UCRL-16239

University of California

Ernest O. Lawrence Radiation Laboratory

EFFECT OF PRESSURE ON EUROPIUM METAL

Berkeley, California

UCRL-16239

UNIVERSITY OF CALIFORNIA
Lawrence Radiation Laboratory
Berkeley, California

AEC Contract No. W-7405-eng-48

EFFECT OF PRESSURE ON EUROPIUM METAL

G. Jura and P. C. Souers

June 1965

EFFECT OF PRESSURE ON EUROPIUM METAL

G. Jura and P. C. Souers

Inorganic Materials Research Division, Lawrence Radiation Laboratory,
and Department of Chemistry, College of Chemistry,
University of California, Berkeley, California

June 1965

ABSTRACT

The electrical resistance of europium metal has been studied to loads above 300 kbars and in the temperature region 77° to 300°K. A room temperature resistance peak was found at a load of 325 kbars (pressure, probably about 200 kbars). No peak was found at -75°C up to a load of 230 kbars. The Néel point was studied between 20 and 90 kbars. The value of $\frac{dT_N}{dp}$ lies in the region zero to +0.1 degree/kbar. These results agree with the published data.

Some work has been done on europium under pressure. Spedding et al.[1] found a smooth decrease in volume between 2 and 12 kbars at 77°K and 300°K. Stephens[2] found a smooth volume decrease between 4 and 43 kbars at room temperature. Stromberg and Stephens[3] also found a smooth increase in electrical resistance to 160 kbars at room temperature. Stager and Drickamer[4] are the first to report evidence of a high pressure phase transition. They find a resistance peak at 175, 190, and 210 kbars at 296°, 197°, and 77°K respectively.

In measuring the electrical resistance of europium as a function of temperature at 1 atmosphere, Curry et al.[5] found a peak at 90°±0.3°K. Olsen et al.[6] found a magnetic transition at 87°±1°K by neutron diffraction. They showed europium to be antiferromagnetic below this temperature and paramagnetic above. The presence of a transition between 86° and 90°K has also been confirmed by Mössbauer resonance.[7] Stager and Drickamer[4] studied the Néel transition under pressure, using electrical resistance. They found T_N to occur at about 100°, 110°, and 110° at 85, 310, and 460 kbars respectively.

The europium was analyzed by emission spectroscopy and no impurities were present within the limits of detection.[8] The europium was extruded into sodium-dried benzene in the form of 3-mil diameter wire. The europium was then handled in a glove box with an argon atmosphere dried by phosphorus pentoxide. Some samples were annealed under argon for several minutes at 400°C and some were not. It did not seem to make any difference. In any case, the light oxide film was scraped off only at the ends of each wire. The europium wires were then built into the usual silver chloride samples.[9] The silver chloride discs in the sample were covered with clear acrylate paint to prevent reaction with the europium. The sample was sealed at the edges with the acrylate paint to maintain dry argon near the europium until compressed.

Bridgman anvils were used. The measurement techniques for pressure, temperature, and resistance, as well as pressure calibration, have been discussed.[10] Room temperature pressure calibration, good to about 100 kbars, was used to all temperatures. Runs at 198°K were obtained by immersing the bare anvils and sample in dry ice-isopropyl alcohol. For the Néel point measurements, the bare anvils were immersed in liquid nitrogen, which was allowed to boil off slowly. This rather crude method caused temperature differences of 15° to 20° across the sample.

The electrical resistance was studied at room temperature from a pressure of 3 kbars to loads well over 300. The best run is shown in Fig. 1. A resistance peak is found at a load of 325 kbars going up and at 85 kbars going down. Only this run showed the full peak. Three other runs showed the peak starting to rise at a load of about 200 kbars but the anvils broke. Since no pressure calibration above 100 kbars was available, only loads (values read off the strain guage) were recorded. The 325 kbar peak value is probably less due to deformation of the anvils. Our peak is probably the same found by Stager and Drickamer at 175 kbars.

At -75°C, the resistance was examined between 10 kbars and a top load of 230. The resistance increased slightly, but the peak seen by Stager and Drickamer was not reached.

The Néel points were measured between 20 and 90 kbars. Our points are shown in Fig. 2. Curry's[5] one atmosphere point and Stager and Drickamer's[4] 85 kbar point are also included. From the data, $\frac{dT_N}{dp}$ lies between zero and +0.1 degrees/kbar. It is not possible to be more accurate for the following reason. Curry's resistance curve showed an actual peak at the Néel point.

Our curves, taken under less ideal conditions, do not show a peak but only a change in slope. It is difficult, therefore to compare the results. Stager and Drickamer's 85 kbar curve shows a peak, but there are not enough points in the Néel point region to be sure of the value of T_N. Since their Néel point has risen to only 110°K at 460 kbars, this is further evidence that the effect of pressure is not very great.

