0.00	0.00	1.31	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
707	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	Meydan Dag
707	0.00	0.04	0.00	0.00	0.00	0.20	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
708	0.00	11.59	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
708	0.00	25.43	0.00	0.00	0.00	0.43	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
709	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
709	0.00	0.02	0.00	0.00	0.00	0.23	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
710	0.00	6.54	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
710	0.00	15.30	0.00	0.00	0.00	0.43	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
711	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
711	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
712	0.01	0.01	0.00	0.00	30.46	14.94	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni?
712	0.00	0.05	0.00	0.00	10.98	10.35	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
713	0.00	0.01	0.00	0.00	36.13	51.36	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
713	0.00	0.05	0.00	0.00	87.03	35.93	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
714	0.00	0.06	31.94	0.90	0.00	0.41	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
714	0.00	0.66	36.29	3.49	20.01	12.92	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
715	0.00	1.31	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
715	0.00	5.16	0.00	0.00	0.00	0.31	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
716	0.00	0.09	0.22	1.42	0.00	0.16	0.00	0.00	Fe Sr Y Zr	Hatis-2	None
716	0.00	0.93	0.17	0.03	0.03	4.09	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
717	0.00	0.08	2.37	7.67	0.00	0.16	0.00	0.00	Fe Sr Y Zr	Hatis-2	None
717	0.00	0.92	0.45	0.06	0.17	5.11	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
718	0.00	0.06	15.96	1.61	0.00	0.31	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
718	0.00	0.68	4.88	0.74	1.29	5.91	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
719	0.00	0.06	25.12	0.26	0.01	0.60	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
719	0.00	0.66	22.35	1.71	2.95	12.84	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
720	0.00	0.10	3.31	7.93	0.00	0.13	0.00	0.00	Fe Sr Y Zr	Hatis-2	None
720	0.00	1.13	0.47	0.04	0.44	4.87	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
721	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
721	0.00	0.02	0.00	0.00	0.00	0.29	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
722	16.48	0.00	0.00	0.00	0.15	3.00	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
722	54.57	0.01	0.00	0.00	0.00	3.73	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
723	0.00	0.04	61.27	4.29	0.00	0.40	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
723	0.00	0.54	80.29	6.35	1.90	8.68	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
724	0.03	0.00	0.00	0.00	11.61	5.37	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
724	0.00	0.02	0.00	0.00	22.22	13.26	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
725	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	Meydan Dag
725	0.00	0.03	0.00	0.00	0.00	0.19	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
726	0.00	0.01	0.00	0.00	0.00	0.07	2.81	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
726	0.00	0.06	0.00	0.00	0.00	0.94	13.48	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
727	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
727	0.00	0.08	0.00	0.00	0.00	0.43	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
728	0.00	56.05	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
728	0.00	55.61	0.00	0.00	0.00	0.63	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
729	0.00	0.06	28.67	0.28	0.01	0.56	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
729	0.00	0.72	37.33	2.97	6.00	17.24	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
730	0.00	0.01	0.00	0.00	0.00	0.08	1.23	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
730	0.00	0.07	0.00	0.00	0.00	1.16	10.90	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
731	0.00	0.01	0.00	0.00	0.16	1.98	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
731	0.00	0.04	0.00	0.00	6.74	5.54	0.01	0.00	Rb Sr Y Zr Nb	M.Arteni	
732	70.38	0.00	0.00	0.00	3.91	18.79	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
732	60.54	0.01	0.00	0.00	0.00	3.69	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
733	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	Meydan Dag
733	0.00	0.03	0.00	0.00	0.00	0.18	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
734	0.02	0.01	0.00	0.00	26.27	39.08	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
734	0.00	0.05	0.00	0.00	68.07	60.06	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
735	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
735	0.00	0.03	0.00	0.00	0.00	0.65	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
736	0.03	0.00	0.00	0.00	6.19	7.29	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
736	0.01	0.02	0.00	0.00	45.90	25.08	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
737	0.00	0.01	0.00	0.00	14.51	8.52	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
737	0.00	0.05	0.00	0.00	2.00	6.76	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
738	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
738	0.00	0.02	0.00	0.00	0.00	0.25	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
739	7.86	0.00	0.00	0.00	2.87	5.64	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
739	10.07	0.01	0.00	0.00	0.00	2.46	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
740	0.00	0.00	0.00	0.00	0.00	0.19	99.18	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
740	0.00	0.05	0.00	0.00	0.00	0.77	97.38	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
741	0.00	20.86	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
741	0.00	12.32	0.00	0.00	0.00	0.62	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
742	61.69	0.00	0.00	0.00	0.12	8.75	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
742	52.99	0.01	0.00	0.00	0.00	3.42	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
743	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
743	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
744	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
744	0.00	0.22	0.00	0.00	0.00	0.37	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
745	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	Meydan Dag
745	0.00	0.03	0.00	0.00	0.00	0.17	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
746	0.00	0.48	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
746	0.00	2.50	0.00	0.00	0.00	0.27	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
747	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
747	0.00	0.01	0.00	0.00	0.00	0.47	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
748	0.00	0.08	1.56	39.27	0.00	0.11	0.00	0.00	Fe Sr Y Zr	Hatis-2	Hatis-2
748	0.00	0.98	0.17	0.02	0.11	3.32	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
749	0.00	0.07		1.42	0.00	0.35	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
749	0.00	0.76		2.25	18.00	16.15	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
750	0.00	1.11	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
750	0.00	4.92	0.00	0.00	0.00	0.32	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
751	0.01	0.00	0.00	0.00	0.00	0.26	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
751	0.01	0.01	0.00	0.00	0.00	0.79	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
752	0.07	0.00	0.00	0.00	90.44	89.35	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
752	0.00	0.02	0.00	0.00	60.87	42.65	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
753	0.01	0.00	0.00	0.00	51.99	65.76	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
753	0.00	0.04	0.00	0.00	76.58	88.89	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
754	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
754	0.00	0.03	0.00	0.00	0.00	4.19	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
755	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
755	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
756	0.00	4.33	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
756	0.00	11.36	0.00	0.00	0.00	0.40	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
757	0.00	27.54	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
757	0.00	35.36	0.00	0.00	0.00	0.56	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
758	0.00	0.06	58.44	0.33	0.00	0.59	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
758	0.00	0.74	79.20	14.48	13.05	23.37	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
759	0.00	79.93	0.00	0.00	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
759	0.00	40.34	0.00	0.00	0.00	0.74	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
760	0.00	7.48	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
760	0.00	15.27	0.00	0.00	0.00	0.44	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
761	0.00	0.01	0.00	0.00	0.03	0.88	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
761	0.00	0.09	0.00	0.00	12.90	7.95	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
762	1.86	0.00	0.00	0.00	13.99	6.83	0.00	0.00	Fe Sr Y Zr	M.Arteni	None
762	2.36	0.01	0.00	0.00	0.00	1.93	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
763	0.00	93.47	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
763	0.00	57.18	0.00	0.00	0.00	0.61	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
764	33.03	0.00	0.00	0.00	0.01	1.94	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
764	75.13	0.01	0.00	0.00	0.00	3.37	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
765	0.00	0.08	12.72	0.55	0.00	0.32	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
765	0.00	0.88	6.80	2.54	6.78	18.60	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
766	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
766	0.00	0.01	0.00	0.00	0.00	0.60	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
767	0.00	0.01	0.00	0.00	7.21	10.12	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
767	0.00	0.05	0.00	0.00	56.20	19.41	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
768	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
768	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
769	0.00	0.00	0.00	0.00	0.00	0.13	21.65	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
769	0.00	0.05	0.00	0.00	0.00	1.08	12.72	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
770	0.00	51.74	0.00	0.00	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
770	0.00	45.09	0.00	0.00	0.00	0.68	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
771	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
771	0.00	0.01	0.00	0.00	0.00	0.56	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
772	0.07	0.00	0.00	0.00	62.29	36.68	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
772	0.00	0.02	0.00	0.00	60.49	55.22	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
773	0.14	0.00	0.00	0.00	62.83	67.35	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
773	0.00	0.02	0.00	0.00	77.64	83.75	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
774	0.00	0.01	0.00	0.00	44.87	23.89	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
