derivatives of the source time functions. That technique is applicable only at very long periods; as periods become shorter, lateral variations in dispersion become important. Dziewonski and Gilbert computed the transforms of the source rate functions only for periods of more than 78 s. Their procedure is exactly equivalent (if their reconstruction of the source rate transforms is correct) to taking the transforms of the source rate functions over the entire frequency range and then filtering the transforms by setting to zero all Fourier components with periods of less than 78 s, without changing the longer periods.

That type of filtering is 'non-causal.' If a delta function at $t=0$ is passed through this filter, energy will emerge from the filter at negative times, before the source energy arrives (Fig. 1). Dziewonski and Gilbert's procedure is defensible only in cases where almost all of the source rate energy is concentrated in the ultra-low frequency band. But more than 85% of the energy of the (far field) source functions is contained, however, in the short periods, and so they cannot determine an accurate origin time from the free oscillation data set. If the Fourier transforms which they inverted to get their Fig. 2 had included all periods (instead of only the ultra long periods) it is quite likely that the time functions would all have been uniformly zero before the origin time.

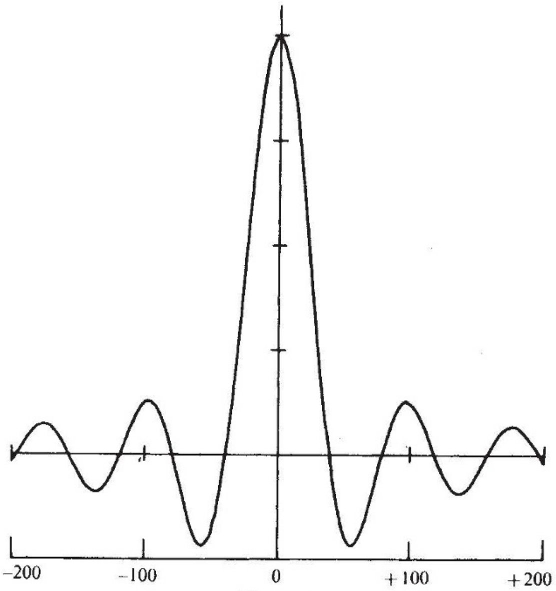


**Fig. 1** Impulse response of the filtering procedure used by Dziewonski and Gilbert.

The estimate that more than 85% of the spectral energy density was outside the frequency range considered by Dziewonski and Gilbert was derived by combining Aki's statistical scaling rule[2] with observational data. Aki's rule states that the far field displacement (or source moment rate) spectrum will be flat up to some 'corner frequency', above which amplitude falls proportionally to $\omega^{-2}$. Because the energy density of the source moment rate is constant below the corner frequency, the total energy in a frequency band from zero to a cutoff below the corner frequency is proportional to $\omega$. The results of Wyss and Molnar[3] indicate that 0.1 Hz is a conservative estimate of corner frequency for the deep earthquakes considered by Dziewonski and Gilbert. Thus their cutoff frequency (0.013 Hz) eliminated well over 85% of the signal energy.

The conclusion that the hypocentral region began to undergo compresion 80 s before the observed origin time is, therefore, unjustified.

I thank Freeman Gilbert for comments, and the Advanced Research Projects Agency of the US Department of Defense for financial support.

ROBERT J. GELLER

*Seismological Laboratory,*
*California Institute of Technology,*
*Pasadena, California 91109*

Received March 25; revised May 2, 1974.


1 Dziewonski, A. M., and Gilbert, F., *Nature*, **247**, 185–188 (1974).
2 Aki, K., *J. geophys. Res.*, **72**, 1217–1231 (1967).
3 Wyss, M., and Molnar, P., *Phys. Earth planet Interiors*, **6**, 263–278 (1972).
4 Mendiguren, J., thesis, Massachusetts Institute of Technology, Cambridge (1972).
5 Dziewonski, A. M., and Gilbert, F., *Trans. Am. geophys. Un.*, **54**, 374 (1973).
6 Dziewonski, A. M., and Gilbert, F., *Geophys. J. R. astr. Soc.*, **35**, 401–437 (1973).


DRS DZIEWONSKI AND GILBERT REPLY: Although Geller discusses the problem of the rate of release of seismic energy, his criticism of our paper is concerned with our statement that the isotropic part of the moment rate tensor is precursive by 80 s. In this reply, we address ourselves to this precursive behaviour.

If $g(\omega)$ is the Fourier transform of $f(t)$, then $g(-\omega)$ is the Fourier transform of $f(-t)$. If $g(\omega)=g(-\omega)$ then $f(t)=f(-t)$. If $g(\omega)$ is an even function of frequency then $f(t)$ is an even function of time. If $f(t)$ is an even function of time it is precursive. The experimental evidence for the isotropic part of the moment rate tensor shows its cosine transform, an even function, to be large at low frequencies, and its sine transform, an odd function, to be small everywhere. Consequently, the isotropic part of the moment rate tensor has a Fourier transform that is an even function of frequency, from which follows that it is an even function of time, and, necessarily, precursive. The spectrum of the isotropic part of the moment rate tensor is very small for frequencies above 0.0048 Hz (0.03 $s^{-1}$). The precursor therefore should persist into negative time for about 105 s ($\pi/0.03\ s^{-1}$), which is in accord with our original, conservative estimate of 80 s.

Mr Geller shows a symmetric function of time that has a nearly flat cosine spectrum below 0.01313 Hz (0.0825 $s^{-1}$). It is nothing more than a low-passed delta function. The observed spectrum of the isotropic part of the moment rate tensor decays rapidly with increasing frequency, and is nearly zero above 0.0048 Hz (0.03 $s^{-1}$). Consequently it is not a low-passed delta function and must therefore be precursive.

The only way to invalidate this conclusion is to have the sine transform differ significantly from zero at very low frequencies, below 0.002 Hz (0.0125 $s^{-1}$).

A. M. DZIEWONSKI

*Department of Geological Sciences,*
*Harvard University,*
*Cambridge,*
*Massachusetts 02138*

F. GILBERT

*Institute of Geophysics and Planetary Physics,*
*University of California,*
*San Diego,*
*La Jolla,*
*California 92037*