ACKNOWLEDGMENT

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

REFERENCES

1. F. H. Spedding, J. J. Hanak, and A. H. Daane, Trans. Met. Soc. AIME 212, 379-383 (1958).

2. D. R. Stephens, J. Phys. Chem. Solids, 25, 423-429 (1964).

3. H. D. Stromberg and D. R. Stephens, J. Phys. Chem. Solids, 25, 1015-1022 (1964).

4. R. A. Stager and H. G. Drickamer, Phys. Rev., 133A, 830-5 (1964).

5. M. A. Curry, S. Legvold, and F. H. Spedding, Phys. Rev., 117, 953-954 (1960); See too C. E. Olsen, USAEC LASL-2406, 21 (1960).

6. C. E. Olsen, N. G. Nereson, and G. P. Arnold, J. Appl. Phys., 33 Suppl, 1135-1136 (1962).

7. P. H. Barrett and D. A. Shirley, Phys. Rev., 131, 123-127 (1963).

8. The europium was produced by the Michigan Chemical Corporation, St. Louis, Michigan. It was given to us by Harold Stromberg. The analysis was performed by G. Shalimoff of this laboratory.

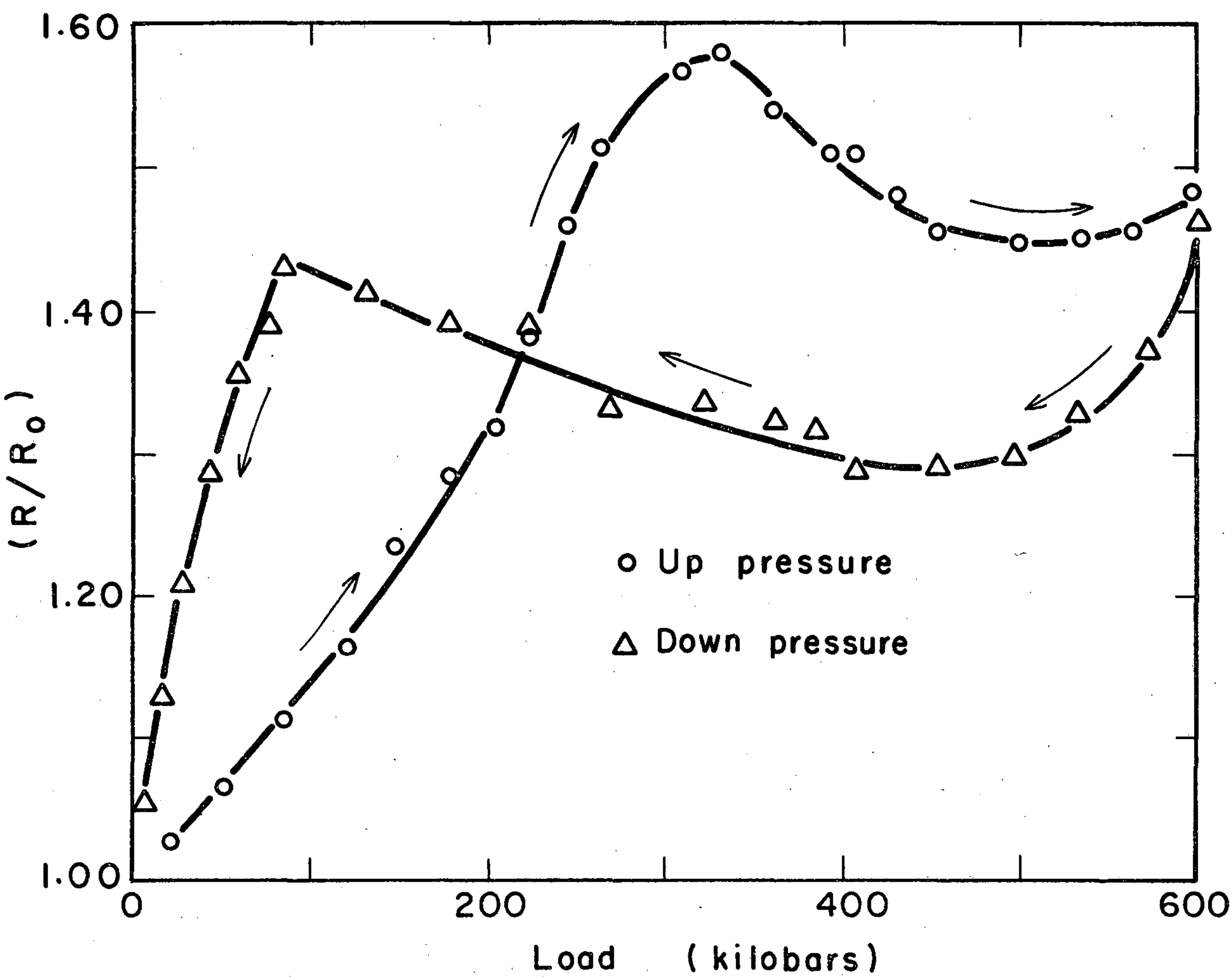
9. P. W. Montgomery, H. D. Stromberg, G. H. Jura, and G. Jura, in High Pressure Measurement, A. A. Giardini and E. E. Lloyd, Eds. (Butterworths, Washington, 1963) p. 1.

