rocks in which the tectonic history is simple and interfering problems of recrystallization and preferred orientations of c_v are minimal.

Recrystallization

General. Recrystallization of a given mineral species in a poly-crystalline aggregate can occur below the melting temperature by solution and redeposition and/or solid diffusion. There is a large literature on the subject, especially in metallurgy, ceramic engineering, and glass technology.[94,152-158] Of concern here is the fact that the petrofabric literature abounds with descriptions of preferred crystallographic orientations of crystals, which for textural reasons can not be explained on the basis of cataclastic or gliding flow. That is, there is no visual evidence of grain breakage or intragranular gliding. Presumably these orientations have resulted from recrystallization during deformation (the paratectonic or syntectonic recrystallization of Sander[1]), i.e., under conditions of nonhydrostatic stress. Most of them have been interpreted only kinematically by means of the symmetry argument. The same crystallographic orientations, however, might be amenable to dynamic analysis if one understood the relationships between the orientations of the recrystallized grains and the principal stresses. Significant contributions to the problem have been made through thermodynamic and experimental investigations. Initial results are encouraging and suggest the potential usefulness of these approaches.[159]

Thermodynamic Approach. The thermodynamic principles of the behavior of elastically strained solids under nonhydrostatic stress in contact with fluids were laid down by Gibbs.[160] Significant departures from the Gibbs treatment were given by Goranson,[161-163] Verhoogen,[164] and MacDonald.[165] Kamb[166] has reviewed these in detail and finds that all are essentially identical with respect to prediction of the most stable crystal orientation. Kamb[167] believes that only the Gibbs theory is valid and applies it to the simplest possible model of the recrystallization process. Recently, Kamb[168] has demonstrated experimentally the validity of the Gibbs approach

and the inadequacy of all other theories so far advanced. It is in-
structive to compare the MacDonald and the Gibbs-Kamb approaches and
the crystal orientations they predict.

MacDonald[165] assumed that the most stable orientation for a
mineral would be the one for which the potential energy of the external
forces plus the potential energy of strain was minimized. If the de-
formation is isothermal and obeys a linear elastic stress-strain law,
then the most stable orientation will be the one in which the Helmholtz
free energy is a maximum. This neglects any permanent strain energy,
and the nature of the path from the initial to final states of the
mineral, i.e., the final orientation, is supposed to be independent
of the orienting mechanisms.

Brace,[169] using MacDonald's prediction, calculated the most stable
orientations for calcite, high and low quartz, and ice for a uniaxial
stress. His results show that the following crystallographic planes
should be nearly normal to the load axis: $\{10\bar{1}1\}$ in ice and calcite,
$\{10\bar{1}2\}$ in high quartz, and $\{02\bar{2}1\}$ in low quartz. Their respective c_v
will then tend to lie along small circles or girdles of specific half-
angle about the unique stress axis (Fig. 47). Brace also examined the
equilibrium orientation in a stress field of three different, nonzero,
principal stresses. He found that the position of most stable orienta-
tion is a function of the confining pressure as well as the stress
difference. Accordingly, different orientation patterns of grains
might occur in rocks for which the stress difference was similar but
the depth of burial different.

Very different results have been obtained by Kamb[167] from the
Gibbs theory. He considers that the orientation of a mineral depends
only on the stress deviators and is therefore independent of changes
in hydrostatic pressure. When recrystallization takes place by solu-
tion and redeposition, the most stable orientation of the crystal is
that which minimizes the chemical potential across the plane normal
to the greatest principal pressure. Accordingly, the axis of least
elastic modulus (e.g., the c_v of calcite) tends to align itself paral-
lel to the greatest principal stress axis (axes), and the axis of
greatest elastic modulus (e.g., the c_v of quartz) tends to become