774	0.00	0.06	0.00	0.00	40.96	11.49	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
775	0.00	0.16	0.17	1.20	0.00	0.07	0.00	0.00	Fe Sr Y Zr	Hatis-2	None
775	0.00	1.74	0.03	0.00	0.03	2.60	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
776	23.54	0.00	0.00	0.00	1.32	30.51	0.00	0.00	Fe Sr Y Zr	P.Arteni	Geghasar
776	9.74	0.01	0.00	0.00	0.00	2.04	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
777	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
777	0.00	0.06	0.00	0.00	0.00	0.70	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
778	0.00	0.00	0.00	0.00	0.01	0.56	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
778	0.02	0.02	0.00	0.00	0.14	3.80	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
779	0.00	43.43	0.00	0.00	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
779	0.00	29.59	0.00	0.00	0.00	0.74	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
780	52.58	0.00	0.00	0.00	0.03	1.94	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
780	27.94	0.01	0.00	0.00	0.00	4.58	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
781	82.88	0.00	0.00	0.00	2.16	7.95	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
781	82.68	0.01	0.00	0.00	0.00	3.90	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
782	0.00	25.00	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
782	0.00	20.68	0.00	0.00	0.00	0.48	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
783	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
783	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
784	0.00	0.01	0.00	0.00	0.00	0.07	0.70	0.00	Fe Sr Y Zr	Sarikamis-2	None
784	0.00	0.06	0.00	0.00	0.00	1.47	11.36	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
785	0.01	0.01	0.00	0.00	23.29	10.67	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
785	0.00	0.05	0.00	0.00	22.23	16.21	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
786	0.01	0.01	0.00	0.00	19.00	5.78	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
786	0.00	0.04	0.00	0.00	15.67	12.32	0.05	0.00	Rb Sr Y Zr Nb	M.Arteni	
787	0.01	0.01	0.00	0.00	62.33	36.29	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
787	0.00	0.05	0.00	0.00	58.87	47.06	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
788	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
788	0.00	0.14	0.00	0.00	0.00	0.38	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
789	0.24	0.00	0.00	0.00	5.63	36.21	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
789	0.00	0.03	0.00	0.00	31.50	58.99	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
790	0.01	0.01	0.00	0.00	69.81	42.01	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
790	0.00	0.05	0.00	0.00	63.74	37.18	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
791	0.03	0.01	0.00	0.00	6.53	15.21	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
791	0.00	0.05	0.00	0.00	27.78	23.13	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
792	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
792	0.00	0.02	0.00	0.00	0.00	0.29	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
793	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
793	0.00	0.02	0.00	0.00	0.00	0.29	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
794	0.00	24.12	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
794	0.00	35.78	0.00	0.00	0.00	0.53	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
795	0.00	28.77	0.00	0.00	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
795	0.00	24.21	0.00	0.00	0.00	0.72	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
796	0.00	0.07	0.28	16.55	0.00	0.16	0.00	0.00	Fe Sr Y Zr	Hatis-2	Hatis-2
796	0.00	0.82	0.79	30.94	2.63	12.48	0.00	0.00	Rb Sr Y Zr Nb	Hatis-2	
797	0.00	0.03	1.15	0.07	0.14	0.86	0.00	0.00	Fe Sr Y Zr	Hatis-1	None
797	0.00	0.46	3.12	0.35	0.42	5.17	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
798	0.00	0.04	15.14	0.40	0.02	0.70	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
798	0.00	0.50	16.11	1.58	2.64	11.36	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
799	0.03	0.00	0.00	0.00	0.00	0.48	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
799	0.07	0.01	0.00	0.00	0.00	1.14	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
800	0.00	0.04	85.26	1.73	0.00	0.53	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
800	0.00	0.50	78.93	3.50	4.41	9.60	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
801	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
801	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
802	0.11	0.00	0.00	0.00	4.36	3.46	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
802	0.01	0.01	0.00	0.00	13.74	12.28	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
803	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Pasinler
803	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
804	0.00	0.06	0.00	0.00	0.03	0.87	0.00	0.70	Fe Sr Y Zr	P.Arteni	None
804	0.00	0.64	0.00	1.26	0.02	7.13	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
805	0.00	0.05	0.00	0.00	0.00	0.04	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
805	0.00	0.34	0.00	0.00	0.00	3.18	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
806	0.00	1.61	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
806	0.00	5.51	0.00	0.00	0.00	0.35	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
807	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
807	0.00	0.02	0.00	0.00	0.00	0.26	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
808	0.74	0.00	0.00	0.00	0.70	2.26	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
808	0.16	0.01	0.00	0.00	0.00	3.32	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
809	0.44	0.00	0.00	0.00	0.11	0.91	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
809	0.24	0.01	0.00	0.00	0.00	1.60	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
810	0.00	0.01	0.00	0.00	0.03	0.89	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
810	0.01	0.07	0.00	0.00	0.02	2.41	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
811	0.00	0.14	0.00	24.49	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Hatis-2	Hatis-2
811	0.00	0.41	0.00	1.20	2.86	7.55	0.00	0.11	Rb Sr Y Zr Nb	P.Arteni	
812	0.00	0.04	0.00	0.00	0.00	0.51	0.00	0.09	Fe Sr Y Zr	P.Arteni	None
812	0.00	0.46	0.00	5.25	0.00	4.15	0.00	0.00	Rb Sr Y Zr Nb	Hatis-2	
813	0.00	0.04	0.00	0.00	0.01	0.44	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
813	0.00	0.50	0.00	1.50	0.02	3.78	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
814	0.04	0.00	0.00	0.00	5.30	2.61	0.00	0.00	Fe Sr Y Zr	M.Arteni	None
814	0.01	0.02	0.00	0.00	7.34	10.21	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
815	29.68	0.00	0.00	0.00	8.55	12.14	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
815	11.29	0.01	0.00	0.00	0.00	3.76	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
816	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	P.Arteni	Sarikamiş
816	0.00	0.01	0.00	0.00	0.00	0.27	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
817	0.00	0.08	0.65	19.23	0.00	0.14	0.00	0.00	Fe Sr Y Zr	Hatis-2	Hatis-2
817	0.00	0.91	2.06	0.72	0.50	6.23	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
818	0.00	0.01	0.00	0.00	0.00	0.16	27.14	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
818	0.00	0.06	0.00	0.00	0.00	0.72	49.33	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
819	0.00	0.00	0.00	0.00	0.00	0.38	6.34	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
819	0.00	0.04	0.00	0.00	0.00	1.38	40.90	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
820	47.04	0.00	0.00	0.00	7.10	26.03	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
820	15.83	0.01	0.00	0.00	0.00	2.40	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
821	0.00	0.04	52.11	0.84	0.00	0.57	0.00	0.00	Fe Sr Y Zr	Hatis-1	Hatis-1
821	0.00	0.52	57.06	6.82	7.17	11.30	0.00	0.00	Rb Sr Y Zr Nb	Hatis-1	
822	0.01	0.01	0.00	0.00	7.73	33.95	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
822	0.00	0.06	0.00	0.00	56.11	43.34	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
823	0.00	72.03	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
823	0.00	26.99	0.00	0.00	0.00	0.57	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
824	0.04	0.00	0.00	0.00	0.28	2.79	0.00	0.00	Fe Sr Y Zr	P.Arteni	None
824	0.10	0.01	0.00	0.00	0.63	4.71	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
825	39.46	0.00	0.00	0.00	0.80	10.52	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
825	57.01	0.01	0.00	0.00	0.00	3.67	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
826	0.02	0.00	0.00	0.00	83.13	81.69	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
826	0.00	0.04	0.00	0.00	30.78	26.44	0.01	0.00	Rb Sr Y Zr Nb	M.Arteni	
827	0.01	0.01	0.00	0.00	22.88	10.71	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
827	0.00	0.04	0.00	0.00	39.76	16.68	0.01	0.00	Rb Sr Y Zr Nb	M.Arteni	
828	0.01	0.01	0.00	0.00	67.37	62.01	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
828	0.00	0.05	0.00	0.00	82.38	74.60	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
829	12.07	0.00	0.00	0.00	2.02	3.09	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
829	7.57	0.01	0.00	0.00	0.00	3.31	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
830	38.62	0.00	0.00	0.00	3.17	20.12	0.00	0.00	Fe Sr Y Zr	Geghasar	Geghasar
830	19.20	0.01	0.00	0.00	0.00	2.32	0.00	0.00	Rb Sr Y Zr Nb	Geghasar	
831	0.00	0.01	0.00	0.00	9.40	4.49	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
831	0.00	0.05	0.00	0.00	41.10	27.93	0.01	0.00	Rb Sr Y Zr Nb	M.Arteni	
832	0.02	0.00	0.00	0.00	86.31	76.14	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
832	0.00	0.04	0.00	0.00	82.92	48.60	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
833	0.00	0.01	0.00	0.00	57.28	38.55	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
833	0.00	0.05	0.00	0.00	61.09	42.95	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
834	0.00	25.38	0.00	0.00	0.00	0.03	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
834	0.00	28.70	0.00	0.00	0.00	0.85	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
835	0.02	0.01	0.00	0.00	31.41	19.93	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
835	0.00	0.04	0.00	0.00	7.45	21.84	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
836	0.01	0.01	0.00	0.00	76.17	72.86	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
836	0.00	0.05	0.00	0.00	80.32	57.29	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
837	0.00	3.25	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
837	0.00	9.53	0.00	0.00	0.00	0.38	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
838	0.00	1.28	0.00	0.00	0.00	0.01	0.00	0.00	Fe Sr Y Zr	Gutanasar	Hatis-2
838	0.00	89.89	0.00	0.00	0.00	0.56	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
839	0.02	0.01	0.00	0.00	6.59	16.33	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
839	0.00	0.06	0.00	0.00	35.90	31.74	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
840	0.00	0.02	0.00	0.00	0.35	1.38	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
840	0.00	0.10	0.00	0.00	16.61	9.27	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
841	0.00	53.40	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar

