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RELATIONSHIP BETWEEN PRESSURE SHADOWS AND SHEAR FRACTURE ORIENTATION

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ABSTRACT

Quartz pressure shadows surrounding authigenic pyrite grains in a shale from the Porsanger Dolomite Formation, West Finnmark, Norway, are associated with contemporaneous shear and extension fractures. Maximum compressive stress (σ_1) orientations based on pressure shadow geometry agree with σ_1 orientations derived from fracture sets.

Numerous shale samples from a unit within the Porsanger Dolomite Formation near West Finnmark, Norway, contain abundant pyrite grains wholly or partially surrounded by growths of feather quartz. These structures represent what has classically been known as "pressure shadows" and commonly are thought to illustrate pressure-solution phenomena. Detailed and comprehensive studies of pressure shadow relationships and genesis are few, but the works of Mügge (1930) and Pabst (1931) do present thorough analyses; the reader is referred to these works for a general introduction to the subject.

The significant aspect of the pressure shadows found in the Norway samples is their occurrence with sets of shear and extension fractures (Fig. 1). The consistent angular relationship among the fractures which agrees with that derived experimentally (Fig. 2), observation of the correct sense of movement on fractures believed to be shear fractures, and lack of any observed movement on fractures ascribed as extensional in origin supports the belief that the fractures in these samples form sets from which the direction of the maximum compressive stress (σ_1) can be

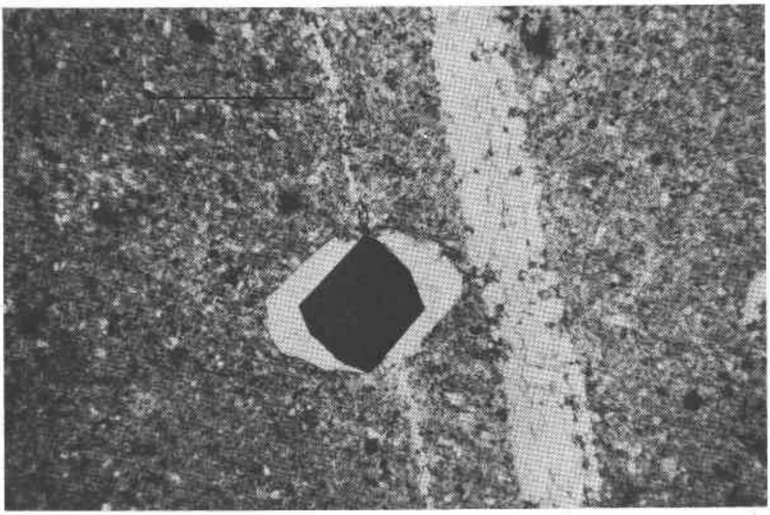

FIG. 1. Symmetrical pressure shadow of quartz surrounding pyrite grain. Quartz-filled fractures are extension fractures. Note unfilled shear fracture that transects thick extension fracture. Bar scale is 0.5 mm.

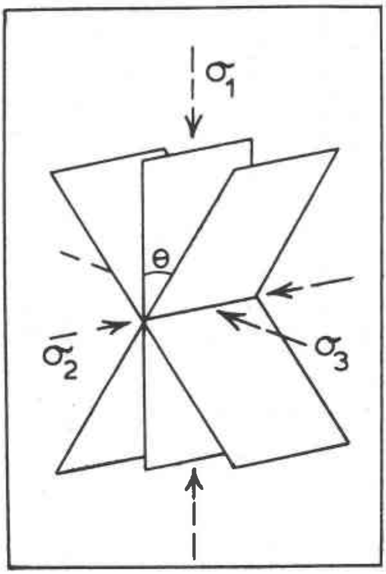

FIG. 2. Sketch of relationships among fractures and principal stresses $\theta=30°$.

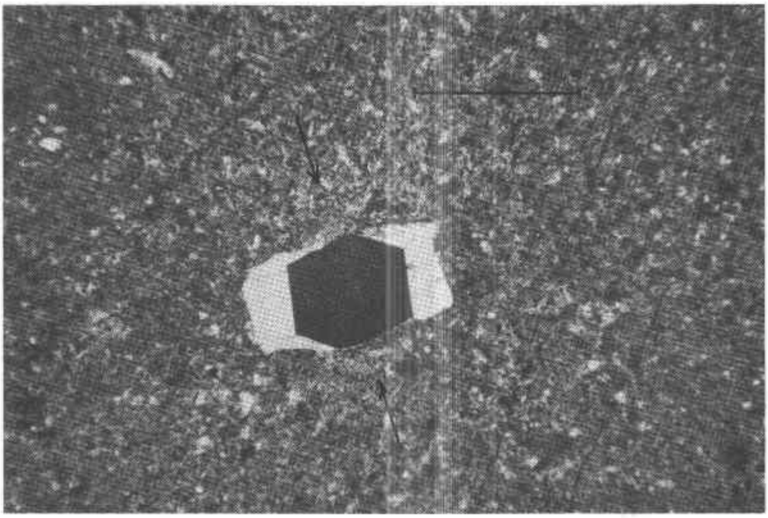

FIG. 3. Symmetrical shadows around pyrite grain. Arrows show orientation of σ_1 responsible for shadow geometry. Note presence of unfilled shear fractures. Bar scale is 0.5 mm.

determined. Fracture abundances are sufficient to permit σ_1 orientations to be mapped over areas of several square inches. Within these limits there is a slight but distinct rotation of σ_1 through an angle of 3° to 6°, depending upon the particular sample.

The most common pressure-shadow shape is that of equally developed symmetrical fringes located on both sides of a regular geometric figure (Fig. 3). For grains of this type little doubt exists about the orientation of σ_1 that controlled growth of the shadow. Although only a few such perfect grains exist, they are sufficiently abundant to provide an approximate idea of the degree of variation in σ_1 orientation. Variation of the maximum compressive stress constructed from this evidence alone agrees with the variation based on fracture geometry, both in angular divergence and sense of rotation. This agreement suggests that both fractures and shadows are contemporaneous in origin (related to the same stress system). Textural evidence is not definitive but offers no contradictions to this idea. The possibility of using this mineralogical criterion to map stress orientations in rocks devoid of other more suitable criteria appears favorable.

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