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AN IN SITU STUDY OF PRISMATIC GLIDE IN HCP METALS

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The prismatic glide in two HCP metals, Magnesium and Beryllium, has been studied by in situ deformation in a Jeol 200 CX electron microscope. Microsamples are cut in single crystals, and oriented so as to inhibit basal glide.

1 - MAGNESIUM [1-3]

Between 200 K and 650 K, the deformation is achieved by the glide of straight screw dislocations, submitted to a strong friction force. This observation leads to the conclusion that the strain rate is controlled by a Peierls mechanism acting on screws, with a thermally activated nucleation and propagation of kink pairs (Friedel-Escaig, or pseudo-Peierls mechanism) (Fig. 1).

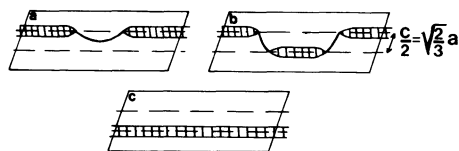


Fig. 1 - Mechanism of glide in a prismatic plane in Magnesium, by nucleation and propagation of kink pairs. Screw dislocations are always dissociated in the basal plane (note a mistake in the $c/2$ distance in [1,3]).

Sources and multiplication mechanisms on open and closed loops have also been observed. The velocity of screw dislocations is proportional to their length, in agreement to the model. The measurement of the velocity of screw dislocations as a function of stress and temperature leads to the determination of the microscopic activation area ($9b^2$ at 300 K) and microscopic activation energy (0.8 eV between 300 and 373 K) (Fig. 2).

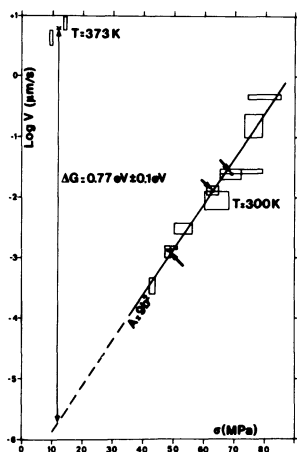


Fig. 2 - Experimental determination of the microscopic activation area and energy of screw dislocations gliding in a prismatic plane, in Mg.

All these results are in agreement with macroscopic results, provided the latter are corrected from some artefacts, and with theoretical developments of the models.

2 - BERYLLIUM [3]

Like in Magnesium, the deformation is controlled by the movement of rectilinear screw dislocations, between 300 K and 432 K. However, contrary to the case of Magnesium, screw dislocations in prismatic planes of Beryllium have a jerky movement, corresponding to thermally activated locking and unlocking followed by very rapid glide. Locking is a cross slip from prismatic to basal plane, i.e. from a plane of high stacking fault energy (metastable configuration) to a plane of lower stacking fault energy (more stable configuration), and unlocking is the reverse mechanism (Fig. 3).

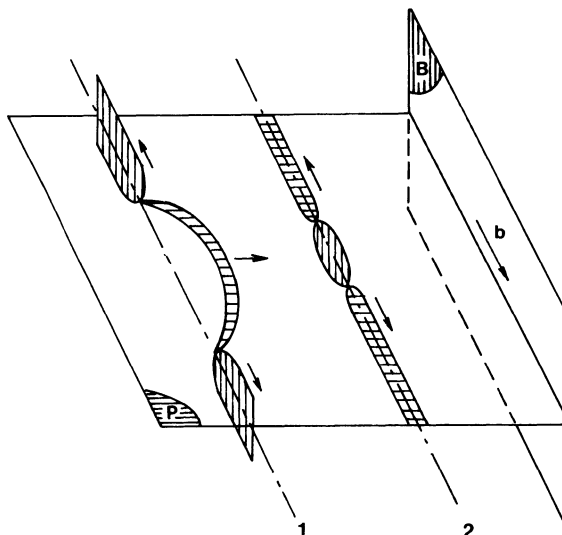


Fig. 3 - Mechanism of glide in a prismatic plane in Beryllium. 1) Unlocking by cross slip from basal to prismatic plane. 2) Locking by cross slip onto the basal plane.

A quantitative study of this process has been done : locking and unlocking obey to simple laws of probability, the average velocity of dislocations is proportional to their length, and local stress measurements as a function of temperature agree with macroscopic ones.

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