ANID	Geghasar	Gutanasar	Hatis-1	Hatis-2	M.Arteni	P.Arteni	Sarikamis-2	Ttujur	Elements Used in MD probabilities	Best Fit	Assignment
841	0.00	75.76	0.00	0.00	0.00	0.76	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
842	0.00	77.27	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
842	0.00	25.82	0.00	0.00	0.00	0.55	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
843	0.01	0.01	0.00	0.00	61.28	67.08	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
843	0.00	0.07	0.00	0.00	22.26	36.51	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
844	0.00	69.23	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
844	0.00	75.32	0.00	0.00	0.00	0.64	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
845	0.00	0.00	0.00	0.00	0.00	0.08	6.00	0.00	Fe Sr Y Zr	Sarikamis-2	Sarikamiş
845	0.00	0.05	0.00	0.00	0.00	0.75	12.56	0.00	Rb Sr Y Zr Nb	Sarikamis-2	
846	0.00	24.26	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
846	0.00	31.67	0.00	0.00	0.00	0.54	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
847	0.04	0.00	0.00	0.00	93.87	98.65	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
847	0.00	0.03	0.00	0.00	66.37	41.51	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
848	0.00	0.01	0.00	0.00	47.71	43.11	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
848	0.00	0.05	0.00	0.00	39.47	72.59	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
849	0.00	88.47	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
849	0.00	76.00	0.00	0.00	0.00	0.64	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
850	0.00	33.07	0.00	0.00	0.00	0.02	0.00	0.00	Fe Sr Y Zr	Gutanasar	Gutanasar
850	0.00	41.93	0.00	0.00	0.00	0.54	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	
851	0.01	0.01	0.00	0.00	50.73	22.23	0.00	0.00	Fe Sr Y Zr	M.Arteni	Arteni
851	0.00	0.04	0.00	0.00	53.92	31.90	0.01	0.00	Rb Sr Y Zr Nb	M.Arteni	
852	0.00	0.01	0.00	0.00	32.32	40.25	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
852	0.00	0.05	0.00	0.00	78.63	31.40	0.00	0.00	Rb Sr Y Zr Nb	M.Arteni	
853	0.00	0.01	0.00	0.00	0.18	1.63	0.00	0.00	Fe Sr Y Zr	P.Arteni	Arteni
853	0.00	0.06	0.00	0.00	3.18	4.83	0.00	0.00	Rb Sr Y Zr Nb	P.Arteni	
854	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	Fe Sr Y Zr	Gutanasar	None
854	0.00	6.66	0.00	0.00	0.00	0.52	0.00	0.00	Rb Sr Y Zr Nb	Gutanasar	

