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# How Warm *Were* They? Thermal Properties of Rabbit Skin Robes and Blankets

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*Rabbit skin robes and blankets have both considerable time depth and a wide geographic distribution throughout western North America. Primary and secondary accounts of rabbit skin robes and blankets suggest that these items are very warm. But compared to modern materials, how warm could rabbit skin robes actually have been? To determine a standardized intrinsic warmth value of rabbit skin robes we perform two tests. In the first we compare the relative temperature loss between a rabbit skin robe reproduction and four modern articles of clothing and bedding. In the second we establish the thermal conductivity (k-value) for the rabbit skin robe reproduction, which allows us to make a standardized comparison between the rabbit skin and other materials. We find that the rabbit skin robes outperform most modern materials in basic heat retention but that this may be offset by benefits in modern items such as weight and versatility.*

**R**abbit skin robes and blankets are ubiquitous items of material culture in western North America. They have both considerable time depth and a wide geographic distribution (Hedges 1973). They are one of the items of material culture that remained constant from the Archaic period up into the historic period. Many explorers, pioneers, and ethnographers saw these robes and blankets both being manufactured and in daily use (Fig. 1). When rabbit skin robes and blankets are mentioned in the literature, a comment that is often made is that the items are very warm. These references to warmth are seen early in the literature of primary accounts but have been carried over into the secondary literature. Howard Egan, a pioneer and explorer of the west, regularly encountered groups of Shoshone. During one such encounter, he observed Shoshone women making rabbit skin robes, and later wrote in his diary, "When hung around the neck the person so clothed can stand in a hard rain or snow storm and not one drop of wet will pass through the robe. They are wind and rain proof and almost cold proof" (Egan 1917:238). Robert Lowie, in his 1924 ethnography of the Northern Shoshone, wrote that "they made a very warm robe out of rabbit skins" (Lowie 1924:216). The idea that rabbit

skin robes are very warm has been carried over into the modern literature, as shown by comments made by respected researchers such as Kate Kent when she wrote that "warm (fur) blankets were made by the Anasazi, Mogollon, and Hohokam" and "soft, warm weft-twined blankets of fur or feather cord are found in such quantity in Anasazi and Mogollon sites and in Ventana Cave as to suggest that every member of the group, regardless of sex or age, owned one to wear on chilly days, to sleep in at night, and to be interred in after death" (Kent 1983:43, 112).

Firsthand accounts of the warmth of rabbit skin robes and blankets invariably come from the 1800s and early 1900s. The materials that are used to keep people warm obviously have greatly changed since then. Advances in technology have allowed humans to manufacture materials that can keep them alive in such extreme environs as the top of Mt. Everest to the depths of Antarctica. A question that begs to be answered is this: compared to modern materials, how warm could rabbit skin robes actually have been? Is there a standardized intrinsic warmth value that can be given to rabbit skin robes? This paper answers this question in two ways. First, we compare the relative temperature loss between



Figure 1. Mojave man wearing a rabbit skin blanket  
(from James 1914:Figure 3).

a rabbit skin robe reproduction and four modern articles of clothing and bedding. Second, we establish the thermal conductivity ( $k$ -value) for the rabbit skin robe reproduction, which allows us to make a standardized comparison between the rabbit skin and other materials. We are thus able to establish a relatively standardized baseline of rabbit skin robe and blanket warmth in comparison with modern materials, thus answering the question "How warm *were* they?"

### GEOGRAPHIC DISTRIBUTION AND TIME DEPTH

Rabbit skin robes are found both archaeologically and ethnographically throughout the Great Basin, Southwest, and California. As Wissler (1922:57) noted, "Very widely spread is the weaving of blankets from twisted strips of rabbit fur, a method which has a continuous distribution from Yucatan northward in

Mexico and thence over the great plateau area of the United States to Canada."

Within the Great Basin, archaeological examples come from such places as Gypsum and Lovelock caves in Nevada (Harrington 1933:156-157; Jennings 1964:153-161; Grosscup 1960:52-53; Loud and Harrington 1929:50-53). Within the Southwest, examples include those from Tularosa and Cordova caves in New Mexico (Martin et al. 1952:211-212), and the WhiteDog, Ventana, and the Basketmaker caves in Arizona (Guernsey and Kidder 1921:54, 74-75; Haury 1950:395-396, 430-432; Morris 1980:111), among others (Guernsey 1931:65, 75, 92-93, Plate 54a; Kent 1983:24-25, 43, 112-118, 221, 225; Kidder and Guernsey 1919:156, 174-175).

Ethnographic accounts include reports from the Great Basin (Egan 1917:237-238; Lowie 1924:216-217, 228; Steward 1938:45, 227; 1939:17, Plates 2b, 7, 12, 13), the Southwest (Colton 1938:12-13; Stephen 1936:273-74), and the California area (Drucker 1937:21; Gifford 1931:33; Simpson 1961:34; and Spier 1923:346-347).

Not only is the geographic distribution of rabbit skin robes extensive, so is their time depth. Hedges (1973:6) provides an excellent summary of both the geographic and temporal span of rabbit skin robes, and concludes, "These examples and numerous others in the literature show that fur cordage blankets, including those made of rabbit skin, have been in continuous use in western North America for the last ten thousand years." Rabbit skin robes are one of the few artifact types that began being manufactured as early as the beginning of the Archaic and continued through time into the historic period.

