proaches the fracture strength, and brittle rupturing will occur on the failure plane.

Overall, the shear strength curve for granodiorite with interstitial AgCl is not greatly different from that obtained with dry granodiorite. Transitions and other features beyond the initial region of low shear strength appear only to be displaced 5–10 kbar to higher pressures. The rather large but limited stress drop at about 75 kbar coincides with the phase transition of AgCl. The shear strength of granodiorite with AgCl failed at about 95 kbar of confining pressure.

The experimental data for granodiorite do generally conform with the failure model. The transitional span between the region of pore-pressure-controlled low shear strength and that of brittle failure (~5–7 kbar) was recognized in the model. The transitional span between the brittle and slip modes of failure (~15–40 kbar) was overlooked owing to the lack of data. The predicted pressure for the transition from a slip to a brittlelike mode of failure (~100 kbar) is about 15% greater than that found for dry granodiorite (~85 kbar) but very close to that found for granodiorite with interstitial AgCl (~95 kbar). The latter agreement reflects the pore pressure influence in the triaxial data from which the upper transition pressure was derived [*Giardini*, 1969].

Although agreement between prediction and observation is satisfactory for granodiorite, the model was purported to be applicable to plutonic rock in general. *Giardini and Abey* [1973] also performed some exploratory tests on a granite from Westerly, Massachusetts, and a quartz-plagioclase-biotite gneiss from Clarke County, Georgia, to pressures of about 70 kbar. Shear strength behaviors were found to be quite similar to the behavior of granodiorite under equivalent conditions of test.

The average grain sizes of the granite and gneiss were similar and less than the grain size of the granodiorite. The textures of the granite and granodiorite were similar; the texture of the gneiss was highly foliated. Tests on the gneiss with the plane of foliation parallel and perpendicular to the apparatus torquing surface yielded no significantly different results. Variation in the rate of torsional strain application on granodiorite over three orders of magnitude ($10^{-3}-10^{-5}$ rad/s) also did not produce significant change in the strength characteristics. It is concluded therefore that within the range of mineralogy, grain size, texture, rate of shear application, and pressure described, felsic plutonic rocks generally conform with behavior predicted by the failure model.

Dunite. To more generally test the validity of the room temperature failure model relative to subsurface geology, the strength characteristics of ultramafic rock also must be explored. *Giardini and Abey* [1973] carried out torsional tests on unaltered dunites from San Bernardino County, California, and Mt. Burnette, southeastern Alaska. The typical shear strength of dry unaltered dunite to about 95 kbar of confining pressure is shown in Figure 6.

The initial smooth rise in strength to about 15 kbar corresponds to the pressure region where failure takes place by brittle shear. Intragranular slips begin to occur over the pressure span 15–50 kbar, but they become a predominant mechanism of strain only beyond 50 kbar. The abrupt minor shear stress drops that appear in the shear strength curve beyond about 25 kbar of pressure are believed due to sudden onsets of slips that sequentially occur within intragranular regions. Intragranular slips were observed in sample thin sections.

The cause of the gradual transition to a diminished torsional strength at about 75 kbar, with recovery at about 85 kbar, is not known. It may be due to a reversible reconstructive phase change in the olivine. This type of transformation has been reported in shock wave work, although at higher pressure [*Carter et al.*, 1968].

If the inflection between 75 and 85 kbar is neglected, the rate of increase in maximum shear strength is relatively constant from a pressure of about 50 kbar to the operational limit of the apparatus (~100 kbar). An explosivelike sample failure did not occur to this pressure. Residual microstructures contained considerable ruptures, anomalous birefringences, and multiple slips. However, all existed within intragranular boundaries.

A comparison of the strength curves of unaltered dunite (Figure 6) and granodiorite (Figure 3) shows that the stress response of these examples of ultramafic and felsic rocks is similar. The relative intensity of structural damage in dunite after 95 kbar of pressure with torsional shear is comparable to that found in granodiorite after about 65 kbar of pressure with shear. By resorting to comparative extrapolation, it can be inferred that dunite also will undergo a catastrophic failure by shear-induced fusion at a pressure not far from 125 kbar. In this respect it is interesting to note that the pressure ratio, 85 : 125 kbar, is in reasonable agreement with the ratio of the respective initial melting temperatures of dry granitic rock and dunite of low to intermediate iron content.

REVISION OF FAILURE MODEL BASED ON ROOM TEMPERATURE TORSIONAL DATA REVIEWED ABOVE

A revised model based on the high-pressure torsional data reviewed above and the triaxial data previously reported is given in Figure 7. The strength shown is based on the averaged measured values for granodiorite to 85 kbar and dunite to 95 kbar. The diagram is presented as typical for unaltered plutonic rock at room temperature. The maximum strength of about 22 kbar indicated at 125 kbar of confining pressure was determined by applying the ratio of shear strength change relative to pressure ($\Delta S/\Delta P$) observed with granodiorite between 40 and 85 kbar to the averaged strength of granodiorite and dunite (12.2 kbar) at 40 kbar of pressure.

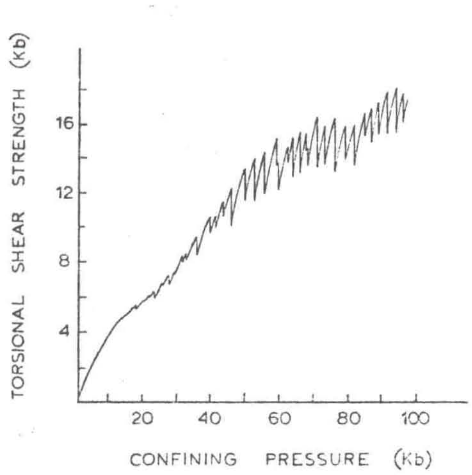

Fig. 6. The room temperature shear strength of unaltered dunite from Mt. Burnette, southeastern Alaska. The cause of the drop and recovery in maximum torsional strength between 75 and 85 kbar of confining pressure is not known. It may reflect a reversible nondisruptive phase change in the olivine. No new crystalline phase was found in the recovered sample.