Appendix 6: GPS Points of Obsidian Specimens Collected from Armenian, Georgian, and eastern Turkish Sources

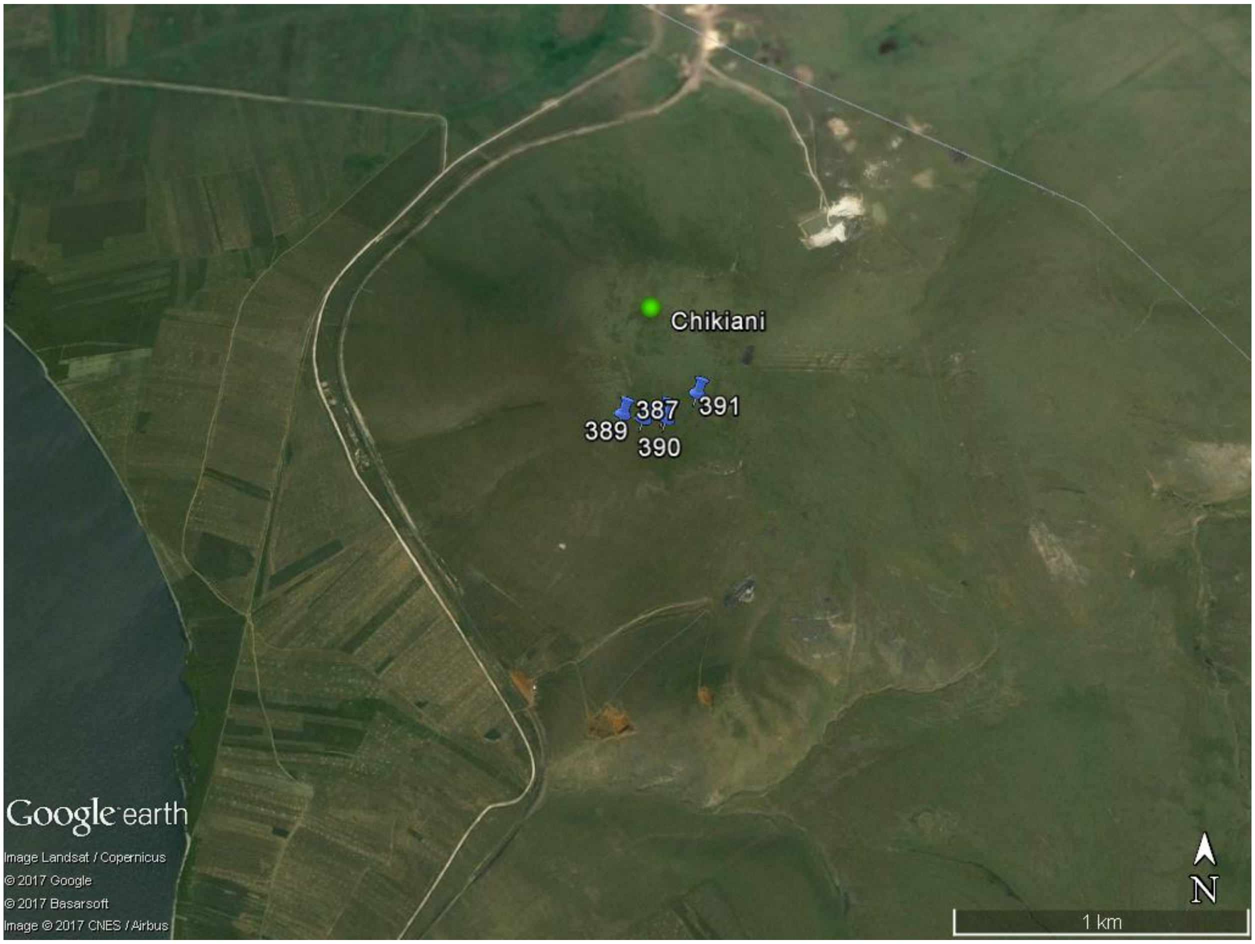

Figure A6.1 – Chikiani (Georgia) obsidian source with specimens collection sites indicated by GPS numbers.

Figure A6.2 – Aghvorik and Sizavet (Armenia) obsidian sources with specimens collection sites indicated by GPS umbers.