### CONSTRUCTION

The basic construction techniques used in manufacturing rabbit skin robes were essentially the same throughout western North America, although the particulars could vary. The main element used in making rabbit skin robes and blankets was fur yarn or cordage. To create a fur cord, raw rabbit skin was cut into narrow strips 3 to 7 mm. wide, which were then coiled or wrapped around fiber cordage (Kent 1983:25; see Fig. 2). As the rabbit skin dried, it shrank and tightened, binding it firmly around the fiber cordage. This fur cord, sometimes called a fur rope, was usually used as the warp of the robe or blanket, with fiber cordage acting as

the weft. Kent (1983:113) notes that two structural details of rabbit skin robes and blankets seem to remain constant, namely that "warps are established by winding one continuous fur or feathercord back and forth with each successive turn resting parallel to the preceding one, and are held close together in this position by paired fiber yarn wefts twined through them at intervals of 1" to 12" (2.5 cm. to 30.5 cm.)" Although twining was the most common technique employed, plain weave, weft-wrapping, and loop coiling were also used in parts of western North America (Hedges 1973:5-6, Plate 6). In ethnographic and historic examples, some type of frame was usually employed in the construction process (Drucker 1937:21; Egan 1917:237-238; Gifford 1931:33; Lowie 1924:228; Spier 1923:346-347; Stephen 1936:273-274). Kent (1983:113-114, Fig. 56 E) gives a good description of the common ethnographic frame types, which have the following primary characteristics: (1) the frame is rectangular or square; (2) the frame can be either horizontal or vertical to the ground surface; and (3) the rabbit skin yarn or cordage is usually the warp element, which typically attached to both the top and the bottom of the frame, although in one type of vertical frame the warp is left unattached at the bottom. Guernsey and Kidder described a Basketmaker II rabbit skin blanket that could be seen as a typical example of rabbit skin robes and blankets in western North America:

The commonest method was to wrap a yucca cord with narrow strips of the hide of small animals applied raw and with the fur on.... The

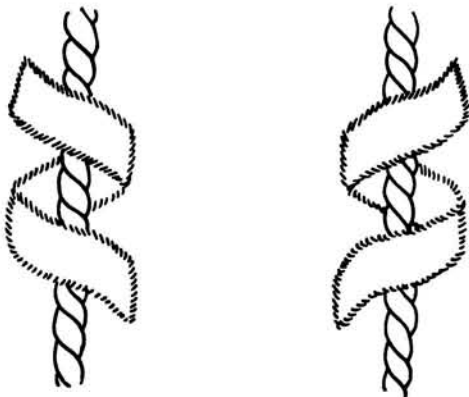


Figure 2. Construction technique for rabbit skin cord (from Hedges 1973:Plate 4).

strips were applied spirally, the end of one piece holding down the beginning of the next. The tight wrapping of the hide caused the hair to stand out in all directions, thus giving the finished string the appearance of a greatly magnified pipe-cleaner....

The weaving process was very simple; the prepared string was wound about some sort of frame, or perhaps around a pair of long pegs driven in the ground. The winding was done in such a way as to lay each succeeding turn of the string parallel to and close against the preceding one. When the desired size was reached, the strings were fastened together by twined rows of yucca cord; finally, the frame was removed [1921:74-75].

Once the rabbit skin item was completed, it could be used as a blanket for bedding or could be worn as a robe. The robes were worn around the shoulders and were usually tied in place with cordage from the weft, which was extended beyond the borders of the robe. Rabbit skin robes and blankets were of variable sizes throughout western North America, as they were manufactured for infants, children, and adults. Optimal size also varied for differing Native American groups. The Halchidhoma and Maricopa of the Southwest apparently preferred a smaller robe that hung from the shoulders to the waist (Kent 1983:112-113), while the Paiute of the Great Basin seemed to favor a larger robe that could hang from the shoulders to below the knees (like the type seen in Figure 3).

The rabbit skin robe used in the experiments described in this paper is a reproduction belonging to Fremont Indian State Park in Sevier, Utah (Fig. 4).

The robe is 12 to 13 years old and was manufactured by Corrine Springer, a museum volunteer. It was produced on the vertical frame shown in Figure 5. The construction technique differed slightly from that used for most other examples in western North America, in that the warp was fiber cordage and the weft fur cord. In most examples this situation was reversed, with the warp being fur cord and the weft being fiber cordage. To the best of our knowledge, this warp/weft reversal does not affect the functional aspects of the reproduction, which was made by using a plain weave construction

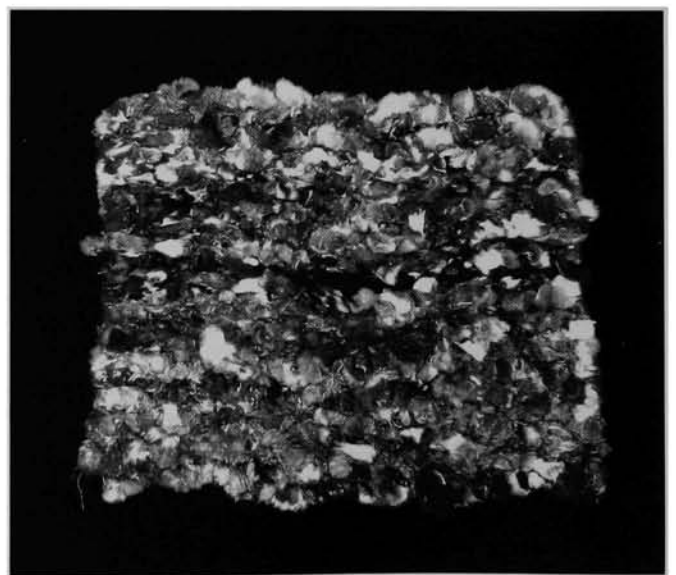


*Figure 3. Paviotso Paiute woman, Stillwater Nevada (1924).  
(National Museum of the American Indian, Smithsonian Institution, #9673)*

style with the fur cord wefts running over one warp and under one warp. The warps are three-ply z-spun S-twist (z-S) cordage; the wefts appear to be made of the same type of cordage, which was then wrapped with strips of rabbit skin. The reproduction is rectangular in shape; and is approximately 95 cm. long, 80 cm. wide, and 4 cm. thick.

