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MARINE AND CONTINENTAL K/T BOUNDARY CLAYS COMPARED, B. Schmitz, 70/110A, Lawrence Berkeley Laboratory, Berkeley, Ca 94720, U.S.A.

Detailed geochemical and mineralogical studies [1-5] of sediments across the K/T boundary at Stevns Klint, Karlstrup, Nye Klov, Dania, and Kjolby Gaard in Denmark, at Limhamn in Sweden, at Caravaca in Spain, at Waipara and Woodside Creek in New Zealand, at Trinidad in Colorado, and at various sites in Montana, have induced the following conclusions and reflections:

First, the marine K/T boundary clays, that I have studied, are definitely not fallout layers, and it is questionable (see below) whether they contain even a minor fraction of fallout material. Instead, the clastic fraction of the clays is made up of locally derived, water-transported material. Metal enrichments are associated with different kinds of biogenic and authigenic phases, and there are strong arguments that the metals have precipitated from sea water. The anomalous osmium isotope ratios in the clays [6-7] may be explained by different Os-isotope composition of sea water during K/T boundary time than at present. For example, vaporisation of a large, water-rich asteroid in connection with an oceanic impact could have led to substantial changes in the noble-metal composition of sea water. A chondritic asteroid, 10 km in diameter, contains 400 times more Ir than the entire present ocean [8]. Alternatively, sea-water composition could have been affected by abundant mantle-emission of volatile noble metals [9].

At most of the marine sites that I have studied, there is a lithological shift precisely at the K/T boundary. In New Zealand, as well as in Denmark, the lowermost Tertiary sediments were deposited in substantially shallower water than the uppermost Maastrichtian sediments [e.g. 10]. In Denmark the evidence is strong that the boundary clays deposited in precise connection with a dramatic, culminating phase of the end-Cretaceous sea-level fall. Possibly, near-shore material was transported by strong regressive streams to the deeper parts of the ocean. Similar processes working on a global scale could explain the occurrence of a layer of locally derived clay at the marine K/T boundary all over the world. This could also explain why the K/T boundary is characterized by a hiatus and not a clay layer in 90% of the worldwide distributed sediment sequences that span the K/T boundary [11].

Whereas the evidence is strong that the marine K/T boundary clays formed due to regressive water movements and not due to fallout of atmospheric dust, there is, on the other hand, equally strong evidence that the continental K/T boundary layer in western U.S. formed due to fallout of asteroidal impact ejecta. The continental boundary clay contains typically 1 to 20 ppb Ir and a quartz fraction with about 25% shocked grains [e.g. 12]; both facts are in excellent agreement with an impact-related origin of the layer. However, the continental boundary clay is rather thin, and G. Izett, who has made the perhaps most detailed studies of the layer, argues convincingly that it formed in connection with a minor impact, leading to the excavation of the Manson Crater (33 km in diameter) in Iowa [13]. It is difficult to see how such a minor impact event could lead to worldwide extinctions, global sea-level fall and deposition of decimetre-thick clay layers in the marine environment.

To me it seems as if there are two possibilities: (1) If the rare shocked quartz grains (0-2 parts per thousand of total quartz fraction [13]), that have been found in the very Ir-rich marine K/T boundary clays (Denmark, Spain, and New Zealand) represent significant enhancements compared to background, then the marine clays, most likely, formed synchronously with the continental clays. However, accepting this, we must also accept the seemingly unlikely circumstance that an asteroid, in one way or another, can trigger global sea-level fall. (2) If, on the other hand, the few shocked grains reflect typical background values, then the Ir enrichments in the very Ir-rich marine K/T boundary clays are, primarily, only related to the metal-absorbing algal matter that occurs in abundance in the basal parts of the clays, and to anomalous noble-metal concentrations in K/T boundary sea water. The event(s), asteroidal or volcanic, which led to enhanced concentrations of some noble metals in sea water, may have occurred at some time (weeks to several hundred thousand years) before the deposition of the marine K/T boundary clays, and may not necessarily be related to the late-Cretaceous regression with accompanying extinctions.

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