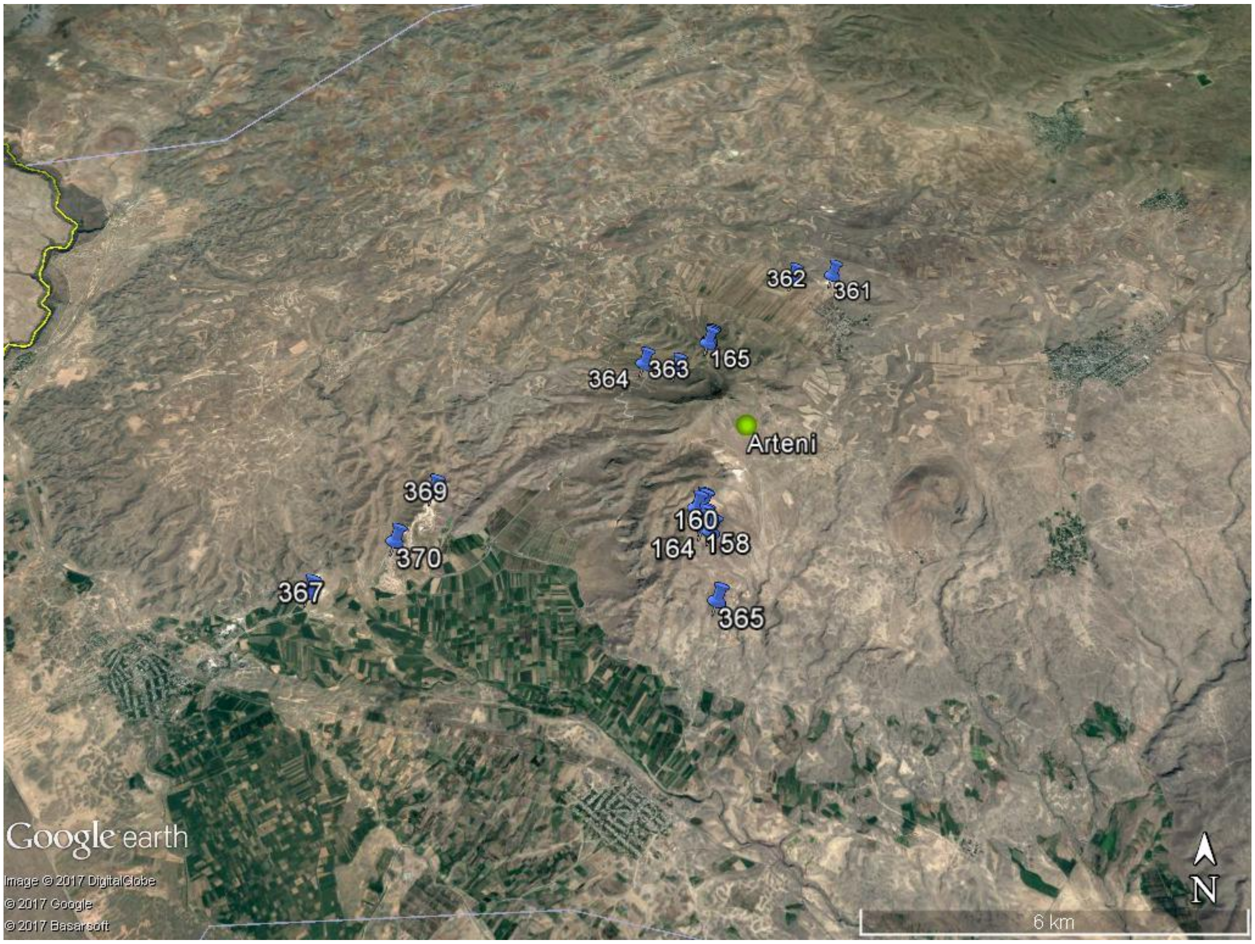

Figure A6.3 – Arteni volcaninc complex (Armenia), including Mets (Big) and Pokr (Speakman, et al.) Arteni, Brusok, and the Aragats obsidian sources with specimen collection sites indicated by GPS umbers.

