N89-21334

THE WESTERN NORTH AMERICAN CRETACEOUS-TERTIARY (K-T) BOUNDARY INTERVAL AND ITS CONTENT OF SHOCK-METAMORPHOSED MINERALS: IMPLICATIONS CONCERNING THE K-T BOUNDARY IMPACT-EXTINCTION THEORY; G.A. Izett, U.S. Geological Survey, Mailstop 913, Denver Federal Center, Denver, Colorado 80225

At 20 sites in the Raton Basin of Colorado and New Mexico, and at several other sites in Wyoming, Montana, and Canada, a pair of claystone units, an Ir abundance anomaly, and a concentration of shock-metamorphosed minerals mark the palynological K-T boundary. The lower unit, the K-T boundary claystone, is about 1 cm thick; the upper unit, the K-T boundary impact layer, is about 5 mm thick. This couplet is generally overlain by a coal bed, 1-16 cm thick.

The K-T boundary claystone, which is composed of kaolinite and small amounts of illite/smectite mixed-layer clay (1), is similar in most respects to kaolinite tonstein layers in coal beds. Typically the boundary claystone has small amounts of carbonaceous material including vitrinite laminae, swirls of vitrinite, root-like structures, plant impressions, and millimeter-size fragments of cellular fusinite. The microscopic texture of the claystone is a polygonal boxwork filled with micrometer-size kaolinite spherules. Locally, the claystone is fragmental and has centimeter-size kaolinite clasts, some of which contain carbonaceous plant material and millimeter-size goyazite (aluminum phosphate containing Sr, Ba, Ca, Ce, and La) spherules. In Saskatchewan, blebs of yellow amber, some as large as 2.5 mm, are found in the claystone. The trace-element suite in the K-T boundary claystone is similar to that in tonsteins and in average North American shale, except that the boundary claystone has about 0.07-0.32 ppb Ir.

At some, but not all, K-T boundary localities, the boundary claystone contains solid kaolinite and hollow and solid goyazite spherules, 0.05-1.2 mm in diameter. In the Raton Basin, spherules are rare (<0.01%), small (<0.1 mm), and widely scattered; in contrast, at Wyoming K-T sites goyazite spherules are abundant (30%), large (mostly 1.0 mm), and concentrated in a 0- to 1.5-cm-thick goyazite-rich layer. The hollow spherules are formed of a thin microlaminated shell of colloform goyazite, and some of the spherule interiors are filled with either granular or bladed gypsum, marcasite, barite, or jarosite. Tiny goyazite spherules can occur within the gypsum cores. This and other observational evidence indicate that the goyazite and kaolinite spherules formed authigenically and are not of impact origin.

The upper unit, the K-T boundary impact layer, consists chiefly of kaolinite and various amounts of illite/smectite mixed-layer clay. Typically the claystone is 3-8 mm thick, microlaminated, and contains planar laminae of vitrinite and ubiquitous kaolinite barley-shaped pellets similar to the "graupen" of tonsteins. The SEM texture of the claystone is, in general, similar to the "cornflake" texture of mixed-layer clay and is different from the texture (microspherulitic) of the underlying boundary claystone. The contact between the impact layer and the underlying boundary claystone is generally sharp and records a subtle change in depositional regime.

The impact layer and boundary claystone are similar chemically, except that the former has slightly more Fe, K, Ba, Cr, Cu, Li, V, and Zn than the latter. Both claystone layers contain only a few ppm of Ni and Co. Ir is most abundant in the impact layer; however, anomalously large values are found in carbonaceous-rich shale and coal below or above the impact layer. Amounts of Ir in the impact layer range from 1.2 to 14.6 ppb; these amounts are more (5-66 times) than those in the underlying boundary claystone. The surface concentration of Ir varies (8-120 ng/cm^2) between localities only a few miles apart. Presumably, during diagenesis Ir was mobilized, transported, and concentrated in adjacent carbonaceous-rich sediments, particularly coal.

The facts that the boundary claystone and impact layer contain anomalous amounts of Ir, comprise a stratigraphic couplet at Western North American sites, and form thin, discrete layers, similar to air-fall units (volcanic or impact), suggest that the claystone units are of impact origin. Other observational evidence, however, implies that the boundary claystone and impact layer are not composed of altered volcanic- or impact-generated material. However, an important observational fact that bears on the origin of the K-T boundary claystone is that shock-metamorphosed minerals are restricted to the K-T boundary impact layer and are not found in the underlying K-T boundary claystone.

Significantly, the impact layer contains as much as 2% clastic mineral grains, about 30% of which contain multiple sets of shock lamellae. Only one such concentration of shocked minerals has been found near the K-T boundary. Of the shocked grains quartzite, metaquartzite, and chert constitute about 60%, and quartz the remainder. Grains of shocked feldspar and granite-like mixtures of quartz and feldspar are rare. The abundance of unshocked quartzite, metaquartzite, and chert in the impact layer and their paucity in underlying rocks suggest that they are continental supracrustal target materials of impact origin. The shocked minerals and Pt-group elements are the only impact-related components in the K-T impact layer claystone.

The type of K-T boundary shock-metamorphosed materials (quartzite and metaquartzite) in the impact layer and the lack of shock lamellae in quartz and feldspar of pumice lapilli and granitic xenoliths in air-fall pumice units of silicic tuffs, such as the Bishop Tuff, eliminate the possibility that the shock-metamorphosed minerals in the K-T impact layer are of volcanic origin.

The global size distribution and abundance of shock-metamorphosed mineral grains suggest that the K-T impact occurred in North America (2). At North American K-T boundary sites, the mean size of shocked quartz grains is as follows: Raton Basin, Colo. (two localities, 0.20±0.06 mm and 0.16±0.06 mm), Teapot Dome, Wyo. (0.14±0.04 mm), Brownie Butte, Mont. (0.15±0.05 mm), Alberta, Canada (0.26±0.06 mm). Rare grains as long as 0.50-0.64 mm are found at all Western North American sites. The mean size of 100 shocked quartz grains in the impact layer at Caravaca, Spain, is 0.09±0.03 mm, and the range is 0.04-0.19 mm, considerably less than the mean size of shocked quartz grains at North American K-T boundary sites (0.14-0.26 mm). Shocked minerals are several orders of magnitude more abundant at Western North American K-T boundary sites as compared to elsewhere in the world.

The Manson, Iowa, impact structure is probably the K-T impact site because of the mineralogic similarity of Manson subsurface rocks and shocked K-T boundary minerals (2), the large size (35 km) of the structure, the compatible isotopic age (66 Ma) of shocked granitic rock from the Manson structure and the K-T boundary (2, 3), and the proximity of the Manson structure to North American K-T boundary sites that contain abundant and large shock-metamorphosed minerals (2). Objections can be raised that the Manson, Iowa, impact structure is not the K-T impact site because it is too small. But the composition, mass, velocity, strike-angle of the K-T asteroid or comet are only speculative, and thus, the resulting K-T impact crater size is also speculative. Moreover, the magnitude and fabric of the K-T boundary extinction event has yet to be thoroughly evaluated. Therefore, the Manson impact structure remains a viable candidate site for the K-T impact.

References. (1) Pillmore, C.L., and Flores, R.M., 1987, Geological Society of America Special Paper 209, p. 111-130; (2) Izett, G.A., 1987, U.S. Geological Survey Open-File Report 87-606, 125 p.; (3) Kunk, M.J., Izett, G.A., and Sutter, J.F., 1987, EOS, p. 1514.