### METHODS

Two separate experiments were performed to determine the thermal properties of the rabbit skin robe reproduction. Test A was designed to determine the relative warmth of the rabbit skin robe in comparison to modern clothing or sleeping items, while Test B was designed to determine the thermal conductivity (k-value) of the robe, and discover the intrinsic thermal value of the material.

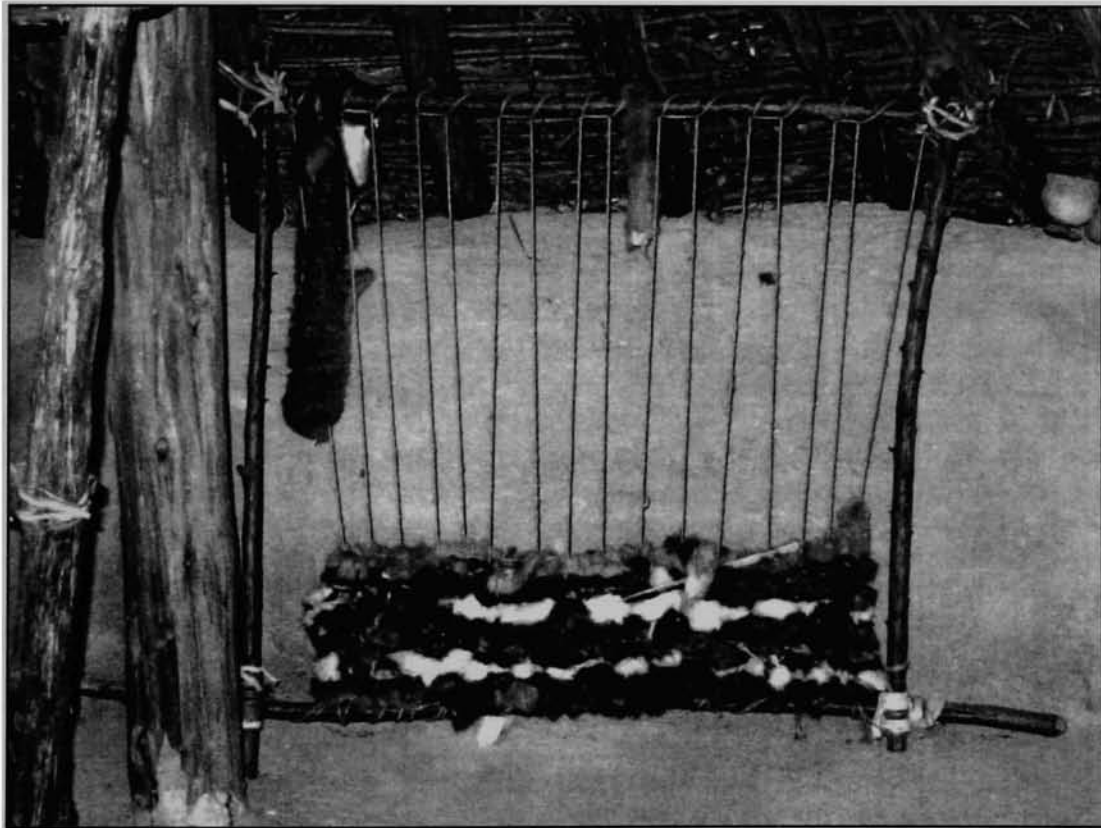


*Figure 4. Rabbit skin robe reproduction from Fremont Indian State Park in Sevier, Utah.*

In Test A, two-liter plastic water bladders were filled with warm water (34°C-41° C) and then had electronic thermometers attached to their surface. A water bladder with attached thermometer was placed inside the specimen being tested; the specimen was then transferred into a walk-in freezer, which was maintained at a steady temperature between -5° C to -10° C, and was placed on a table. Measurements were taken at ten-minute intervals for 140 minutes, in order to record the temperature loss of the water bladders. Specimens were tested within the freezer two at a time, and were matched in the following way: rabbit skin robe reproduction and down coat; wool blanket and sleeping bag; and a synthetic coat, which was tested by itself. The construction of the rabbit skin robe reproduction is discussed above. The down coat was an “Overcast, Down” model with an outer shell and inner lining of 100 percent nylon and a filler of FTC 80/20 goose down; it had an approximate thickness of 4 cm. The wool blanket was constructed of 85 percent wool and 15

percent cotton, and had an approximate thickness of 2.2 cm. The sleeping bag was a “Sierra Designs, Midnight Delight” model constructed from a 100 percent polyester fiber known as Polarguard 3D; it had an approximate thickness of 6 cm. The synthetic coat was a “Columbia Titanium, Ice Dragon Parka” model constructed with an outer shell of 100 percent nylon, an inner lining of 50 percent nylon and 50 percent polyester, and a zip-in fleece liner of 95 percent polyester and 5 percent spandex; it had a total thickness of approximately 0.3 cm. Because the temperatures of the water bladders varied slightly at the outset of each test, the temperatures were standardized for easy comparison. This was done by converting the temperature of each water bladder into a percentage. Each degree of temperature that was lost for a given water bladder was also converted to a percentage and then subtracted from the original.