10. P. C. Souers and G. Jura, Science, 140, 481 (1963). Also reference 9.

FIGURE CAPTIONS

Fig. 1 Change of electrical resistance of europium metal with load (uncorrected strain gauge reading).

Fig. 2 Néel point of europium metal as a function of pressure.



MUB-6997

Fig. 1

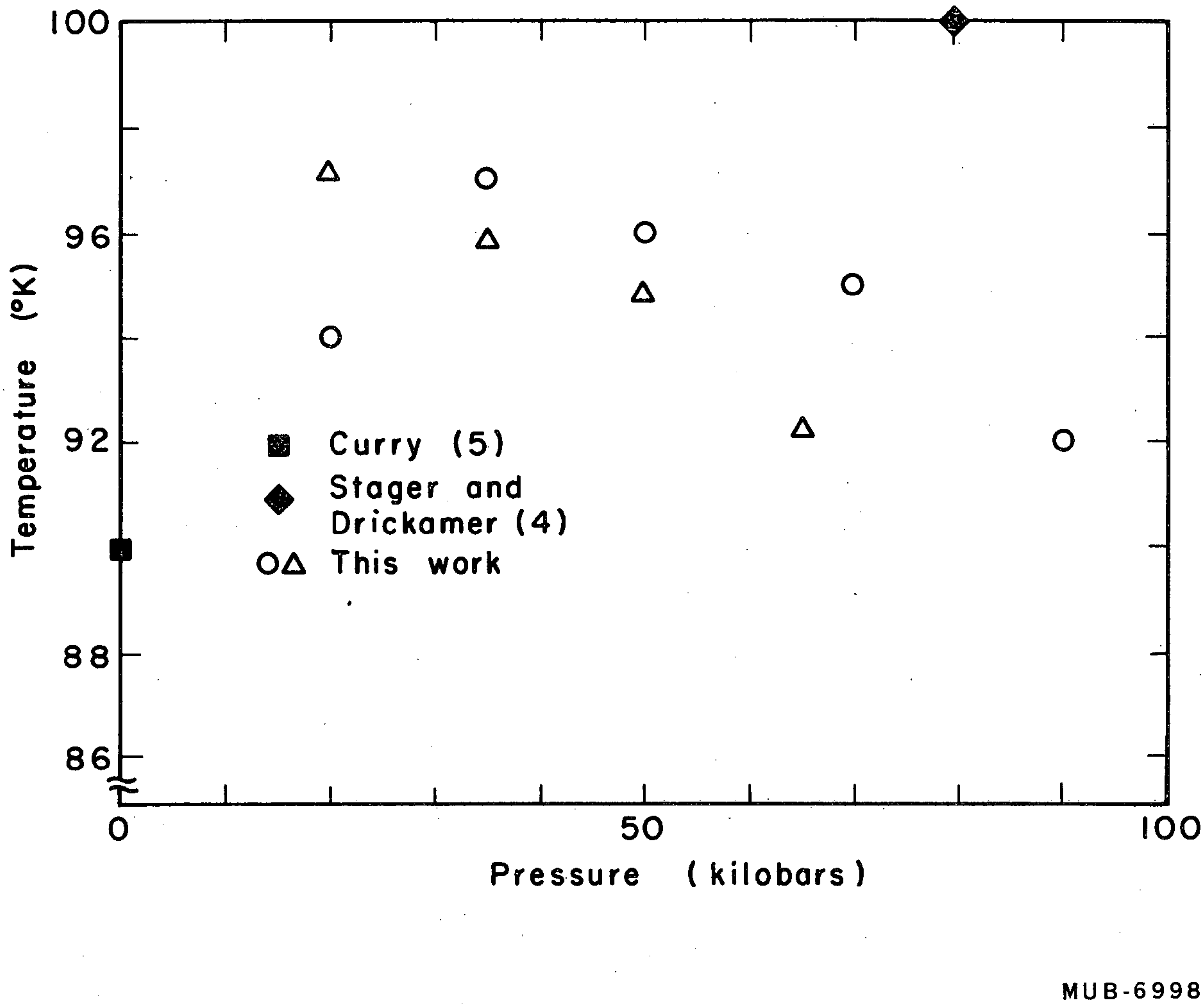

100
96
92
88
86
Temperature (°K)
0
50
100
Pressure (kilobars)
Curry (5)
Stager and Drickamer (4)
This work
MUB-6998

Fig. 2