THE K/T BOUNDARY CLAY LAYER: FALLOUT FROM AN ASTEROID IMPACT

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In 1980, Alvarez et al. (1) announced their discovery of anomalous amounts of Ir in a thin clay layer at the Cretaceous-Tertiary (K/T) boundary at Gubbio, Italy, and proposed that its presence was due to the impact of a large extraterrestrial body (asteroid) upon the Earth. Since then, numerous geochemical studies have been made on the boundary clay layer at various sites worldwide. All of these studies were hampered in their attempts to prove an impact origin for the boundary clay because geochemistry alone can only suggest the presence of extraterrestrial material, given our state of knowledge about the mobility and distribution of platinum-group elements in various terrestrial environments. What was needed was some solid physical evidence of impact, such as has been derived from studies of suspected impact crater features on the earth's surface (2). This physical evidence, in the form of shock-metamorphosed minerals, has been discovered in the K/T boundary claystone layer at a site near Brownie Butte in east-central Montana (3).

The Brownie Butte claystone layer contains an Ir anomaly (1.0 ppb) and is placed at the (K/T) boundary by palynology. It has an unusual clay mineralogy, consisting of equal parts of poorly crystallized smectite and kaolinite, the latter in the form of 0.3 μm microspheres (4). The non-clay mineral fraction consists mostly of quartz grains, a few of which are of the beta-quartz morphology (high-temperature volcanic origin). About 25% of the quartz grains contain planar features due to shock metamorphism (diaplectic quartz, Fig. 1). These planar features have been indexed to specific crystallographic directions in the quartz lattice (Fig. 2). Quartz grains displaying planar features also have reduced refractive indices and show asterism in their Debye-Scherrer X-ray patterns. Trace amounts of stishovite were found in these shock-metamorphosed quartz grains by X-ray techniques. K-feldspar (sanidine) grains from this site also showed planar features. All of these features are characteristic of shock metamorphism as described from rocks associated with known impact craters (2). In addition to the Brownie Butte site, we have seen shocked quartz grains displaying planar features in samples of the K/T boundary claystone at four other sites over a 100 mi^2 area in east-central Montana, and from sites in marine rocks at Stevns Klint and Nye Kløv in Denmark, from Petriccio and Pontedazzo in Italy, and from Caravaca in Spain; others have observed them from sites in the Raton Basin, NM (5).

Compelling mineralogic evidence now exists that the K/T boundary clay layer formed as global fallout from the impact of a large meteorite (asteroid) upon a target terrain that included at least some silicic (possibly volcanic) material.

REFERENCES: 1) Alvarez, L., Alvarez, W., Asaro, F., Michel, H. (1980) Science, 208, p. 1095-1108. 2) French, B., Short, N. (eds) (1968) Shock Metamorphism of Natural Materials Mono Book Corp., Balt. 3) Bohor, B., Foord, E., Modreski, P., Triplehorn, D. Science (in press). 4) Bohor, B. (1983) Prog. and Absts. 20th Ann. Meet., Clay Min. Soc., Bloomington, IN, p. 48. 5) Pillmore, C. L., Tschudy, R. H., Orth, C. J., Gilmore, J. S., Knight, J. D. Science (in press).

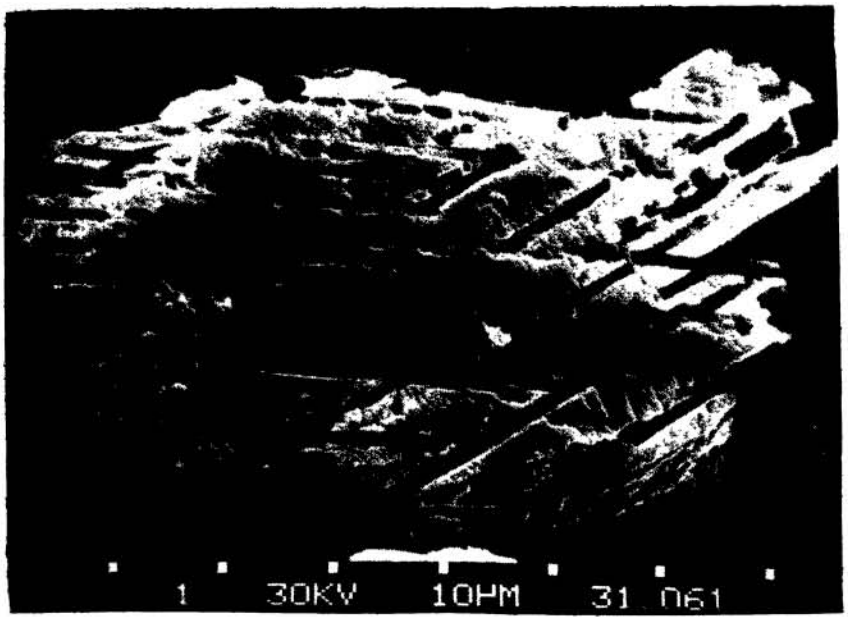

Fig. 1. Shock-metamorphosed quartz grain from K/T boundary claystone at Brownie Butte, MT (HF etched) exhibiting planar features. Distance between tick marks=10 μm.

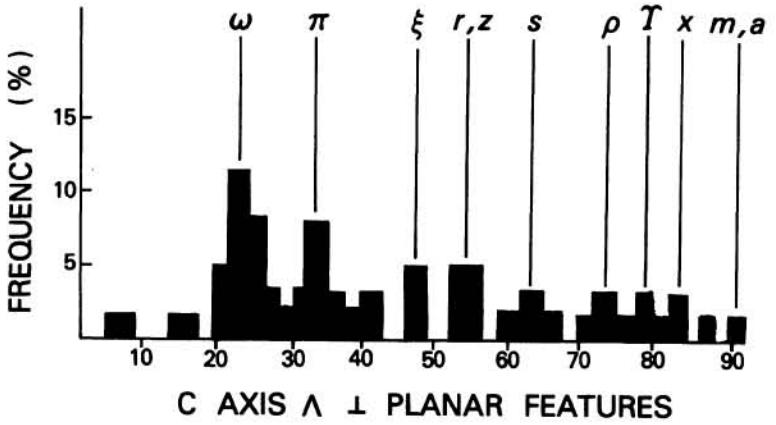

Fig. 2. Histogram of 61 sets of planar features from 15 shock-metamorphosed quartz grains in claystone layer at Brownie Butte. Specific quartz crystallographic directions designated by Greek and Roman letters. Horizontal scale in degrees.