Test B was designed to determine the thermal conductivity  $k$  (W/m\*K) of the rabbit skin robe reproduction. Thermal conductivity is an intrinsic value



*Figure 5. Vertical frame on which the rabbit skin robe reproduction was woven, located at Fremont Indian State Park in Sevier, Utah. Note the fiber cordage warps and the fur cord wefts.*

of all materials, and is a measure of the rate of heat flow through a given amount of material for a given temperature difference. The parameter which expresses the intrinsic insulative value of the rabbit skin robe or other materials, independent of the geometry, is the thermal conductivity  $k$ . A low  $k$  corresponds to a low rate of heat transfer through the material. Coupling this with the thickness  $L$  (m) of the material allows us to determine the rate of heat conduction through the material per unit area, or heat flux  $q''$  ( $W/m^2$ ), according to the empirical formula known as Fourier's law:

$$(1) \quad q'' = -k \cdot \frac{dT}{dx}$$

$$(2) \quad \text{with } q'' = \frac{q}{A}$$

Here  $T$  (K) is the temperature distribution in the direction  $x$  of the thickness of the material and  $A$  ( $m^2$ ) is the surface area over which the temperature gradient exists. Allowing the material to reach steady state makes the derivative collapse to a simple difference, and upon combining with (2), (1) reduces to:

$$(3) \quad q = -k \cdot A \cdot \frac{\Delta T_m}{L}$$

where  $\Delta T_m$  is the difference in temperature through the material. Strictly speaking, the experiments were not conducted at steady state. However, the time rates of temperature change (several degrees per hour) were small enough that equation (3) could be used to analyze the heat flow through the rabbit skin robe and other material.

In order for (3) to be useful, we must determine the heat flux  $q''$  through the material. To accomplish this, Test B was designed in the following manner (Fig. 6 and 7).

A rectangular piece of insulation had a circular hole (16 cm. in diameter) cut out of the center so that it could be placed over a hot plate and would sit flush with the surface. The rabbit skin robe was laid on top of the insulation and hotplate, so that only a  $0.02 \text{ m}^2$  circular area came in contact with the hotplate surface. Another piece of insulation of the same dimensions as the first was placed on top of the rabbit skin robe. This second

piece of insulation also had a circular hole (16 cm.) cut out of the center, exactly over the area where the hotplate surface was located. A steel gallon can (316 g) was placed in the circular hole in the insulation and filled with 751 ml of water at approximately  $1^\circ \text{C}$ . A cardboard box with a circular hole in the bottom was placed over the steel can and slid down so that it sat flush with the second piece of insulation. The steel can (which was now within the box) was surrounded by insulation and the box was closed. This was done to minimize error due to heat transfer to the can from its surroundings. A small hole was placed in the lid of the cardboard box and steel can so that a thermometer could be placed through these and into the water. The hotplate was turned on and monitored with a thermocouple to make sure the temperature stayed at a constant  $53^\circ \text{C}$ . The temperature change of the water inside the steel can was measured every two to three minutes for approximately one hour. Measuring the increase in temperature of the water within the steel can allowed us to determine the rate at which heat was entering the can, using the following formula:

$$(4) \quad q = C_p \cdot \frac{\Delta T_w}{\Delta t}$$

Here,  $C_p$  is the total thermal mass of the water (J/K) and steel can and  $\Delta T_w$  is the change in temperature of the water and the steel can over a time interval  $\Delta t$  (sec).

The can was filled with 751 ml. of water close to freezing, while the hotplate was set to a temperature of  $53^\circ \text{C}$ . The large temperature difference between the can and the hotplate allowed us to approximate the difference in temperature through the material ( $\Delta T_m$ ) to be constant with a small change in the temperature of the water and can over time,  $\Delta T_w$  (less than  $5^\circ \text{C}$ ).

Insulation and a stirring rod were used to reduce error from heat transfer in the can and heat transfer to the can from the atmosphere. However, despite these measures, heat did enter the steel can through the surrounding atmosphere, as was expected. To correct for this, an experimental run was made without a hotplate to "calibrate" the experimental data collected on other runs. This calibration was used to determine the rate of heat entering the can due to the environment. This heat

