NATIVE IRON IN THE CHAIBASA SHALES: RESULT OF A PRE 1.6 GA IMPACT?

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Introduction: **T**he known impact rate implies at least 300 large impacts onto the Earth during the Precambrian (*1*). Only a few Precambrian impact ejecta layers have been found. So far, about 7 Archean impact ejecta layers are known(*2*). Each of these layers has impact spherules that are large enough to be visible with the naked eye. However, most of the large Precambrian impacts did not produce spherules of this size. Because many Phanerozoic layers of impact ejecta are characterized by high magnetic susceptibility, we used measurements of magnetic susceptibility to find prospective impact ejecta layers in the pre 1.6 Ga sediments of the Chaibasa shales from the Singhbhum craton in India (*3*).

Analytical Results: We made polished sections of the magnetic fraction of crushed pieces from the highest susceptibility portions of the Chaibasa shales. The section from 27D had the highest proportion of relatively unaltered opaque grains with a good polish. Most of the opaque grains are crystalline magnetite with straight edges. The magnetite grains are unevenly shiny in reflected light. There are a few uniformly bright grains with broken or curved edges that are surrounded by dark fibrous mica (Fig, 1). These uniformly bright grains are native Fe (Fig.1). The most interesting of the native Fe grains is 27D-2. The left side of the grain has a bulbous shape and the right side is broken. This bulbous grain could not be transported a long distance as a detrital grain. In addition, the overall shape of the grain and the wavy structure near the bottom left of the grain are suggestive of a deforming drop of pure Fe melt.

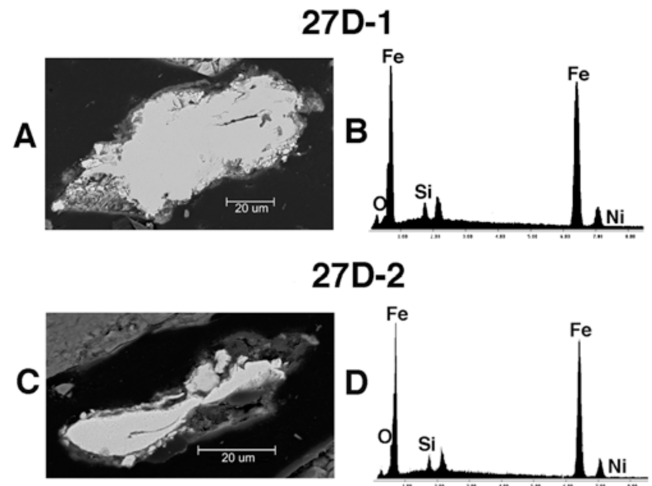

Figure 1. Native iron grains from sample 27D of the Chaibasa shales. A: Scanning electron microscope (SEM) backscatter image of grain 27D-1. B: EDX spectrum from grain 27D-1. The largest spectral peak is iron, with minor silica and oxygen from incorporated SiO_2. There is no Ni peak. The other peaks are secondary peaks of Fe or from the coating of the grains. C: SEM backscatter image of grain 27D-2. D: EDX spectrum from grain 27D-2.

Discussion: The occurrence of native Fe is unusual. The native Fe is found in light green shale. If the shale had been reducing because it contained abundant organic matter, the organic matter would have had sufficient sulfur to convert the iron into pyrite. We did not find any pyrite in the shale, only magnetite. Thus, we infer oxidizing conditions during deposition and later diagenesis of the shale.

If the native Fe is primary, it is the oldest native Fe ever found. Because the grains have rough edges or elongated bulbous shapes, the native Fe cannot be detrital. The melting temperature of pure Fe is 1535 °C. These temperatures do not occur in sedimentary rocks. Because the grain shapes indicate that the native Fe was deposited immediately after it solidified, we propose that the iron melted during a nearby impact event. The melt flew through the air and was deposited either as broken grains or bulbous drops.

Preservation of Native Fe for Millions of Years: The native Fe in the Chaibasa shales has been preserved for over 1.6 billion years. It may seem unlikely that native Fe could remain unoxidized for so long, but there is some precedent. Early Ordovician sandstones contain alloys of metallic Fe and Ni that represent fragmented iron meteorites(*4*). Native metal globules are also associated with the Permo-Triassic boundary at Graphite Peak, Antarctica and at Meishan, China(*5*). The native metals from the Permo-Triassic boundary are interpreted as bits of impactor that survived for over 250 million years. Permo-Triassic sandstones from Japan contain pure iron nuggets(*6*). Less than one percent of the metal nuggets are enriched in Cr and Al. Most nuggets are pure Fe with no appreciable Ni.

The fact that native Fe is not common in sediments implies unusual conditions. We suggest that two special conditions (besides impact) were met. The first is that the sediments were deposited rapidly in a thick layer. Rapid burial is implied by the presence of soft sediment deformation in the Chaibasa shales(*7*). The second is that the sediments were not disturbed by bioturbation. Bioturbation is absent in all Precambrian sediments.

Although we do not know the conditions of deposition of the Ordovician meteorite fragments, the native metals from the Permo-Triassic boundary meet one or both of these conditions. Although most Phanerozoic sediments are heavily bioturbated, the mass extinction at the Permo-Triassic boundary killed all of the bioturbating organisms. As a result, most early Triassic sediments are laminated. At Meishan, the Permo-Triassic boundary is bracketed by numerous ash layers(*6*). There is an ash layer just above the boundary clay. As ash layers are geologically instantaneous deposits, the ash is prima facie evidence for rapid burial of the P/T boundary layer at this location. Thus, where we have sufficient knowledge, the preservation of native metals in sediments is associated both with rapid burial and unbioturbated sediments.

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