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This Week's Citation Classic

Weertman J. Steady-state creep through dislocation climb.
J. Appl. Phys. **28**:362-4, 1957.
[US Naval Research Laboratory, Washington, DC]

A dislocation creep model is used to derive a steady-state creep rate. The rate controlling process is the climb motion of edge dislocations. The climb motion is controlled by diffusion of vacancies between climbing dislocations. At moderate stresses the creep rate is proportional to $(stress)^{4.5}$. [The *SCI*® indicates that this paper has been cited in over 250 publications since 1961.]

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"The story of this paper relates to an earlier paper of mine.[1] My wife (J.R. Weertman) and I were at the Naval Research Laboratory (NRL) not too long out of graduate school. A fellow researcher, John E. Breen, asked me to be his 'in-house' MS thesis adviser in addition to his adviser at the University of Maryland. His thesis work on creep of tin was to be carried out at NRL. I knew little about creep and to understand it I attempted to derive a creep equation from dislocation models. The wisdom of the day was that creep rate $\dot{\epsilon}$ of metals is proportional to sinhσ, where σ = stress. I was not able to obtain this relationship. Instead, at moderate stresses, the power law equation of $\dot{\epsilon}$ proportional to σ^n always came up with $n \simeq 3$ to 4. I worked on it mainly on weekends while driving on the Pennsylvania Turnpike to our parents' homes near Pittsburgh. My wife knew when I was thinking about it because of an ever slowing down car, a sign for her to take over driving.

"I used N.F. Mott's idea that dislocations could climb. I found climb velocities by letting dislocations be perfect sources or sinks for vacancies. Thus the creep activation energy equals that of self-diffusion, a result well established by O.D. Sherby, R.L. Orr, and J.E. Dorn.[2] Before my paper was published, Dorn[3] showed that aluminum obeyed power law creep. My paper was published later because it and a revised version were both rejected by *Acta Metallurgica*. *Physical Review* in their turn suggested sending it to *Journal of Applied Physics*, which published it after more revision.

"My 1957 paper is probably highly cited because in it I attempted to improve the theory and came up with an exponent, n = 4.5, which is closer to what is observed. The story goes on. Peter Haasen visited NRL and told me that John Glen earlier had found power law creep in ice.[4] This led me into the glaciological literature and I learned that how glaciers slide was not understood. From my thermo course, I dimly remembered reading in Fermi's book[5] that glaciers slide around bed bumps by the pressure melting phenomenon. A simple calculation showed me that this is too slow a process for large bumps. But it was immediately clear that creep lets ice get around big bed bumps quickly. So I was able to write the first theory[6] on glacier sliding. In 1980, I was awarded the Acta Metallurgica Gold Medal, and in 1983, I will be awarded the Seligman Crystal of the International Glaciological Society. I owe much to the stimulation of the Carnegie Tech fellow graduate students who came to NRL about the time I did—my wife, the late E.I. Salkovitz, and A.I. Schindler; to NRLers J.R. Lane, G.S. Ansell, and P. Shahinian; and to my thesis adviser, J.S. Koehler, who introduced me to dislocations. Above all, I thank you, Jack Breen."

1. **Weertman J.** Theory of steady-state creep based on dislocation climb. *J. Appl. Phys.* **26**:1213-17, 1955.
2. **Sherby O D, Orr R L & Dorn J E.** Creep correlations of metals at elevated temperatures. *Trans. AIME* **200**:71-80, 1954.
3. **Dorn J E.** Some fundamental experiments on high temperature creep. *J. Mech. Phys. Solids* **3**:85-116, 1954.
4. **Glen J W.** The creep of polycrystalline ice. *Proc. Roy. Soc. London Ser. A* **228**:519-38, 1955.
5. **Fermi E.** *Thermodynamics.* New York: Prentice-Hall, 1937. p. 68-9.
6. **Weertman J.** On the sliding of glaciers. *J. Glaciology* **3**:33-8, 1957.