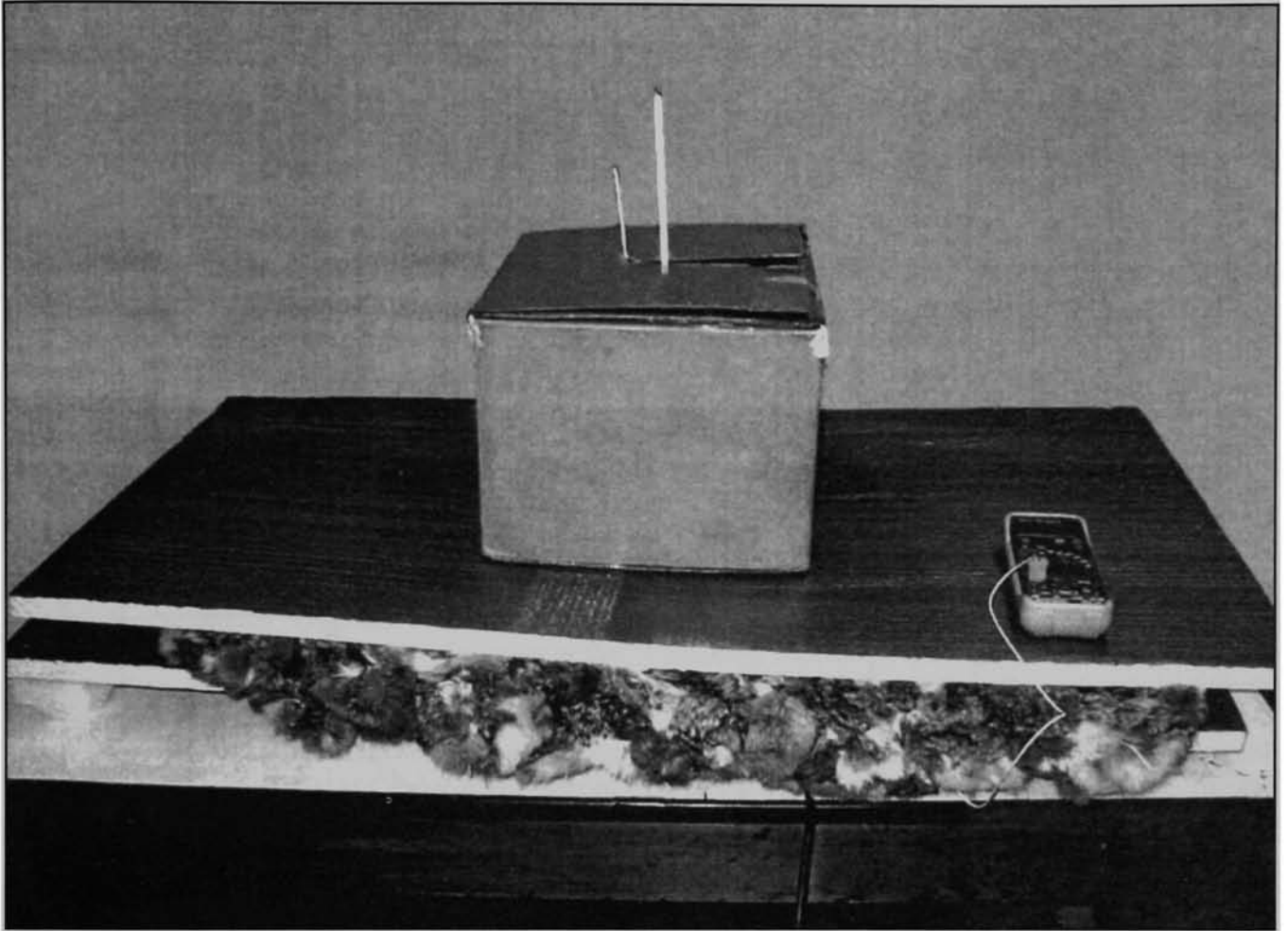


Figure 6. Experimental set up for Test B.

rate was simply subtracted from the heat rate found while using the hotplate. The new heat rate was then used to determine the thermal conductivity by dividing the temperature difference and the area over which the heat was transferred through the robe. This number was then multiplied by the thickness of the robe to produce the thermal conductivity as shown in equation (3).

Data collection for each test involved measuring the temperature of the water in the can over a sufficient time interval to determine the heat rate, the temperature at which the hotplate was maintained, the thickness of the test material, the amount of time over which the experiment was run, the amount of water in the can, the mass of the can itself, and the surface area between the hot plate and the can. The heat capacity of the steel can was estimated to be that of carbon steel.

## DATA

Test A was designed to determine the relative warmth of the rabbit skin robe in comparison to modern clothing or sleeping items. This was done by measuring the amount of temperature loss over time for the experimental items. During the 140-minute testing period, the water bladder within the rabbit skin robe retained 89 percent of its heat ( $5^{\circ}\text{C}$  loss), the water bladder within the sleeping bag retained 87 percent of its heat ( $6^{\circ}\text{C}$  loss), the water bladder within the down coat retained 80 percent of its heat ( $9^{\circ}\text{C}$  loss), the water bladder within the synthetic coat retained 78 percent of its heat ( $10^{\circ}\text{C}$  loss), and the water bladder within the wool blanket retained 71 percent of its heat ( $14^{\circ}\text{C}$  loss). Figure 8 shows the standardized data represented graphically.



