Table II. Pressure-Induced Deformations

Material	k_c/k_a	Pressure, kbars								
		1	2	3	4	5	10	15	20	26
Cadmium	11.27	GBM	GBM	GBM S T	GBM S T	GBM S T	GBM S T	GBM S T	GBM S T MS	GBM S T MS
Zinc	7.55	X	X	GBM S	GBM S	GBM S	GBM S	GBM S	GBM S T MS	–
Bismuth	2.43	X	X	GBM	GBM S	GBM S	GBM S MS	GBM S MS	GBM S MS	Transformation
Tin	1.11	–	–	–	–	X	X	X	X	GBM
Zirconium	0.86	–	–	–	–	–	–	–	X	X
Magnesium	1.04	–	–	–	–	–	–	–	X	X
Copper	1.00	–	–	–	–	–	–	–	X	X
Iron	1.00	–	–	–	–	–	–	–	X	X

GBM = grain-boundary migration,
S = slip,
T = twinning,
MS = multiple slip,
X = no deformation.

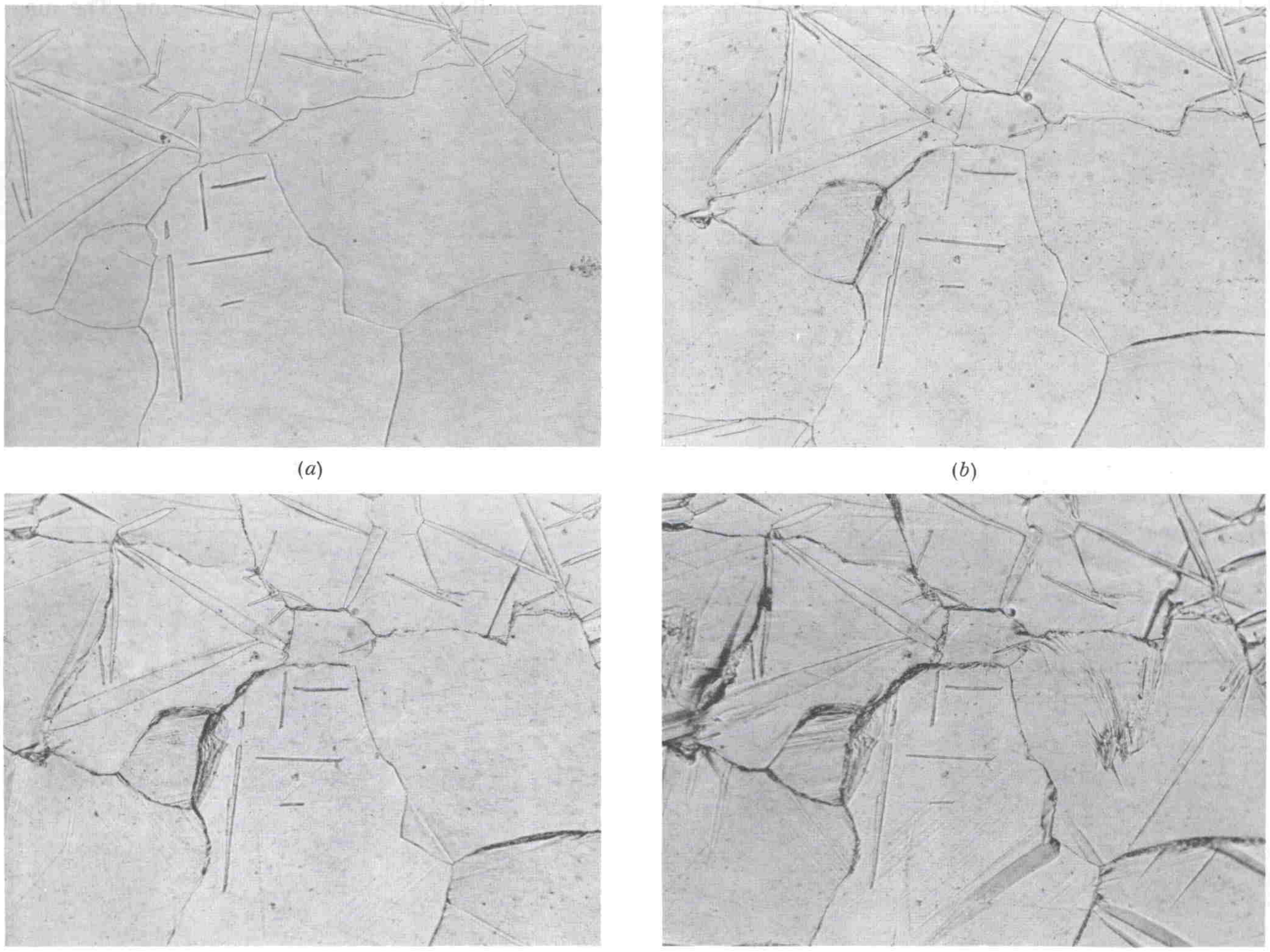
(*a*) (*b*)
(*c*) (*d*)