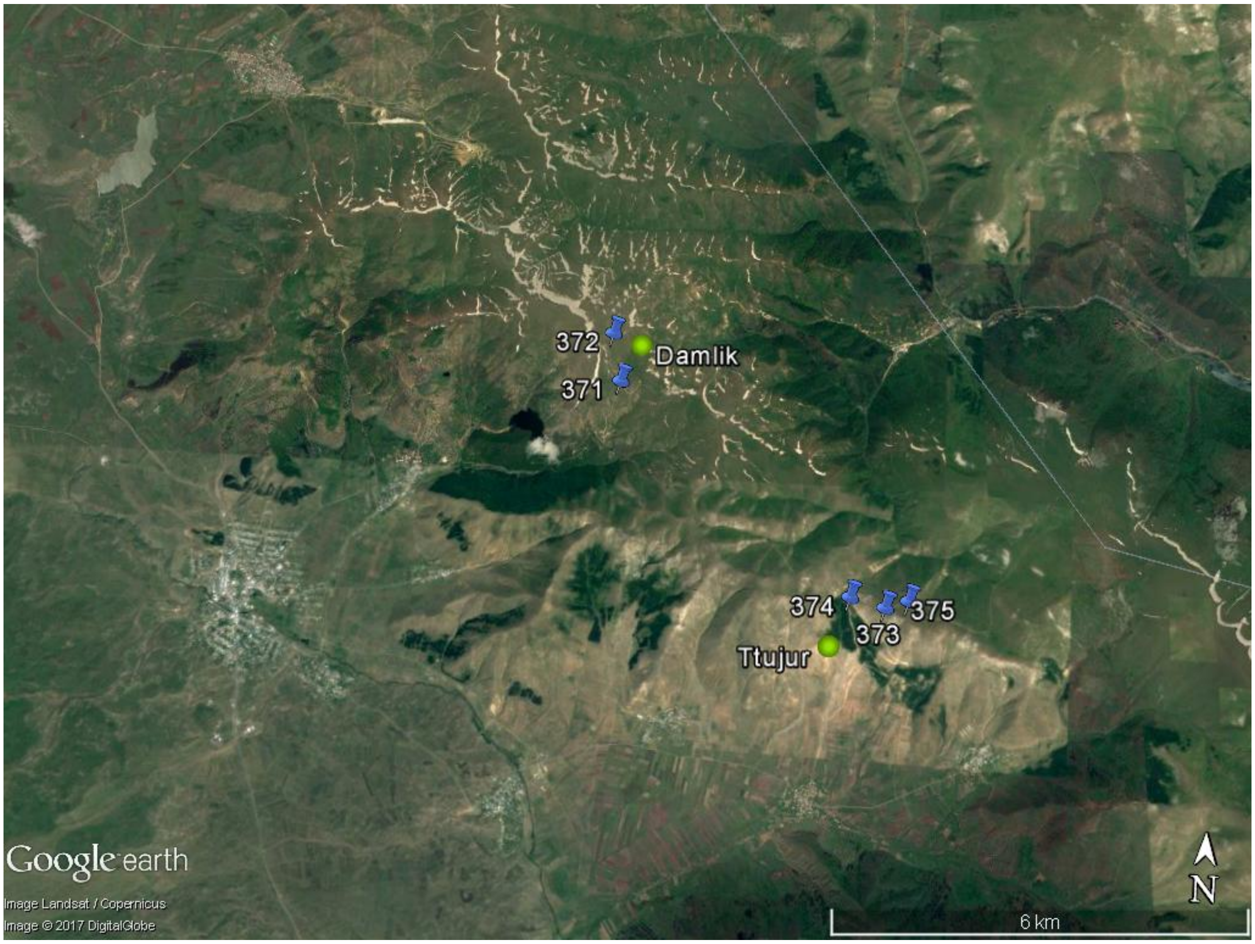

Figure A6.4 – Damlik and Ttujur (Tsaghkunyats Range, Armenia) obsidian sources with specimens collection sites indicated by GPS umbers.

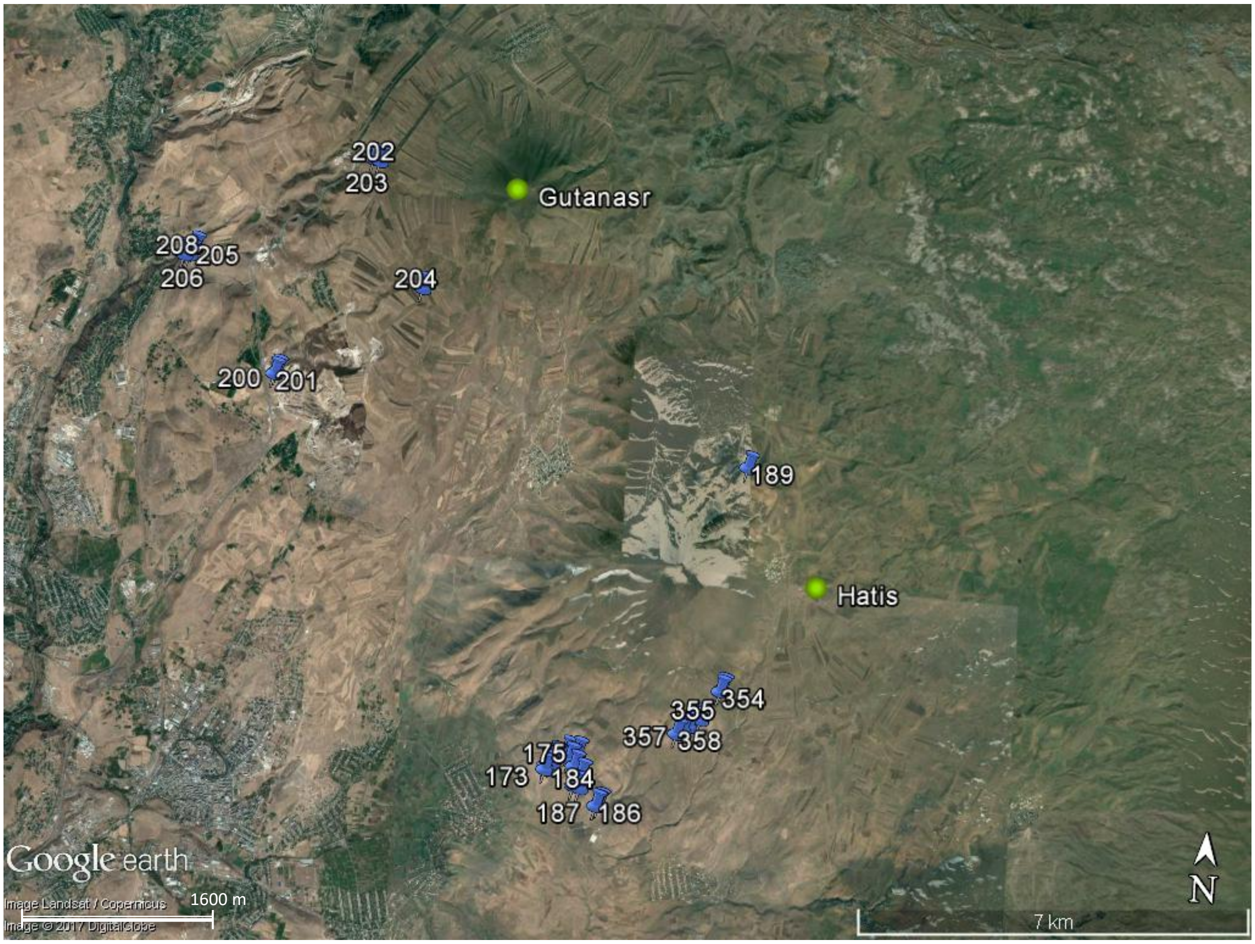

Figure A6.5 – Gutanasar and Hatis (Geghama Range, Armenia) obsidian sources with specimens collection sites indicated by GPS umbers.

