Origin and Clay-Mineral Genesis of the Cretaceous/Tertiary Boundary Unit, Western Interior of North America

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Abstract: A 3-cm-thick, two-layered clay unit that records mineralogic and textural evidence of a catastrophic event that occurred at a time now marked as the end of the Cretaceous Period was preserved in ancient peat-forming environments of the Western Interior Basin of North America. The two layers of this unit consist of altered distal ejecta and are easily distinguished by their distinctive texture and impact components from other clay beds, mainly tonsteins and detrital shales, occurring within the sequence of rocks enclosing the Cretaceous/Tertiary (K/T) boundary interval.

The lower claystone layer of the K/T boundary unit represents melted silicic target rock that has altered mainly to kaolin minerals. Impact components and signatures of this lower layer include a relict imbricate fabric of glass fragments, shards, bubbles, hollow spherules (altered microtektites), small amounts of shocked mineral grains, and a subdued iridium anomaly. These components and textures, combined with the layer's restricted areal distribution, indicate that this layer, called the "melt ejecta layer," is the distal part of an ejecta blanket deposit. We interpret the melt ejecta layer to be an altered deposit of mostly impact-derived, shock-melted, silicic target material that traveled through the atmosphere within a detached ejecta curtain and on other ballistic trajectories.

The upper laminated layer of the K/T boundary unit consists mostly of altered vitric dust and abundant shocked minerals whose size and amounts decrease away from the putative crater site in the Caribbean area. High-nickel magnesioferrite crystals, high iridium content, geochemical signature, and worldwide distribution all suggest this upper layer originated from a cloud of vaporized bolide and entrained target-rock materials ejected above the atmosphere. The components of this layer, called the "fireball layer," settled slowly by gravitational processes from an Earth-girdling vapor cloud and were deposited immediately on top of the already-emplaced melt ejecta layer.

The clay minerals that formed in the two layers are largely a function of composition and the highly unstable, shock-modified state of the fallout materials altered in acidic, organic-rich waters of ancient peat swamps. The fireball layer is mostly altered to smectitic clay from a mafic glass condensed from the vaporized chondritic bolide, along with some kaolinite formed from blebs of melted silicic target material entrained in the vapor plume cloud during ejection. In contrast, the melt ejecta layer is mainly kaolinitic, derived from silicic glass formed from melted target rocks. In this layer, the glass rapidly altered to mostly disordered, micrometer-sized "cabbage-like" or submicrometer-sized embryonic forms of spherical halloysite, probably from an allophane precursor. These crystallization characteristics of the melt ejecta layer are much different than those which formed coarse vermicular aggregates and platy kaolinite crystals in tonsteins from outside the K/T boundary interval throughout the Western Interior. The contrast in the incipient formation of dominantly kaolinitic clay minerals in the basal melt ejecta layer and of smectitic clay minerals in the overlying fireball layer reflect silicic versus mafic starting materials, respectively, and also supports the proposed two-phased meteorite impact ejection and dispersal model.

During subsequent burial and diagenesis of the K/T boundary unit, the metastable halloysite and smectite aggraded to kaolinite and mixed-layer illite/smectite, respectively. Both the ordering of kaolinite and illitization of smectite varies locally as a function of the degree of diagenetic grade or maturity, probably in response to local variations in temperature due to maximum burial depth (burial diagenesis).

Key Words: Claystone • Ejecta • Glass alteration • Halloysite • Kaolinite • K/T boundary unit • Meteorite impact • SEM • XRD

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