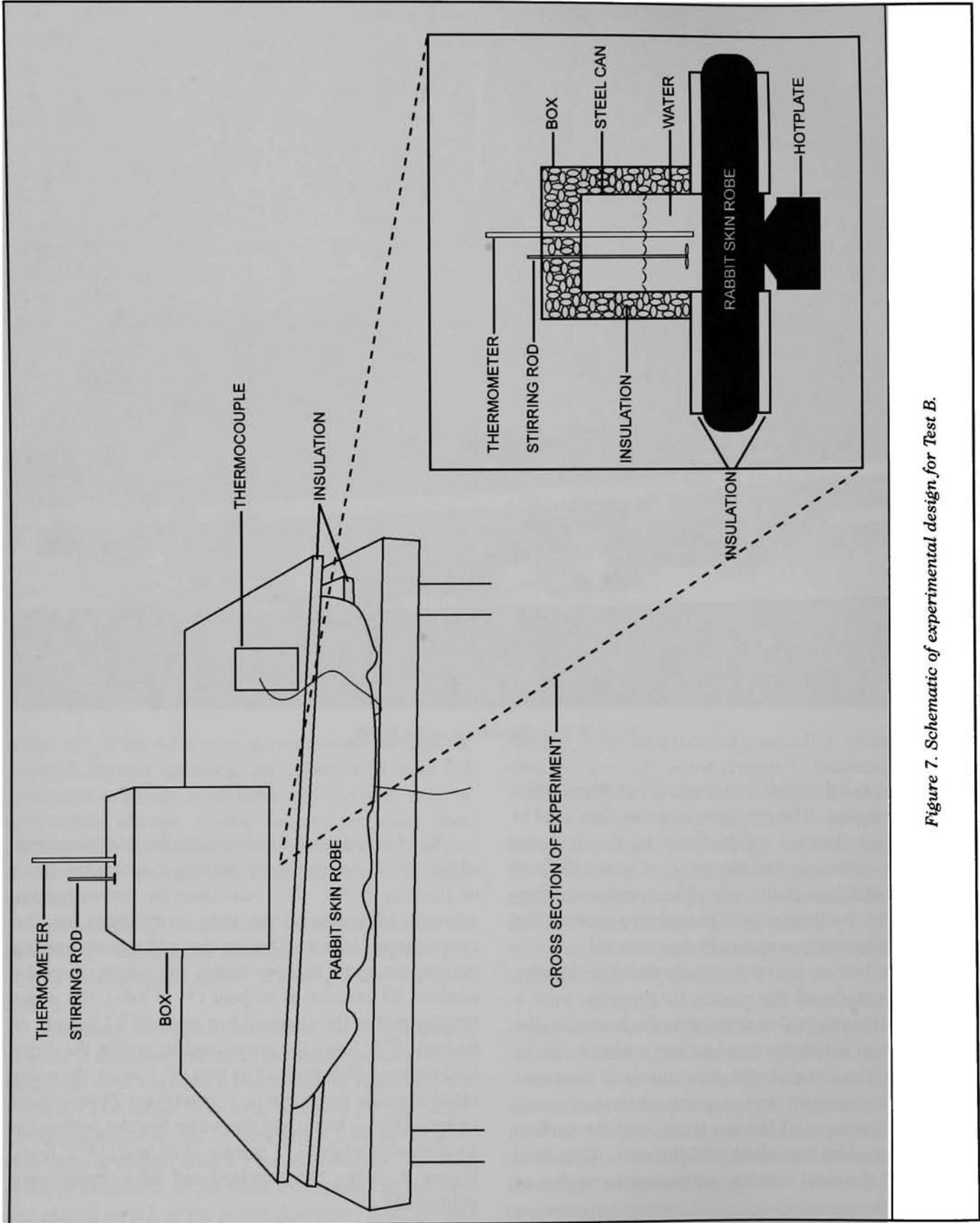


Figure 7. Schematic of experimental design for Test B.

In Test B, the experimental run for the rabbit skin robe reproduction gave a temperature increase of  $4.1^{\circ}\text{C}$  over approximately one hour, while the experimental run for the wool blanket gave a temperature increase of  $2.9^{\circ}\text{C}$  over approximately 15 minutes (Fig. 9). After correcting from the calibration run, which used 902 ml of water giving a heat rate of 3.01W, the rabbit skin robe had a heat rate of 0.78W and the wool blanket a heat rate of 10.14W. Solving for the thermal conductivity using equations (3) and (4) gives  $0.031\text{W/m}^{\circ}\text{K}$  for the rabbit skin and  $0.035\text{W/m}^{\circ}\text{K}$  for the wool blanket.

## DISCUSSION

The results of both tests are rather straightforward. In Test A, which was designed to show the relative warmth of the items being tested, the rabbit skin robe reproduction and the sleeping bag outperformed all other items in heat retention. Over the 140-minute testing period, the rabbit skin robe lost only 11 percent of the total heat from its water bladder, followed closely by the sleeping bag, which lost only 13 percent of the total heat from its bladder. Both items lost heat at a fairly constant rate of approximately  $1^{\circ}\text{C}$  every 20-30 minutes. The two coats that were tested came in third and fourth in heat retention. They fared roughly the same, with the down coat losing 20 percent of the total heat from its water bladder, and the synthetic coat losing 22 percent of the total heat from its bladder. The rate of heat loss was similar between the two coats, with both losing approximately  $1^{\circ}\text{C}$  every 10-20 minutes. Finally, the wool blanket came in last, losing 29 percent of the total heat from its water bladder at an almost constant rate of  $1^{\circ}\text{C}$  every 10 minutes (Table 1).

Although these results seem straightforward, it must be remembered that the items tested have considerably different thicknesses and weight. The rabbit skin robe reproduction and the sleeping bag were the warmest items relative to the others, but they were also two of the thicker items tested, and the rabbit skin robe weighed much more than any other article of clothing or bedding. Another factor to consider is the cut and overall fit of the tested items. The rabbit skin robe is a very basic type of covering which does not conform well to the body. When worn by an active individual (someone in motion), cold air would certainly be able to flow into the robe from the open bottom and from closures in the front. Although the modern coats did not score as well

in Test A, they conform much better to the body both at rest and in motion. They eliminate most cold airflow by means of elastic and various ties, pull strings, and other attachments. In sum, the rabbit skin robe retains heat better than the other items tested, but this might be offset by other benefits in the modern items, which are lightweight and form-fitting in comparison.

Convective currents carry heat away much more efficiently than still air, thus destroying the insulative value of a material. Insulation, both modern and ancient, employs small fibers to hold air still so that convective currents are not generated. In practical terms, the lowest  $k$  value a low-cost insulating material can achieve is the  $k$  value of air. Based on Test B, the rabbit skin robe is significantly less conductive than wool, and has conductivity values close to those of air ( $0.026\text{W/m}^{\circ}\text{K}$ ). By this evaluation, rabbit skin robes are very warm. However, more sensitive testing would have to be carried out to determine the actual thermal conductivity more precisely. More sensitive testing could be accomplished by better isolating the test from the environment; it would require cutting the rabbit skin robe to obtain a small sample of the material. Since the preservation of the robe was important, such testing was not feasible for this experiment.

The majority of the heat gain in Test B came from the atmosphere, through the insulated box. This could have resulted in a large error in the measured thermal conductivity. Despite the poor insulation of the box, the measured thermal conductivity of the wool fell in the range of reported values ( $0.03\text{-}0.04\text{W/m}^{\circ}\text{K}$ ). This suggests that fairly accurate values could still be obtained after correcting for ambient heat gain.