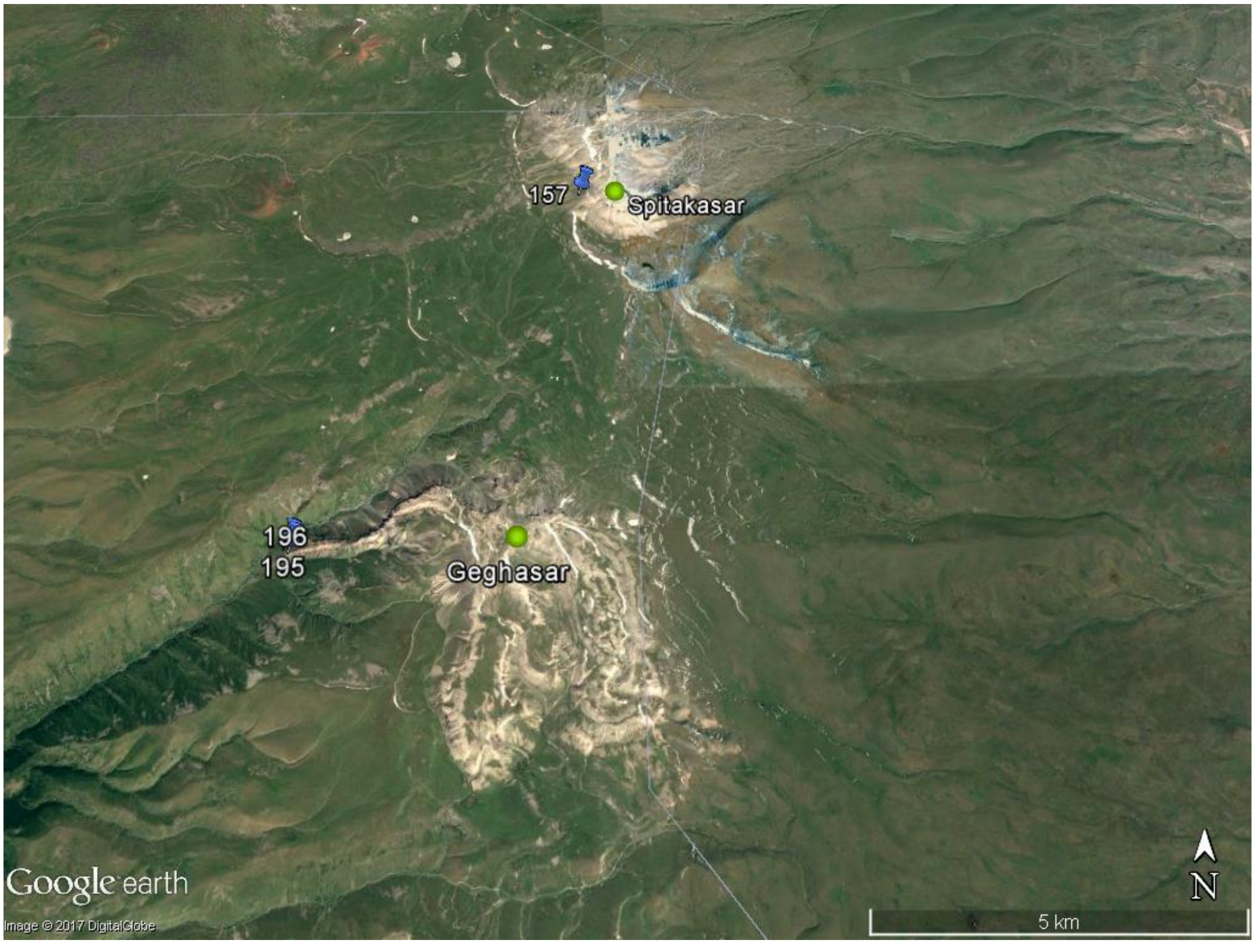

Figure A6.6 – Spitakasar and Geghasar (Geghama Range, Armenia) obsidian sources with specimens collection sites indicated by GPS umbers.

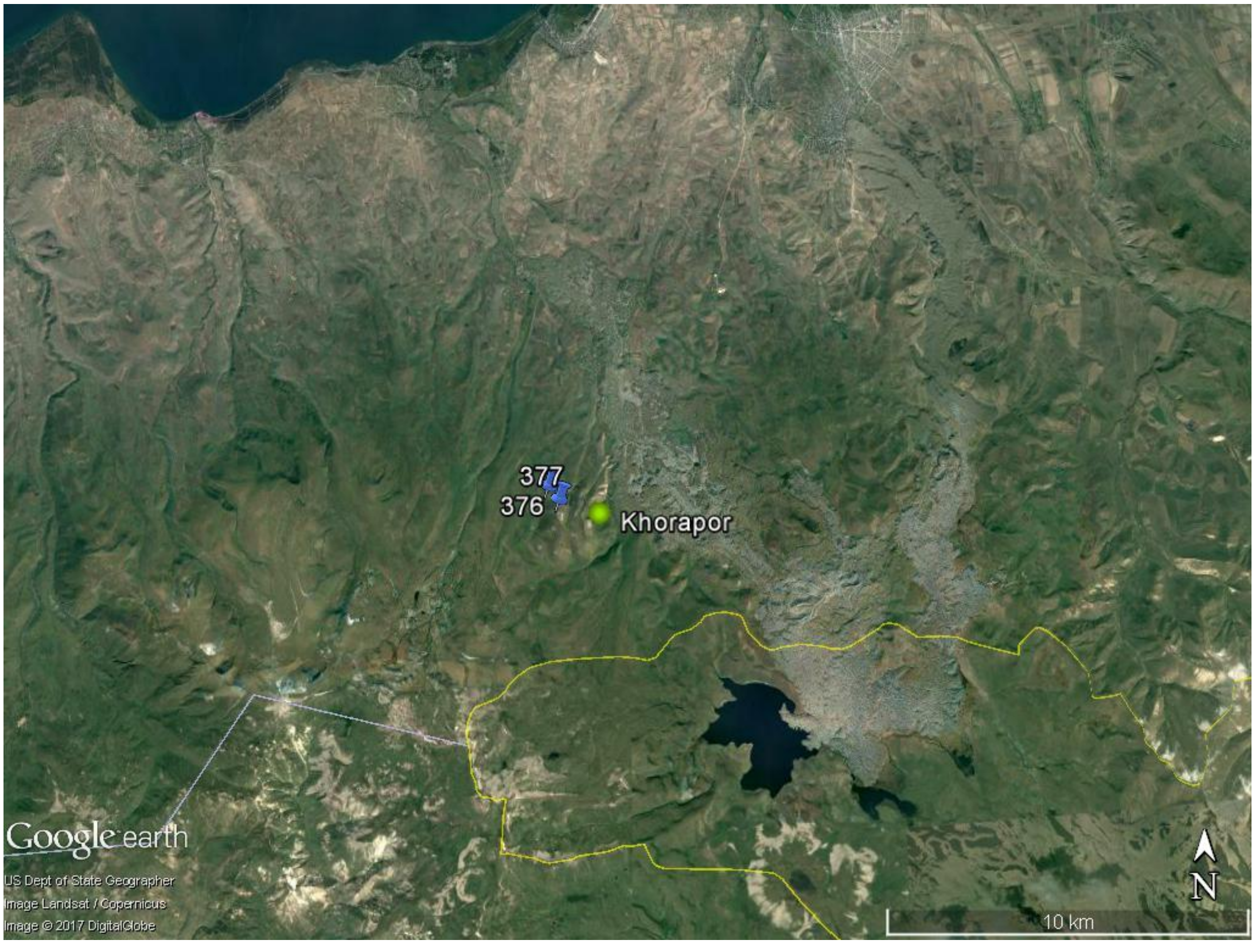

Figure A6.7 – Khorapor (Armenia) obsidian source with specimens collection sites indicated by GPS umbers.

