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The New Element Mendeleevium, Atomic Number 101

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THE NEW ELEMENT MENDELEVIUM, ATOMIC NUMBER 101

A. Ghiorso, B. G. Harvey, G. R. Choppin, S. G. Thompson,  
and G. T. Seaborg

April 4, 1955

Printed for the U. S. Atomic Energy Commission

The New Element Mendeleevium, Atomic Number 101

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and G. T. Seaborg  
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University of California, Berkeley, California

April 4, 1955

We have produced and chemically identified for the first time a few atoms of the element with atomic number 101. Very intense helium ion bombardments of tiny targets of  $99^{253}$  have produced a few spontaneously fissionable atoms which elute in the eka-thulium position on a cation resin column.

The method of production utilized the following techniques. In a special position in the Crocker Laboratory 60-inch cyclotron a very concentrated collimated beam of 48-Mev helium ions (as much as 10 microamperes in an area  $1/32 \times 1/4$  inch) was allowed to pass through a degrading absorber and then through a 2-mil gold foil (yielding 41-Mev helium ions). On the back side of the gold foil approximately  $10^9$  atoms<sup>1</sup> of the 20-day  $99^{253}$  were electroplated in the beam area. From this target the nuclear transmutation recoils were ejected in a narrow spray and caught on 0.1-mil gold foil adjacent to the target. The gold foil was quickly dissolved in aqua regia, the gold extracted with ethyl acetate, and the aqueous phase eluted through a Dowex-1 anion resin column with 6 M HCl to complete the removal of gold and other impurities. The drops containing the actinide fraction were evaporated and the activity was then eluted through a Dowex-50 resin cation column with ammonium  $\alpha$ -hydroxy-isobutyrate<sup>2</sup> to separate the various actinide elements from each other. The radiations from the

various fractions were then examined with various types of counters.

The earliest experiments were confined to looking for short-lived alpha emitting isotopes of element 101 such as  $101^{255}$  and  $101^{253}$  that would be expected from  $(\alpha, 2n)$  and  $(\alpha, 4n)$  reactions. For this purpose it was sufficient to look quickly in the gross actinide fraction as separated by the anion resin column alone. No alpha activity was observed that could be attributed to element 101 even when the time between the end of bombardment and the beginning of alpha pulse analysis had been reduced to 5 minutes. To ascertain that a proper recoil and chemical yield was being obtained a small amount of  $\text{Cm}^{244}$  was included in the target so that the  $\text{Cf}^{246}$  and  $\text{Cf}^{244}$  produced by the helium ion beam would serve as a monitor.

Longer bombardments were then made, and a few spontaneous fission events were observed over a period of several hours in the actinide fractions. At this time the cation resin column procedure was then added to the chemistry so that we could distinguish between elements 101 and 100. The initial experiments were confined to fission counting of the trans-100 and the 100 fractions. Several experiments were consistent in their demonstration of spontaneous fissions occurring in both fractions. To determine more precisely the elution position of the element responsible for the trans-100 spontaneous fission activity a more elaborate experiment was undertaken. Three successive three-hour bombardments were made and in turn their transmutation products were separated quickly on a cation resin column. The isotope  $99^{253}$  was added in each case so that together with the  $\text{Cf}^{246}$  produced it would help to calibrate the column run. Five spontaneous fission counters

were then used to count simultaneously the corresponding drops of eluent from the three runs. The combined and normalized elution curve is shown in Fig. 1. That the drops did not correspond exactly in each run is indicated on the spontaneous fission histogram by the overlapping of the relative drop number limits of the activities that were placed in each counter. By combining the data from all experiments the half-life of the spontaneous fission activity in the 101 and 100 fractions was found to be approximately the same, perhaps 3 to 4 hours as shown in Fig. 2.

Obviously there is insufficient evidence to define the mass numbers concerned in this experiment. However, recent experimental observations of the spontaneous fission decay rates<sup>3</sup> of odd nucleon types indicate that they are hindered by factors of thousands. If we then apply this principle to this experiment it is tempting to draw the following conclusions. By an ( $\alpha, n$ ) reaction on  $99^{253}$  we have produced the isotope  $101^{256}$  which decays by electron capture with a half-life of the order of a half hour to  $100^{256}$ ; this isotope then decays by spontaneous fission with a half-life of the order of 3 to 4 hours. (Since no alpha activity is observed we can rule out the 3.2-hour isotope  $100^{254}$  as being responsible for the spontaneous fission activity on the basis of its known alpha to fission ratio of 1550.) In a total of eight separate experiments we have isolated only 17 atoms of 101 so it has not yet been possible to demonstrate this proposed genetic relationship between  $101^{256}$  and  $100^{256}$ . However another experiment<sup>4</sup> has shown that  $100^{256}$  does have a spontaneous fission half-life of about 3 hours.

The proof that these experiments resulted in the identification of element 101 is as follows:

1. Only the very heaviest elements decay by spontaneous fission with such short half-lives.
2. The elution position immediately ahead of element 100 shows that the chemical properties are those of an element heavier than 100, and probably 101 rather than 102.
3. By this method of production, it would not be possible to produce an element above 101.

