The Albian core is located a little to the north of the former Darwin Rise (Fig. 1). The lithology, fauna, and seismic results suggest that Shatsky Rise may have been a sedimentary basin during Mesozoic time, receiving fragments of shallow marine organisms that inhabited the fringes of nearby atolls or islands on the Darwin Rise; this idea could explain the presence of shallow-water mollusc shells and *Inoceramus* prisms in pelagic sediments. Sometime after early Cretaceous, this basin was uplifted. It appears that the greater thickness of the layers on Shatsky Rise, than of those of the adjacent Pacific floor, results from subsidence and subsequent deposition; and that the subsidence and deposition continued, perhaps in a narrowing belt, considerably beyond Albian time, until uplift to the present position occurred. Determination of the exact age of this uplift must await more cores from Shatsky Rise. We cannot preclude the possibility, however, that the basement arch forming Shatsky Rise is older than the sediments, and that the thickness of the sedimentary layer results from a type of deposition in which the rate is greater in lesser depths. This hypothesis, however, does not explain the presence of *Inoceramus* prisms and molluscs in pelagic sediments of V 21-143.

Zverev, Kobylin, and Udintsev (*36*) reported seismic-reflection traverses over Shatsky Rise very near the traverse in Fig. 1; they assigned sound velocities to the various layers on the basis of the observed amplitude of reflected signals and of Rayleigh's formula relating reflection coefficient to sound velocity and density. Despite the well-known limitations of this method of estimating velocity, they have produced cross sections showing basaltic rocks, probably of Hawaiian type, outcropping near the crest of the rise. If such outcrops are present in the section of Fig. 2, they are the small peaks in sheets 839, 844, and 845.

On the more-northerly crossing of the rise (Figs. 1 and 2) the maximum elevation is about the same as that on the southern crossing; the sediment cover is far less regular, and cores V 21-147 and 148 (Fig. 2) consist of radiolarian clay and red clay respectively. These results suggest that during future work, when the profiler is used to guide selection of coring sites, a substantially larger number of older Tertiary and Mesozoic cores will be obtained from the rise. For example, a steep slope, shown in sheet 839 (Fig. 2), appears to be an even-better site than the source of core 143.

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Superconductivity of Alpha-Uranium and the Role of 5f Electrons

Abstract. *A much sharper and lower superconducting transition has been found for α-uranium than any reported previously. A model that explains the unusual volume dependence of α-uranium below 43°K and the unusual pressure dependence of its superconducting transition temperature is presented.*

We report the superconducting transition of a single crystal of α-uranium. This transition (T_c), between 0.21° and 0.25°K, is sharper by about an order of magnitude and occurs at a much lower temperature than that previously reported for α-uranium (*1–3*). Such behavior was anticipated in the recent work on superconductivity in β-uranium (*4*), although at that time a consideration of published heat-capacity data led to an estimate that T_c would be < 0.15°K. A qualitative model involving the gradual transfer of electrons from the *6d–7sp* band (*5*) to an almost pure *5f* band below 43°K is offered to account for the unusual behavior of α-uranium at low temperatures (see *6, 7*).

The superconducting transition of a small single crystal of α-uranium (approximately 1 by 3 by 5 mm, heavily etched and without any sharp edges) grown by the grain-coarsening technique (*8*) is shown in Fig. 1. The transition is representative of pure α-uranium in a relatively unstrained condition and is not complicated by the presence of filaments of other phases. The small tail

above 0.25°K is presumably due to small residual strains. The sample appeared to be an imperfect type II superconductor as judged by its properties in a magnetic field. A flux jump at 22 gauss was reproducibly observed upon the first application of the magnetic field in a given direction. A magnetic field of 90 gauss was sufficient to destroy all but a few percent of the superconductivity at 0.015°K. The thermodynamic cricital field at $T = 0$, calculated from the measured electronic heat capacity (*9*) (12.1×10^4 erg mole^{-1} deg^{-2}), is 56 gauss. An effort was made to measure the Meissner effect in this sample by warming and cooling it through the superconducting transition in a constant external field ranging from 0.1 to 40 gauss. Within the experimental error, a signal indicating 10 percent of the full Meissner effect was observed. This is not so large as would be expected for a single crystal annealed in high vacuum near its melting point; however, it is considered satisfactory for a crystal which, as in the present case, cannot be so treated.