Figure A6.8 – Mets Satanakar, Sevkar, and Bazenk (Syunik, Armenia) obsidian sources with specimens collection sites indicated by GPS umbers.

Figure A6.9 – Yağlıca Dağ (eastern Turkey) obsidian source with specimens collection sites indicated by GPS umbers.

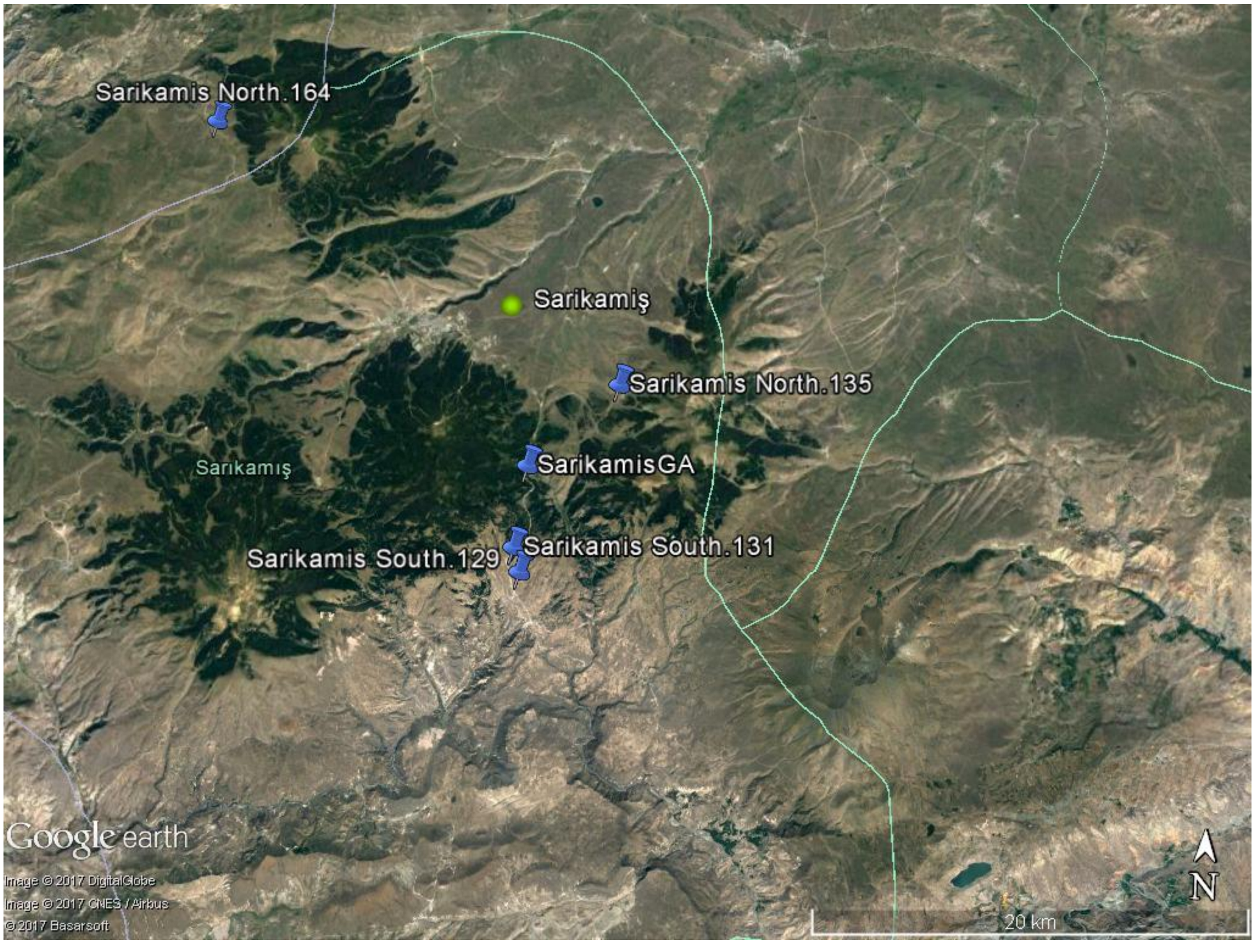

Figure A6.10 – Sarikamiş (eastern Turkey) obsidian sources with specimens collection sites indicated by GPS umbers.

Figure A6.11 – Pasinler and Erzurum (eastern Turkey) obsidian sources with specimens collection sites indicated by GPS umbers.

Appendix 7: Obsidian sources of Georgia and Armenia.


Figure A7.1 – Chikiani volcano (Georgia).


Figure A7.2 – Aghvorik obsidian deposits (Armenia).


Figure A7.3 – Sizavet obsidian deposits (Armenia).

Figure A7.4 – Arteni Volcanic Complex (Armenia) (top); obsidian of Mets Arteni volcano (middle); modern obsidian mine on Pokr Arteni (bottom).

Figure A7.5 – Gutanasar volcano (Armenia).

Figure A7.5 – Gutanasar volcano (Armenia).

Figure A7.6 – Hatis volcano (Armenia).

Figure A7.6 – Hatis volcano (Armenia).

Figure A7.7 – Spitakasar volcano (Geghama Range, Armenia).

Figure A7.8 – Geghasar volcano (Armenia).

Figure A7.8 – Geghasar volcano (Armenia).


Figure A7.9 – Khorapor obsidian deposits (Geghama Range, Armenia).

Figure A7.10 – Satanakar volcano (Armenia).

Figure A7.10 – Satanakar volcano (Armenia).


Figure A7.11 – Sevkar volcano (Armenia).


Figure A7.12 – Bazenk volcano (Armenia).

Appendix 8: Masis Blur Artifacts Attributed to Eastern Turkish Sources.

Figure A8.1 – Artifacts attributed to Erzurum, Pasinler, and Meydan Dag sources in Eastern Turkey.

Figure A8.2 – Examples of Masis Blur artifacts attributed to Sarikamiş sources in Eastern Turkey.

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