We would like to suggest the name mendelevium, symbol Mv, for the new element in recognition of the pioneering role of the great Russian chemist, Dmitri Mendeleev, who was the first to use the periodic system of the elements to predict the chemical properties of undiscovered elements, a principle which has been the key to the discovery of the last seven transuranium (actinide) elements.

We should like to acknowledge the fact that this work was greatly facilitated by the reshaping of the magnetic field of the Crocker Laboratory 60-inch cyclotron so as to secure a more concentrated ion beam. This modification was successfully carried out under the expert supervision of G. B. Rossi and is reported in another letter.<sup>5</sup> In this same communication will be found a more detailed description of the special deflector channel probe used in these bombardments. In this connection we should like to express our appreciation to C. A. Corum for his expert collaboration in the design of this probe. To G. B. Rossi, W. B. Jones, and the crew of the 60-inch cyclotron we extend our thanks for their patience and careful manipulation of the machine which made the bombardments successful. We should like to thank T. O. Parsons, R. Silva,



and A. Chetham-Strode for their considerable assistance. We should also like to express our appreciation to Professor J. G. Hamilton, director of the Crocker Laboratory, for his help and cooperation and to Professor E. O. Lawrence for his continued interest in this program of research.

This work was performed under the auspices of the U. S. Atomic Energy Commission.

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1. The  $99^{253}$  target atoms were made by intense neutron bombardment of  $Cf^{252}$  and the subsequent beta decay of  $Cf^{253}$ . We would like to thank the personnel of the Materials Testing Reactor in Idaho for their very expeditious handling of this bombardment.
  2. Choppin, Harvey, Thompson, unpublished information.
  3. Unpublished data in this laboratory.
  4. Choppin, Harvey, Thompson, and Ghiorso, Phys. Rev. (this issue).
  5. G. B. Rossi and C. A. Corum, Phys. Rev. (this issue).

FIGURE CAPTIONS

- Fig. 1. Elution of elements 98-101 from Dowex-50 column with ammonium  $\alpha$ -hydroxy-isobutyrate.
- Fig. 2. Spontaneous fission decay curve of element 100 and element 101 fractions.