## CONCLUSION

Because ethnographic accounts of rabbit skin robes and blankets state that these items were very warm, modern anthropologists have simply assumed that these statements were true without further investigation. In addition, common sense would suggest that because of advances in fiber and material technology, modern apparel and bedding would be much warmer than their prehistoric counterparts. This paper has tested these ideas by establishing both a relative and a standard baseline for the warmth of rabbit skin robes, and has found that they are, in fact, very warm items of clothing and bedding that outperform their modern counterparts in basic heat retention. Determining the

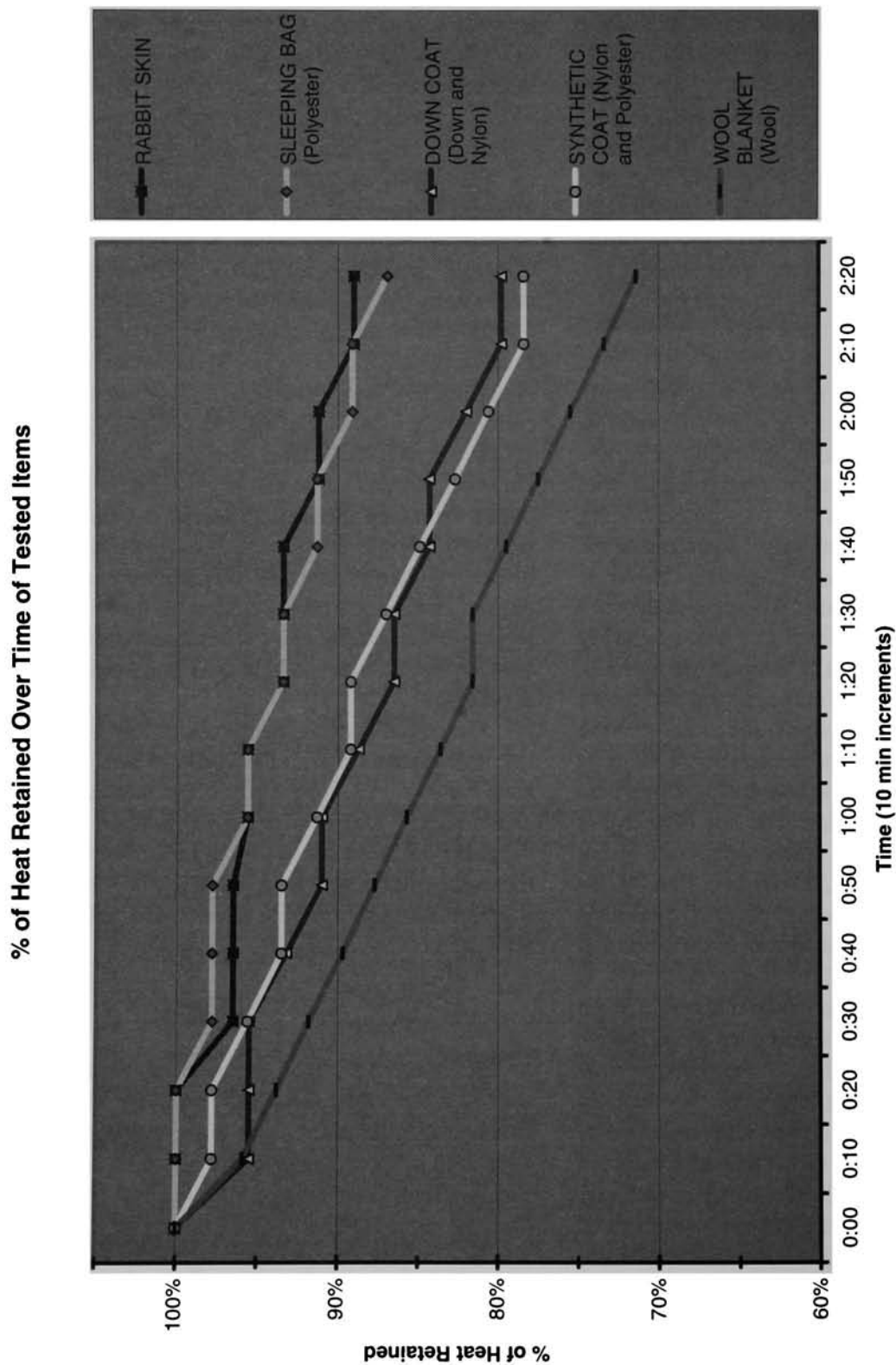


Figure 8. Results from Test A, represented graphically.

