ON THE EXTENSION OF THE JEFFREYS–LOMNITZ LAW FOR ROCK CREEP

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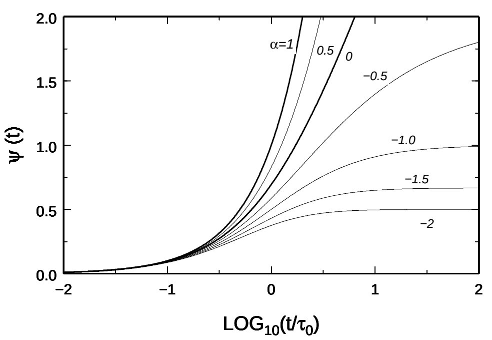
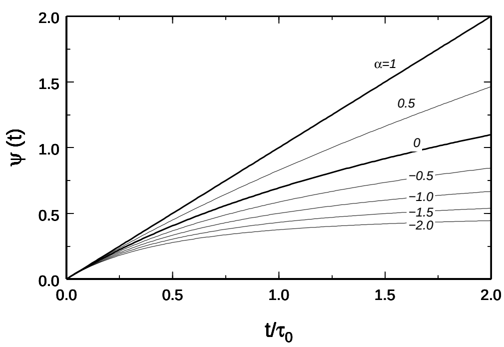
Key words : linear viscoelasticity, rock creep, Jeffreys-Lomnitz law, glacial isostatic deformations .

In 1958 Jeffreys proposed a power law of creep, generalizing the logarithmic law earlier introduced by Lomnitz, to broaden the geophysical applications to fluid-like materials including igneous rocks. We revisit the Jeffreys-Lomnitz law of creep by allowing its power law exponent α, usually limited to the range $0 \le \alpha \le 1$ to all negative values so also solid-like viscoelastic materials are included in the extended law. This approach is consistent with the linear theory of viscoelasticity because the creep function still remains a Bernstein function, that is positive with a completely monotone derivative, with a related spectrum of retardation times. Indeed, in the extended Jeffrey-Lomnitz crrep law the complete range $\alpha \le 1$ (rather than $0 \le \alpha \le 1$) yields a continuous transition from a Hooke elastic solid with no creep $(\alpha \to -\infty)$ to a Maxwell fluid with linear creep $(\alpha = 1)$ passing through the Lomnitz viscoelastic body with logarithmic creep $(\alpha = 0)$, which separates solid-like from fluid-like behaviors. It is convenient to separately consider four cases:

$$t \ge 0\,, \quad \Psi(t) = \begin{cases} t/\tau_0\,, & \alpha = 1\,, \\ \dfrac{(1+t/\tau_0)^{\alpha} - 1}{\alpha}\,, & 0 < \alpha < 1\,, \\ \log(1+t/\tau_0)\,, & \alpha = 0\,, \\ \dfrac{1-(1+t/\tau_0)^{-|\alpha|}}{|\alpha|} & \alpha < 0\,. \end{cases}$$

where we have considered the dimensionless creep function Ψ versus a dimensionless time t/τ_0. The behaviour of $\Psi(t)$ is illustrated in the Figures below, for some values of α in the range $-2 \le \alpha \le 1$, adopting a logarithmic time scale and a linear time scale. Here, geophysical applications of the extended Jeffreys-Lomnitz creep in the realm of global models of glacial isostatic deformations will be discussed.





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