PRELIMINARY INVESTIGATION OF SHOCKED GRAINS (MANSON EJECTA?), PALEONTOLOGY, AND DEPOSITIONAL FEATURES IN THE CROW CREEK MEMBER, PIERRE SHALE (UPPER CRETACEOUS) OF SOUTHEASTERN SOUTH DAKOTA AND NORTHEASTERN NEBRASKA, AND ITS EFFECT ON UPPER CRETACEOUS BIOTA.

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The Crow Creek Member is one of several marl units recognized within the Upper Cretaceous Pierre Shale of eastern South Dakota and northeastern Nebraska. The member has been interpreted as a basal transgressive unit of the Bearpaw Cycle, one of several Upper Cretaceous transgressive-regressive cycles. The recent significant discovery of impact shock-metamorphosed mineral grains in the Crow Creek [1] and the new $^{40}Ar/^{39}Ar$ age (73.8 Ma) for the Manson Impact Structure (northwest Iowa) led to the suggestion that the two were coeval [1]. Shocked grains in the Crow Creek were interpreted as distal impact ejecta derived form the Manson Structure, and it was further suggested that the member displayed evidence of impact-induced tsunami sedimentation triggered by the Manson impact, a tsunami that may account for certain regional unconformities in the Western Interior Basin.

Recent investigations of the Crow Creek [2,3] and subsequent work has added to earlier observations [4,5]. New observations and their implications to Crow Creek geology include: **1)** Shocked quartz and feldspars (many rounded) are present in abundance in the sandy basal portion of the unit (up to 22.6% of quartz and feldspar grains) and are also present in the upper marl (about 10%); however, no evidence of impact melt-rock grains (altered or not) was observed. Impact ejecta is common in the unit, but some process that eliminated melt-rock grains and possible post-ejection transport to round grains need to be invoked (although rounding may have been pre-impact). **2)** While a reworked nannofossil assemblage derived from the underlying Niobrara Formation is present throughout the Crow Creek, they are most common near the base (up to 44 per 500 counts, decreasing to 4 per 500 in upper beds). The reworked assemblage occurs with an autochthonous nannofossil assemblage that is unique to the Crow Creek, implying that sufficient time elapsed during deposition to accumulate fossil debris and develop index species. The ratio of reworked to autochthonous nannofossils decreases progressively from 27 at the base of the unit to 2 near its top, inconsistent with interpretation of the Crow Creek as a single event bed. **3)** Radiolarian and foraminifera assemblages change upward through the Crow Creek marls into the overlying DeGrey Mbr, suggestive of gradual depositional processes, not catastrophic deposition. **4)** Fragile, thin-shelled benthic mollusks are present as whole-shell fossils, inconsistent with high-energy deposition. **5)** Features suggestive of condensed sedimentation above an unconformity surface (sequence boundary) include a phosphate lag concentrate, phosphatized matrix, and glauconitic enrichment.

Although marine shale sedimentation characterized much of the Late Cretaceous in the eastern region of the Western Interior Basin, marl deposition was also significant at times (Mobridge, DeGrey, Crow Creek, Gregory members of the Pierre Shale; Greenhorn and Niobrara formations). Sandy-silty marl facies are not unique to the Crow Creek, but are also recognized in basal Niobrara, Greenhorn, and DeGrey strata. A tsunamite scenario for Crow Creek deposition is not precluded, but many sedimentary and paleontologic observations are not adequately explained by catastrophic sedimentation.

The 74 Ma age for the Manson Impact Structure, and the deposition of probable Manson-derived ejecta within the Crow Creek Member of the Pierre Shale in South Dakota and Nebraska, constrain the Manson impact event within the span of the late Campanian ammonite zones of *Exiteloceras jenneyi* or *Didymoceras stevensoni* in the North American Western Interior Basin [1,6]. Any biotic crises or extinction events that occurred during the range of these zones may be evident from the extensive published paleontologic database for the Western Interior (both marine and nonmarine taxa). A preliminary evaluation of various paleontologic compilations was undertaken, but many details remain to be investigated, particularly inter-regional comparisons.

Since the Manson impact occurred near the eastern margin of the Cretaceous Western Interior Seaway, any effects on the marine biota would presumably be most apparent in the Western Interior faunal succession. Nevertheless, there is little evidence for significant extinctions or ecologic reorganization at the time of the Manson impact among Western Interior marine invertebrates, including ammonites [7], benthic bivalves (see ranges in [8,9]), foraminifera [10] and nannofossils [11]. However, the Manson impact event has been implicated [12,13] in the extinction of an assemblage of marine vertebrates in the Western Interior Seaway, including certain lineages of mosasaurs, marine turtles, and fish.

The terrestrial biota of the western region of the Western Interior prior to the Manson impact is characterized by the extensive fauna and flora of the Judithian vertebrate "age," typified by fossils from the Judith River Group of Montana and Alberta. The Manson impact event roughly coincides with the boundary between the Judithian and Edmontonian vertebrate "ages" (*E. jenneyi* Zone as defined [14], correlative with upper Judith River strata). No large-scale terrestrial extinctions are noted in freshwater fish, amphibian, turtle, lizard, and crocodilian faunas, mammals, or most North American dinosaur lineages at the end of the Judithian vertebrate "age". However, some dinosaur lines apparently did not survive into the Edmontonian, including genera of hadrosaurs, pachycephalosaurs, and centrosaurine ceratopsids. No extinction event within the terrestrial flora is evident at the close of the Judithian.

In summary, the Manson impact event produced few recognizable effects on the terrestrial or marine biota in the Western Interior of North America. The evolving lineages in the region, for the most part, continued unimpeded by any catastrophic ecologic changes that may have been brought about by the Manson impact event. Nevertheless, there is some evidence to suggest that portions of the biota in the Western Interior were significantly affected by the impact event, primarily certain large vertebrate animals, both terrestrial and marine. Higher trophic levels may have been more vulnerable to ecologic disruptions created by a regional catastrophic event, but such speculation requires further testing. Although impact events have been of considerable interest in understanding global extinction events, it is likely that the consequences of a Manson-sized impact would largely be evident at a regional, not global, scale.

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