Fig. 1—Structural changes in polycrystalline cadmium induced by hydrostatic pressure. (*a*) Original structure; (*b*) after 4000 bars; (*c*) after 10,000 bars; (*d*) after 20,000 bars. X100. Reduced approximately 10 pct for reproduction.

tion, which was in the form of boundary migration, became detectable by optical microscopy after pressurizing to 1 kbar with a similar observation for zinc and bismuth at 3 kbars. In the case of tin, the first detectable flow, which was in the form of boundary migration, did not occur until pressures of 26 kbars.

It is apparent from Table II that the propensity to deform under a hydrostatic pressure is related directly to the degree of anisotropy in the linear compressibility. No deformation was observed in the case of copper and iron which are isotropic, nor in zirconium and magnesium which have quite low degrees of anisotropy. Tn, which required a pressure of 26 kbars to initiate plastic flow, is slightly anisotropic whereas bismuth, zinc, and cadmium, which exhibited severe deformation initiating at quite low pressures, are highly anisotropic. It is suspected that zirconium and magnesium would also exhibit pressure-induced plastic flow at some higher pressure than that possible in the equipment used in this experiment. However, due to the low degree of anisotropy and higher strength of magnesium and zirconium, the pressure to cause plastic flow would probably be quite high as compared to the four lower-strength metals in which flow was observed. Vu[5] found no deformation in aluminum, copper, and magnesium which had been pressurized to 9 kbars. In earlier work, Johannin and Vu[6] did observe isolated regions of multiple slip in a single crystal of 24 pct Zn α brass. However, alloy segregation is suspected which could result in localized anisotropy of the linear compressibility. Thus, only unconstrained pure or chemically homogeneous single crystals and totally isotropic polycrystalline metals will not have internal shear stresses introduced by a superimposed hydrostatic pressure. In the case of even slightly anisotropic materials, internal shear stresses will occur and, if the pressure is high enough, microscopic plastic flow will result. This may be an important consideration when attempting to measure pressure effects on structure-sensitive properties of anisotropic polycrystalline materials.

The type of deformation observed in zinc, cadmium, tin, and, for comparison purposes from previous work, bismuth is shown in Figs. 1 to 4, respectively, and the approximate pressure at which each type was observed is summarized in Table II. In all cases, the initiation of deformation was principally in the form of boundary migration with some simultaneous slip observed in zinc. The mag-