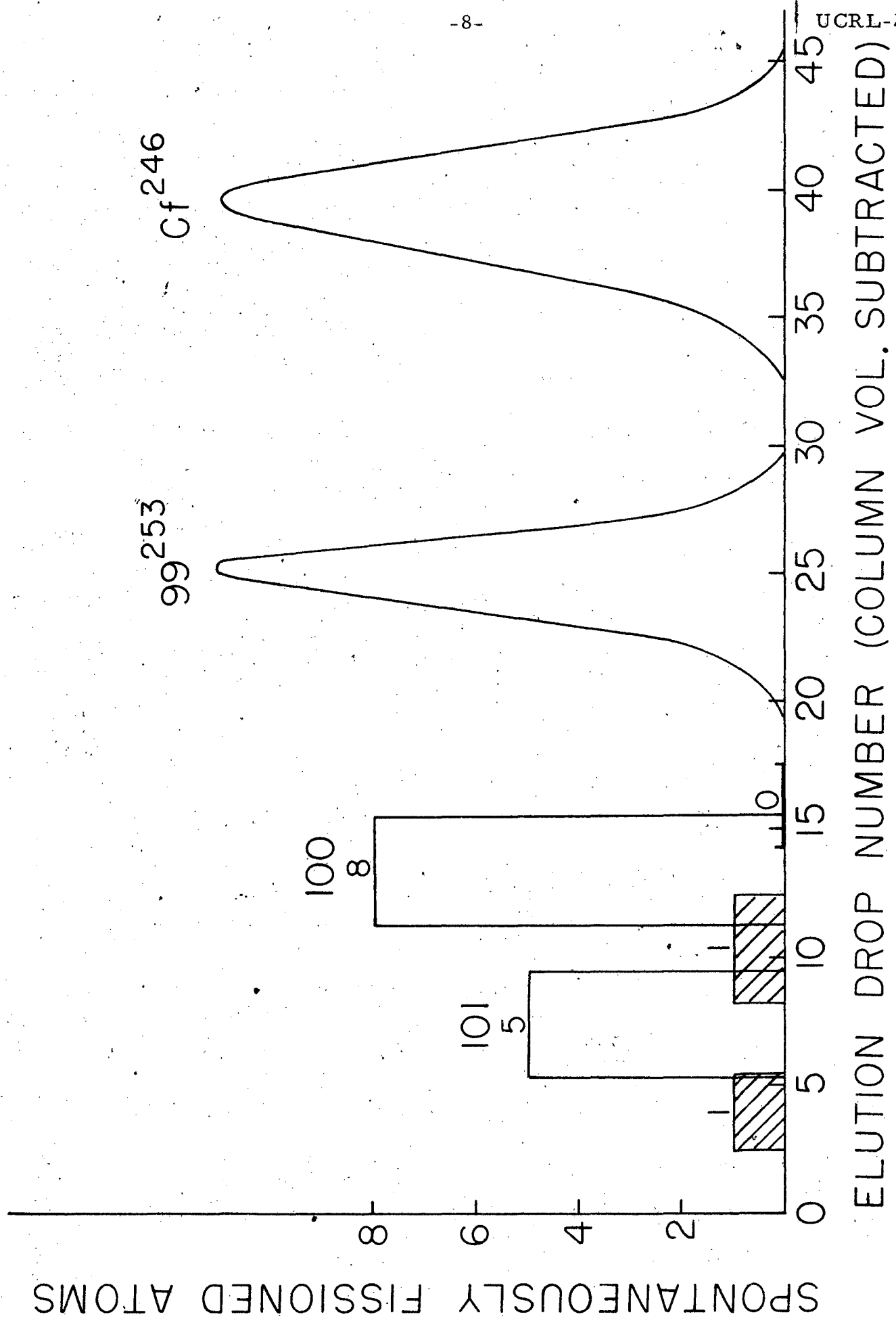


Fig. 1

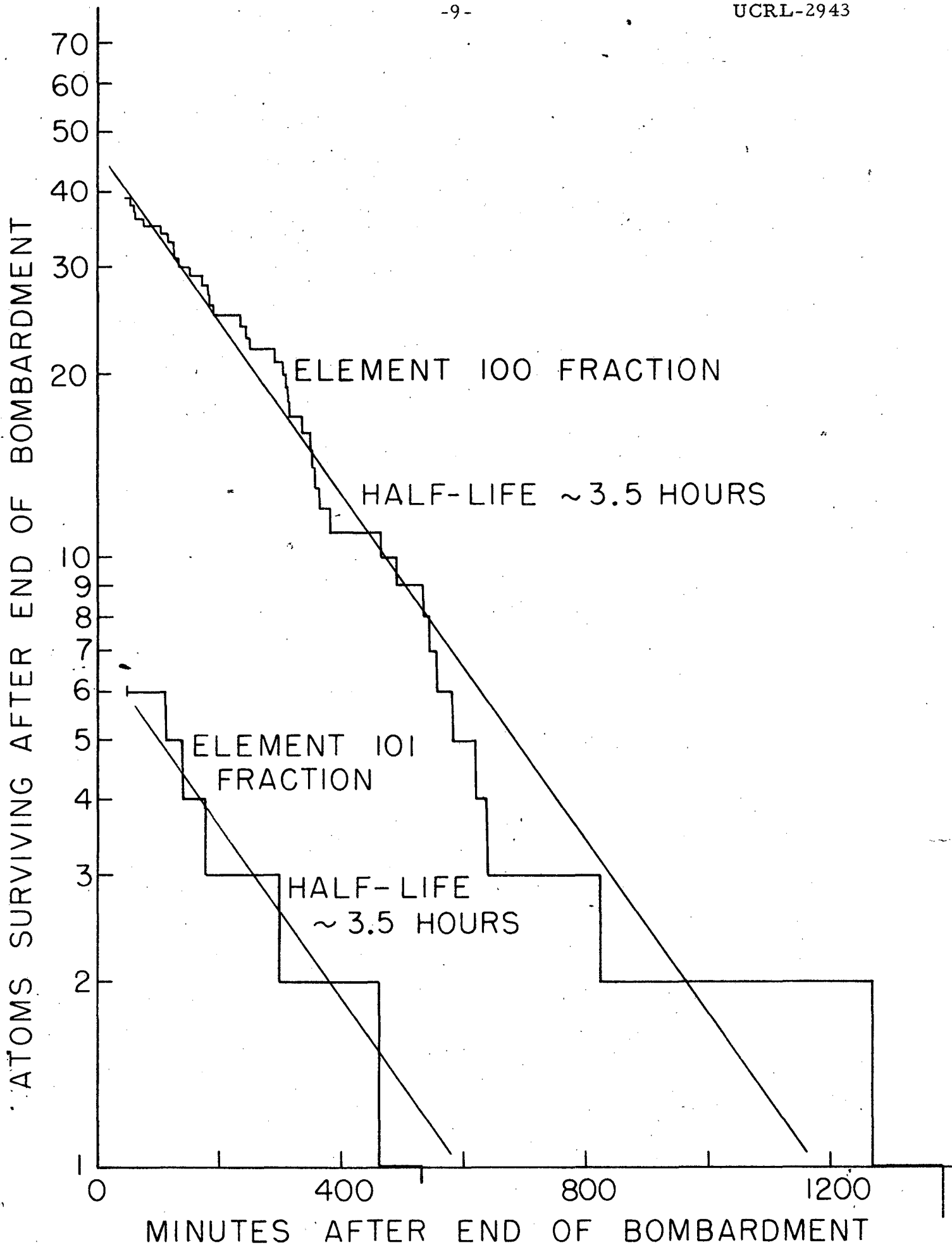


Fig. 2