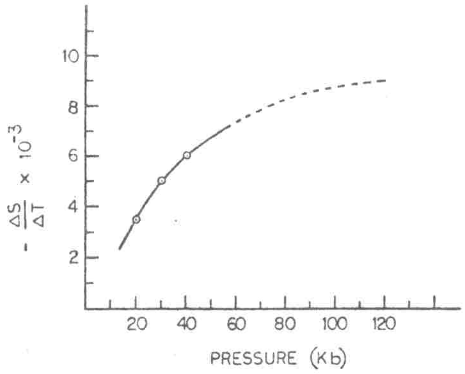

Fig. 10. A plot of the averaged temperature derivative of torsional shear strength $(\Delta S/\Delta T)_P$ obtained from the data of *Riecker and Rooney* [1966*b*] on labradorite, pyrope garnet, dunite, and granodiorite at confining pressures of 20, 30, and 40 kbar (see Figure 9, bottom) with extensive extrapolation to 120 kbar according to the curvature established between 20 and 40 kbar of pressure.

This value of strength is in reasonable agreement with the approximate 9-kbar experimental average for the rocks, dunite, garnet, labradorite, and granodiorite at 40 kbar and 600°C (Figure 9, top).

Similarly, the temperature-corrected strength at 70 kbar is

$$S_{70\text{kbar},775^\circ} = S_{20^\circ} + (\Delta S/\Delta T)_{70\text{kbar}}$$
$$= 15 - 0.008(755^\circ) = 9 \text{ kbar}$$

By following the examples given, the room temperature failure model has been revised to account for what are believed to be reasonable strength changes appropriate to the temperatures assigned to the central part of a downmoving crustal slab. The data and calculated results used are summarized in Table 2. The temperature-revised failure model is shown in Figure 11.

The initial third of the temperature-revised diagram complies with the finding of *Griggs et al.* [1960] that rocks of interest remain brittle to a temperature of about 500°C. Between about 50 and 85 kbar of confining pressure (150–250 km of depth) the increased temperature (650°–875°C) would tend to eliminate the room temperature observed abrupt stress drops and recoveries because of a correspondingly greater susceptibility to plastic deformation. This phenomenon is reflected by the zero to slightly negative slope of the shear strength curve over this region. Over the span 85–125 kbar a saturation of intragranular plastic strains is assumed also to occur as described for room temperature, and further response to stress would be a similar bulk accumulation of elastic strain terminated by a strain-induced fusion of the sample. This condition is reflected by transition of the shear strength curve to a positive slope.

The correlation found at room temperature between predicted regions of catastrophic rock failure and those zones of depth at Fiji-Tonga over which Sykes et al. observed concentrations of seismic activity also persists in the temperature-revised model.

Recalculation of Strain Release Energy Available for Seismic Radiation According to Revised Failure Model

A calculation can be made of the approximate seismic energy in an earthquake by means of the empirically based equation of *Gutenberg and Richter* [1942, 1949]:

$$\log_{10} E_s = A + BM \quad (1)$$

The constants A and B are determined by evaluating integrated wave energy relative to earthquake magnitude M over a range of magnitude. Values given by *Bäth* [1966] for A and B are 12.24 and 1.44, respectively, when M is based on surface wave amplitude. An earthquake of magnitude 4 contains a seismic energy of 1×10^{18} ergs, and one of magnitude 8.5 yields 3×10^{24} ergs.

Since the Gutenberg-Richter equation is based on surface measurements at observatories, losses that may occur in the conversion from stress drop to seismic energy are difficult to recognize. Seismic energies thus calculated are probably low by some uncertain fractional amount. It can be assumed therefore that an earthquake of magnitude 4 can represent between 10^{18} and 10^{19} ergs of seismic energy, and one of magnitude 8.5 can represent between 10^{24} and 10^{25} ergs.

Giardini [1969] calculated the total seismic energy of an hypothetical high-magnitude earthquake according to the failure model presented at that time. He obtained about 10^{27} ergs over the span of the failure model. The equation used was based on the solution given by *Starr* [1928] for a shearing rupture in an isotropic solid. The seismic energy was defined as the difference between the work energy expended for shear rupture and displacement and that dissipated as frictional heat. The equation is

$$E_s = W - H = ch\,(\Delta S)^2 \quad (2)$$

where W is the work energy, H is the heat energy, c is a constant describing the material undergoing failure, h is the rupture width in centimeters, and ΔS is the stress drop associated with failure at any position on the failure diagram.

The material constant is defined by

$$c = \frac{1}{h}\frac{\pi}{4}(1 - 2u)\frac{Lh^2}{G} \quad (3)$$

TABLE 2. Data and Calculated Results Used for Temperature Revision of Room Temperature Failure Diagram (Figure 7)

Confining Pressure, kbar	S, kbar	T, °C	$\Delta T = T_{slab} - T_{20°C}$, °C	$\Delta S/\Delta T$, kbar/°C	ΔS, kbar	S at Slab Temperature, kbar
20	9	375	355	-0.0035	-1.2	7.8
40	12.2	600	580	-0.006	-3.5	8.7
50	13.2	650	630	-0.0067	-4.2	9
70	15	775	755	-0.008	-6	9
100	19	1000	980	-0.0087	-8.5	10.5
120	22.2	1140	1120	-0.009	-10.1	12.1

S, room temperature shear strength; T, average temperature at slab center.