We shall now attempt to explain a number of the unusual properties of α-uranium at low temperatures, specifically: (i) the anomalous increase in volume below 43°K (*7*); (ii) the exceptionally large and positive pressure dependence of the superconducting transition temperature (*3*); (iii) the extremely broad superconducting transition even in annealed polycrystalline samples (*1–3*).

With respect to (i) the volume change suggests the presence of an almost pure 5*f*-like band which in unstrained α-uranium is populated below 43°K to a small extent. The unit cell volume of α-uranium decreases nearly linearly with temperature between 298°K and 50°K and has a broad minimum at about 43°K (*7*). The contraction corresponds to a volume coefficient of 46×10^{-6} per degree. Between 50° and 4.2°K the volume increases by 0.27 percent, and thus the volume at 4.2°K is 0.44 percent larger than that expected from the normal behavior between 298°K and 43°K (*7*).

The interatomic distances in α-uranium above 43°K (as well as the β and γ forms) are consistent with the presence of six electrons in the primarily 6*d*–7*sp* bands and no electron in the pure 5*f* band (*10*). Since spatially 5*f* electrons will be more localized than 6*d* electrons, they contribute significantly less to the cohesive forces (the shielding of a 5*f* electron is empirically estimated to be about 90 percent effective) (*10*). The demotion of electrons from the 6*d*–7*sp* band to the essentially nonbonding 5*f* band causes a volume increase. Specifically, if the number of valence electrons in uranium metal were reduced from six to five, the resulting volume expansion would be about 11 percent (the effective metallic radii are 1.56 Å for hexavalent and 1.62 Å for pentavalent uranium). The unusual behavior of α-uranium below 43°K is analogous to that observed for the δ-phases of plutonium metal (*11*). The δ modifications have much lower densities than the adjoining γ- and ϵ-phases, and throughout their entire existence range, from 476° to 319°C, the δ-phases expand with decreasing temperature (*12*). The anomalously increased volume of α-uranium at 4.2°K may thus be explained by the presence of 0.04 electron per uranium atom in the 5*f* band.

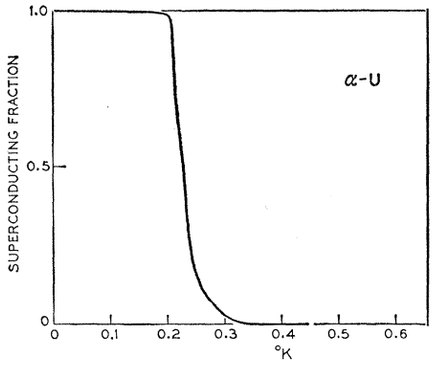

Fig. 1. Superconducting transition for a single crystal of α-uranium measured at 22 cy/sec with a field 0.05 gauss applied along the [020] direction.

With respect to (ii), Smith and Gardner (*3*) have reported that the superconducting transition temperature of uranium, observed as a function of pressure, increased rapidly to between 2.05° and 2.37°K at 10 kb. The plot of T_c as a function of pressure suggests that further application of pressure above 10 kb would have a relatively small effect on T_c (*13*). These results can be explained on the assumption that the occupancy of the 5*f* band decreases as pressure is applied (compare cerium, *14*) and that, above 10 kb, the band rises above the Fermi level and there is then little change in T_c as a function of pressure.

According to our model, the rise in transition temperature from 0.2° to 2.2°K with pressure is due to the transfer of about 0.04 electron per uranium atom from the *f* to the *d*-like band. The rate of change of transition temperature with 5*f* electrons is almost the same as that for 4*f* electrons (produced by alloying with Gd) in La (*15*). The model suggests, therefore, that the 5*f* electrons are capable of destroying the Cooper-paired electrons in the superconducting state just as efficiently as are 4*f* electrons. The magnetic susceptibility on the other hand shows no visible evidence of 5*f* electrons in α-uranium (*16*); in this it is similar to the magnetic behavior of δ-Pu (*17*). A number of different models can be invoked to explain the lack of response of the susceptibility to 5*f* electrons, but, until the magnetic behavior of the elements from Pa to Cm is better understood, it is premature to try to distinguish between them.