Temperature Gain Over Time of Tested Items

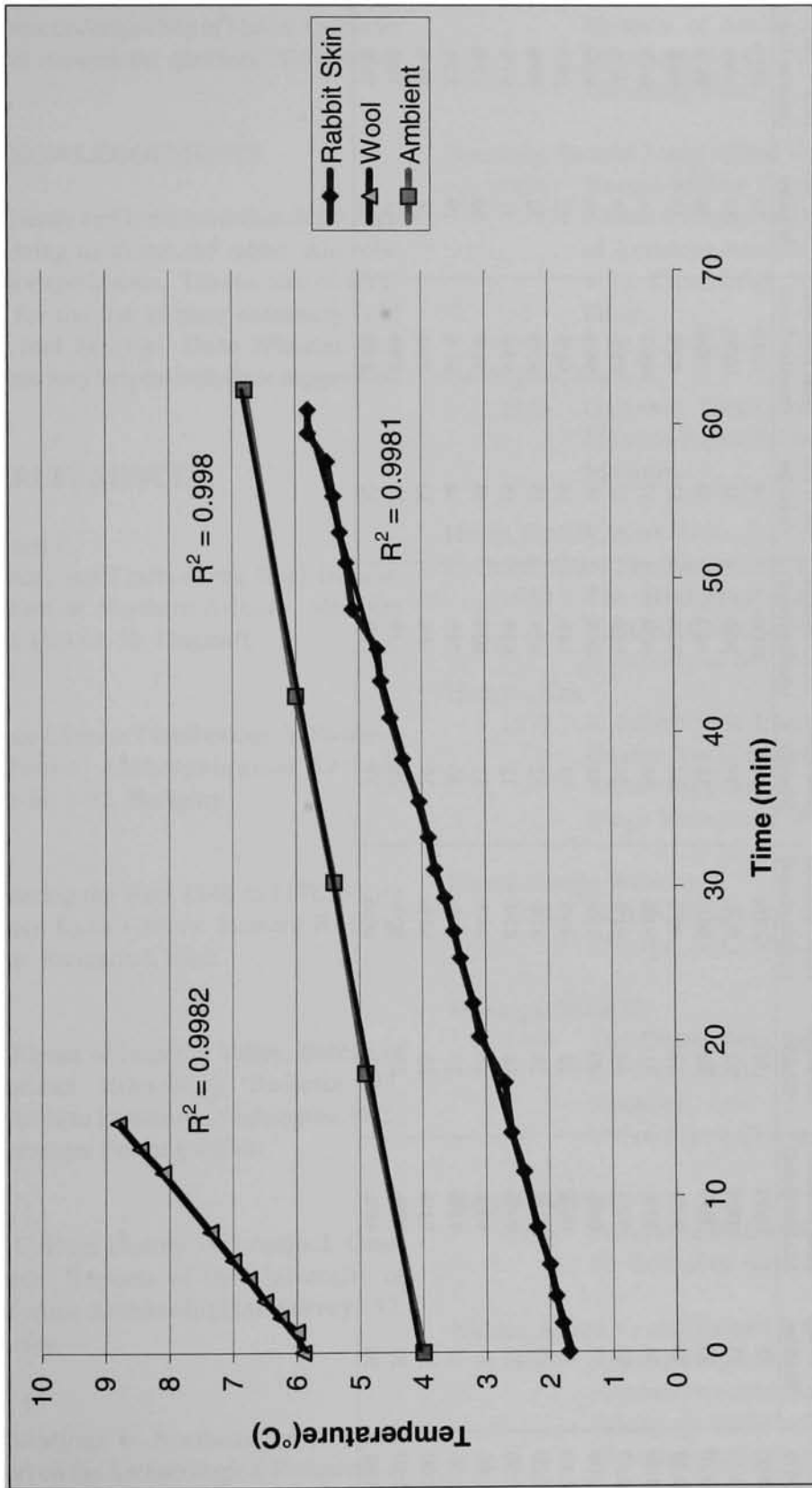


Figure 9. Results from Test B, represented graphically.

**Table 1**  
**RESULTS FOR TEST A (BOTH ORIGINAL AND STANDARDIZED DATA)**

| Time | Rabbit Skin Robe             |                              | Down Coat                    |                              | Wool Blanket                 |                              | Sleeping Bag                 |                              | Synthetic Coat               |                              |
|------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|
|      | Temperature Of Water Bladder | Heat Retained (standardized) | Temperature Of Water Bladder | Heat Retained (standardized) | Temperature Of Water Bladder | Heat Retained (standardized) | Temperature Of Water Bladder | Heat Retained (standardized) | Temperature Of Water Bladder | Heat Retained (standardized) |
| 0:00 | 35                           | 100%                         | 34                           | 100%                         | 41                           | 100%                         | 38                           | 100%                         | 37                           | 100%                         |
| 0:10 | 35                           | 100%                         | 32                           | 96%                          | 39                           | 96%                          | 38                           | 100%                         | 36                           | 98%                          |
| 0:20 | 35                           | 100%                         | 32                           | 96%                          | 38                           | 94%                          | 38                           | 100%                         | 36                           | 98%                          |
| 0:30 | 34                           | 97%                          | 32                           | 96%                          | 37                           | 92%                          | 37                           | 98%                          | 35                           | 96%                          |
| 0:40 | 34                           | 97%                          | 31                           | 93%                          | 36                           | 90%                          | 37                           | 98%                          | 34                           | 94%                          |
| 0:50 | 34                           | 97%                          | 30                           | 91%                          | 35                           | 88%                          | 37                           | 98%                          | 34                           | 94%                          |
| 1:00 | 33                           | 96%                          | 30                           | 91%                          | 34                           | 86%                          | 36                           | 96%                          | 33                           | 91%                          |
| 1:10 | 33                           | 96%                          | 29                           | 89%                          | 33                           | 84%                          | 36                           | 96%                          | 32                           | 89%                          |
| 1:20 | 32                           | 93%                          | 28                           | 87%                          | 32                           | 82%                          | 35                           | 93%                          | 32                           | 89%                          |
| 1:30 | 32                           | 93%                          | 28                           | 87%                          | 32                           | 82%                          | 35                           | 93%                          | 31                           | 87%                          |
| 1:40 | 32                           | 93%                          | 27                           | 84%                          | 31                           | 80%                          | 34                           | 91%                          | 30                           | 85%                          |
| 1:50 | 31                           | 91%                          | 27                           | 84%                          | 30                           | 78%                          | 34                           | 91%                          | 29                           | 83%                          |
| 2:00 | 31                           | 91%                          | 26                           | 82%                          | 29                           | 76%                          | 33                           | 89%                          | 28                           | 81%                          |
| 2:10 | 30                           | 89%                          | 25                           | 80%                          | 28                           | 73%                          | 33                           | 89%                          | 27                           | 78%                          |
| 2:20 | 30                           | 89%                          | 25                           | 80%                          | 27                           | 71%                          | 32                           | 87%                          | 27                           | 78%                          |

thermal properties of rabbit skin robes and blankets gives anthropologists a better understanding of Native American material culture, and answers the question, "How warm were they?"

### ACKNOWLEDGEMENTS

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