mentary rocks. If these microfeatures constitute a deformation record and can be used to obtain a stress pattern, a potentially valuable technique would be added to the tools of petrofabric analysis. It must be demonstrated, however, that these features are meaningful—that in a heterogeneous, porous aggregate the individual mineral components react relative to the principal stresses across the boundaries of the rock as a whole rather than a local stress concentrations at grain contacts. Accordingly, experimentally deformed sand crystals and calcite-cemented sandstones were studied to evaluate the significance of the microfeatures in the calcite and quartz of these materials for which the stress situations across the boundaries of the specimens are known.

Previous Work

The study is based upon the relationships between the three principal compressive stresses (greatest, σ_1; intermediate, σ_2; and least, σ_3) and (1) twin gliding in calcite and (2) fractures in detrital grains such as quartz, feldspars, and rock fragments.

Calcite

Knowledge of the deformation mechanisms in calcite has evolved from Brewster's observatious of mechanical twins in 1826 to the comprehensive experimental studies of deformed calcite single crystals and marbles and the petrofabric analysis of the deformed materials (Knopf, 1949; Turner, 1949; Griggs and Miller, 1951; Handin and Griggs, 1951; Turner and Ch'ih, 1951; Griggs, Turner, Borg, and Sosoka, 1951, 1953; Borg and Turner, 1953; Turner, Griggs, and Heard, 1954; Turner, Griggs, Clark, and Dixon, 1956; Griggs, Turner, and Heard, 1960). As a result, flow in calcite can be primarily explained by three glide systems (fig. 1):

1. Twin gliding parallel to $e\ \{01\bar{1}2\}$ with $[e_1:r_2]$ as the glide direction, and with a positive sense of shear.[4] This mechanism is effective throughout the temperature range of 20°–800° C.

2. Translation gliding on $r\{10\bar{1}1\}$ with $[r_1:f_2]$ as the glide direction, sense of shear negative. It is effective over the temperature range 20°–800° C.[5]

3. Translation gliding on $f\{02\bar{2}1\}$ with $[f_1:r_3]$ as the glide direction, sense of shear negative. It is effective at 20° C. and at 500°–800° C., and in the latter temperature range it predominates over r translation.

Twin gliding[6] is dependent upon a critical resolved shear stress (τ_c) on the twin plane but is essentially independent of normal stress across the twin plane (Turner, Griggs, and Heard, 1954, p. 889). Turner and Ch'ih (1951, p. 899–900) amply demonstrated for experimentally deformed Yule marble that the greatest amount of twinning occurs on that e-plane (designated e_1) on which the shear stress, or the resolved shear-stress coefficient (S_0),[7] is highest. Turner (1953) made a dynamic interpretation of twin lamellae in naturally deformed marbles by employing the petrofabric technique of locating the mutually perpendicular directions of compression and extension that most favored development of the observed twin lamellae. The geometry of these relationships was initially set forth by Handin and Griggs (1951, p. 866–869). If a maximum S_0 value (0.5) for twinning is assumed, the position of the load axis can be uniquely defined, because both χ_0 and λ_0 must be 45°. Accordingly, σ_1' and σ_3'[8] are fixed for twin gliding when $S_0 = 0.5$ (fig. 2, a); σ_1' (com-

[4] Arbitrarily, relative displacement of the upper layers of the lattice upward toward the optic axis (c_V) is called gliding in the positive sense; relative displacement of the upper layers downward from the upper end of the c_V is called gliding in the negative sense.

[5] Translation gliding does not result in reorientation of the crystal structure as in twin gliding. Moreover, visible evidence of translation (such as slip lines) is rare. Because of this, translation gliding systems were not utilized in this study.

[6] For a more detailed treatment of the twinning process see Bell (1941), Hall (1954), Pabst (1955), and Higgs and Handin (1959), among others.

[7] $S_0 = \sin \chi_0 \cos \lambda_0$ where χ_0 = angle between load axis and glide plane and λ_0 = angle between load axis and glide line.

[8] Primes are used to denote derived principal stress axes.