The unique behavior of α-uranium is further emphasized by considering the pressure dependence of T_c of the stabilized β- and γ-phases of uranium. Two β-phase samples, stabilized by the addition of either 2 atomic percent of Pt (T_c, 0.87°K) or 2 atomic percent of Rh (T_c, 0.96°K), were subjected to a pressure of $\sim$ 9.5 kb. Neither sample was superconductive above 1.2°K. A γ-phase sample, stabilized by 15 atomic percent of Mo ($T_c = 2.08$°K at atmospheric pressure), exhibited a pressure dependence of $\partial T_c/\partial P \sim 0.9 \times 10^{-5}$ deg K bar^{-1} which is an order of magnitude lower than that observed for α-uranium (*3*). In addition, the superconducting transition temperature of the compounds U_6Fe and U_6Mn ($T_c =$ 3.88°K and 2.23°K, respectively) was found to be independent of pressure up to 10 kb (*13*). The sharpness of the superconducting transition in all these phases, together with the absence of any appreciable pressure dependence, is taken as evidence for the absence of any 5*f* character.

With respect to (iii) the broad superconducting transitions observed in polycrystalline α-uranium can be divided into two groups: those ranging from about 0.8° to 1.3°K, and those ranging from about 0.2° to 0.7°K. (Representative transitions are given in Fig. 4 of the paper by Hein, Henry, and Wolcott, *2*.) Recent superconductivity results (*4*) led to the suggestion that the transitions above 0.8°K are due to filaments of stabilized β- or γ-phases of uranium. Further experiments performed in the course of the present investigation reinforce this suggestion (*18*).

It is difficult to decide to what extent the presence of filaments is responsible for the broad transitions below 0.7°K. Furthermore, the presence of filaments cannot convincingly explain the observed (*3*) pressure dependence of T_c above 1.3°K. However, no such difficulty exists with the present model, which suggests that the broadening of the transition below 0.7°K might equally well be due to the presence of an inhomogeneous strain field. The development of this strain throughout part of the sample is unavoidable during the cooling of polycrystalline material because of the highly anisotropic nature of the thermal expansion below 43°K. A crude estimate of the maximum internal pressure developed can be made from a consideration of the measured volume increase (0.27 percent) of a single crystal between 50°K and 4.2°K (*7*). If we assume that the total volume increase is effective in producing the internal pressure, with a compressibility of 9×10^{-7} bar^{-1}, the pressure developed is expected to be of the order of 3 kb. Such a pressure would be sufficient to account for the difference in the superconducting transitions of single-crystal and polycrystalline material. It would seem that such pressures are easily generated at grain boundaries since other uranium samples prepared by the grain-coarsening technique, but containing more than one single-crystal grain, have broad transitions similar to those reported by Hein, Henry, and Wolcott (*2*).

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19. We thank a number of our colleagues for helpful discussions, particularly A. M. Clogston, Mrs. V. B. Compton, W. E. Gardner, W. M. Lomer, and N. E. Phillips; and G. W. Hull, Jr. for help with the superconductivity measurements. Work at Argonne National Laboratory supported by AEC. Work at La Jolla supported in part by U.S. Air Force Office of Scientific Research.

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Contact Photomicrography in the Ultraviolet on High-Resolution Plates

Abstract. *Ultraviolet photographs of cells can be made without quartz optics by placing the cells on high-resolution plates capable of resolving more than 2000 lines per millimeter and by passing monochromatic radiation of the desired wavelength through them to the emulsion. Prints can be made by enlarging the resulting negative with a microscope to the magnification desired.*

Kodak high-resolution plates, originally marketed for microphotography (*1*), proved usable for contact photomicrography with 2300- to 3650-angstrom radiation. Thus, minute biological subjects, tissue cultures, or thin sections can be photographed in the ultraviolet without recourse to quartz microscope lenses (*2*). The properties of the plates that make contact photomicrography possible with intense radiation are: (i) extremely high resolution, at least 2000 lines per millimeter, sufficient to permit enlargement of the negative 1000 times with minimum or no grain notable in prints or lantern slides; (ii) very slow speed (the ASA rating is currently 0.003); (iii) extreme contrast; and (iv) thin emulsion that obviates scattering of light in the emulsion plane.

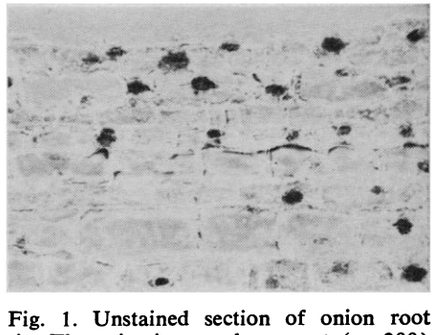

Fig. 1. Unstained section of onion root tip. The print is an enlargement (× 200) from a contact negative made with 2600-angstrom monochromatic radiation. Absorbance by nuclei is clearly shown.