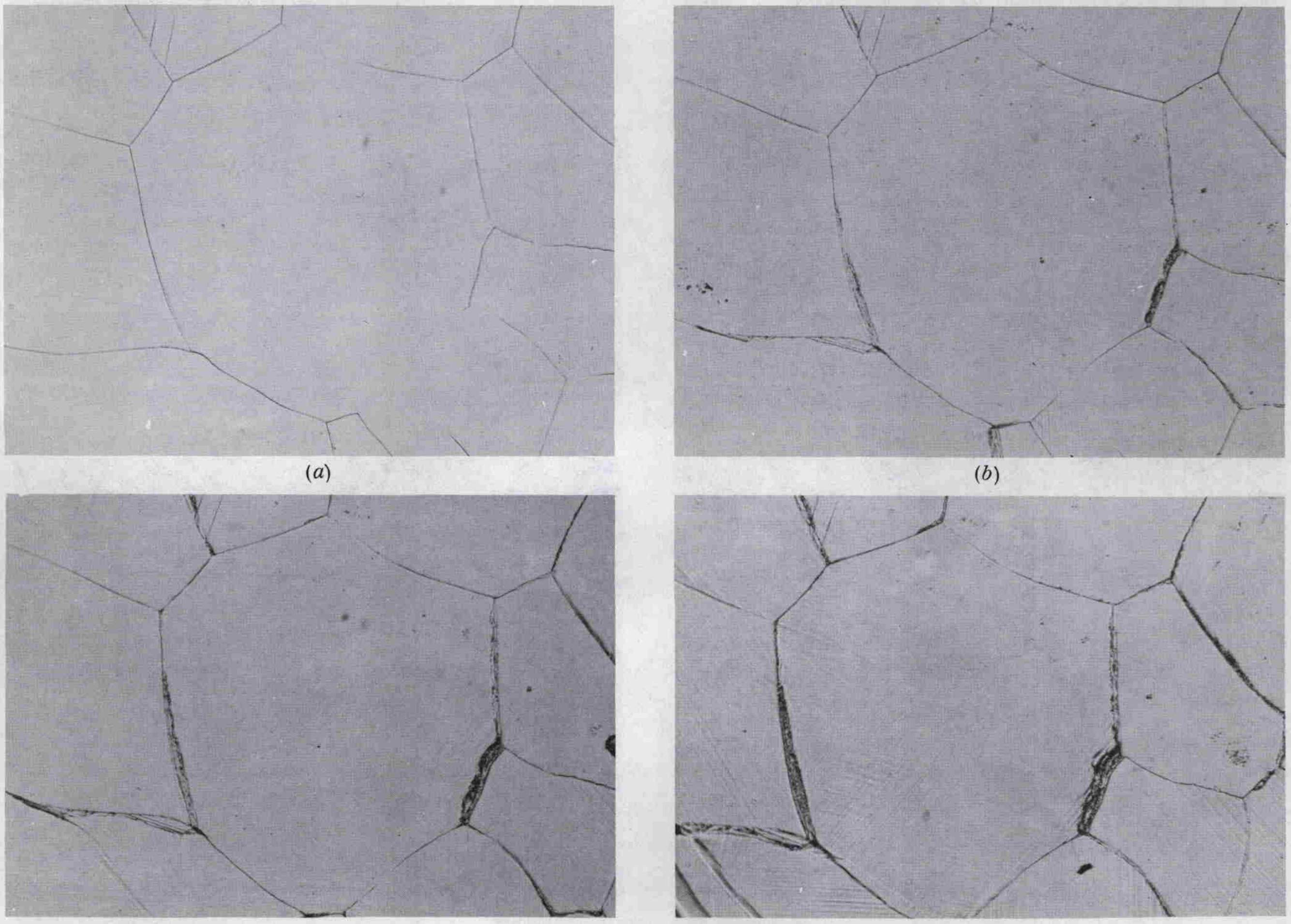
(*a*) (*b*) (*c*) (*d*)

Fig. 2—Structural changes in polycrystalline zinc induced by hydrostatic pressure. (*a*) Original structure; (*b*) after 5000 bars; (*c*) after 10,000 bars; (*d*) after 20,000 bars. X100. Reduced approximately 10 pct for reproduction.