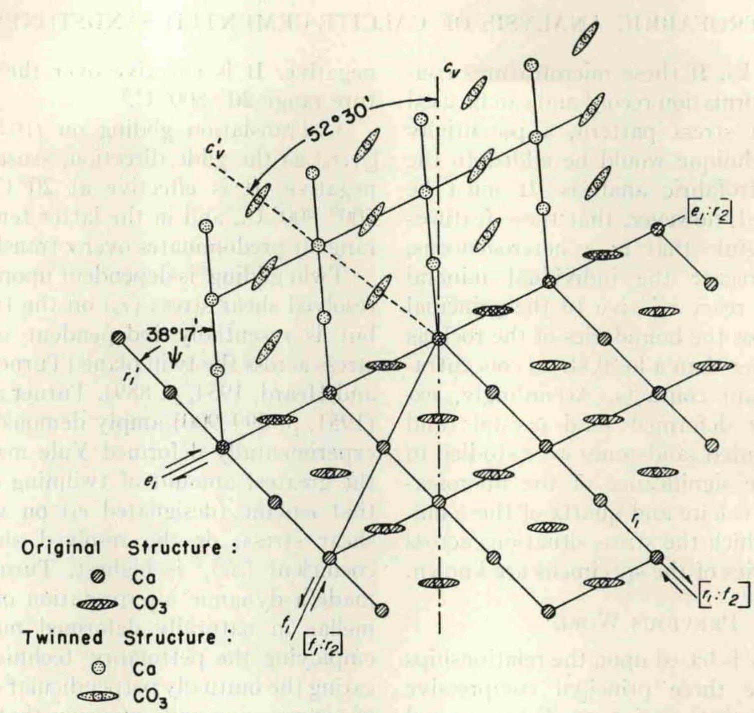

FIG. 1.—Diagrammatic representation of section through calcite structure. Section is drawn normal to a_2 axis, i.e., plane of section is normal to twin plane e_1 and contains glide line $[e_1:r_2]$. Structure is twinned on e_1 plane, with glide direction and sense of shear indicated. r_1 and f_1 translation glide planes, glide directions, and senses of shear are also indicated.

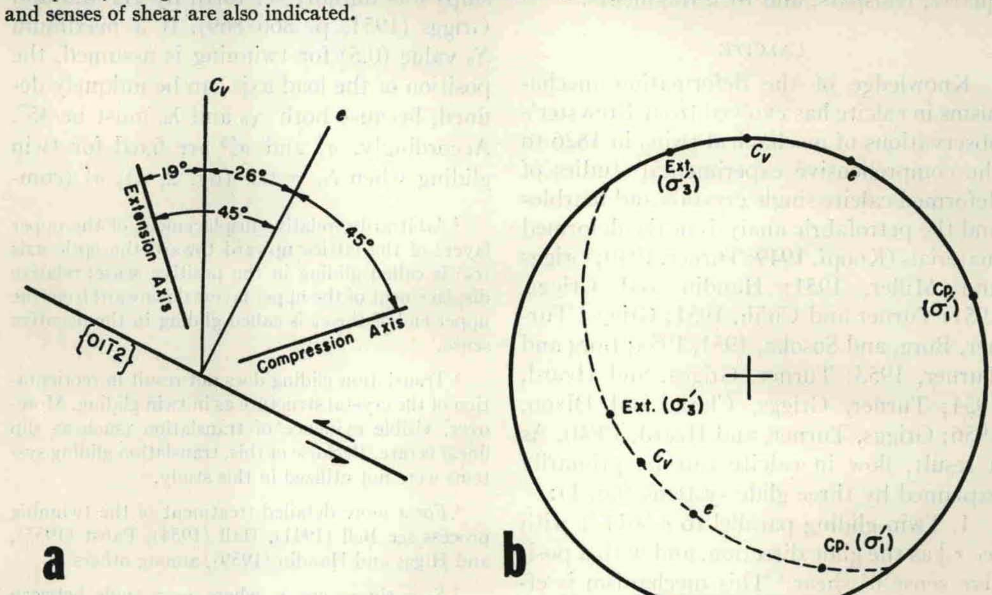

FIG. 2.—Diagrams (*a*) and (*b*) illustrating position of compression (σ'_1) and extension (σ'_3) axes that would be most effective in causing observed *e* twin lamellae in a calcite crystal. Section is normal to *e* plane and contains glide direction and optic axis (c_V).