

UNMELTED METEORITIC MATERIAL DISCOVERED IN THE LATE PLIOCENE IR ANOMALY

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An important aspect of the study of extraterrestrial particles in deep sea sediments has been the possibility that samples might be identified from individual large impact events. This hope was supported by the identification of microtektites in sediment cores by B. P. Glass (1) and by the fact that the Earth collides with kilometer-sized objects on a time scale comparable to the time of deposition of a single meter of Pacific sediment. Negative aspects of the problem are the uncertain survival of material from large impacts, its atmospheric dispersal and its chemical stability in the sediment environment.

We report here the discovery of unmelted millimeter sized particles derived from a substantial extraterrestrial body which collided with the Earth 2.3 million years ago. The particles were found in the deep sea core layer discovered by Kyte et al. (2) to have high Au and Ir contents comparable to those found at the Cretaceous-Tertiary boundary. The layer was found in the USNS Eltair 13-3 core recovered from 5090m depth at 57° 00'S 89° 29' W in the Antarctic Ocean. The layer of interest was ~790cm below the sediment surface and was deposited at a rate of ~3m my⁻¹ approximately 2.3 million years ago (2). It is not currently known if the layer is global or localized but it was estimated (2) that if the Ir anomaly was produced by a chondritic body the minimum size of the object must have been 20m.

As described in Kyte et al. (2) the layer contains a large number of millimeter-sized Ir rich extraterrestrial particles which appear to have melted during the event. The observed concentration is such that the surface of the sediment must originally have been covered with a monolayer of millimeter particles. These once melted particles are similar to type S meteor ablation spherules and chondrite fusion crusts (3) (4) in that they are composed of olivine, magnetite and a Ca, Al, Fe rich glass. They differ from at least 95% of the type S spheres found in sediments in that they are highly vesicular and that they have a very high ratio of glass to olivine. The vesicle content is similar to that in some impactites. The glass content is relatively high because the particles do not have olivine normative compositions like type S spheres. They do not have chondritic abundance ratios and their most conspicuous compositional difference relative to type S spheres is enhancement in Ca and Al. It is also significant that few or none of these melted particles are spherical while most ablation debris in deep sea sediments is spherical. The morphology of the particles does not appear to be compatible with a normal ablative origin and the elemental composition of the particles is extremely unusual for cosmic ablation debris.

An apparent solution to the origin of these particles is suggested by the composition of two unmelted one-millimeter particles which were discovered in the Ir rich layer. These are believed to be unmelted samples of the projectile. One particle is basically monomineralic composed of orthopyroxene (Fs₃₀) with minor amounts of chromite and troilite which occurs as filling material in fractures in the OPX. The second particle is composed of OPX (Fs₃₀₋₄₃), augite and plagioclase (An₉₀). The pyroxene contains numerous fractures filled with troilite and contains isolated grains of chromite, ilmenite and Fe, Ni metal. No olivine was found. Point analyses of the pyroxenes are shown in figure 1 and their Fe/Mn contents are shown in figure 2. Some of the pyroxenes have augite lamellae which are highly fractured and disturbed suggestive of shock deformation. A thin section was not prepared from the sample but examination of a bulk polished sample revealed no birefringence in the "plagioclase" implying that it is actually maskelynite. The plagioclase composition is low in Na for origin from chondritic source but the mineralogy of the particle is compatible with origin from a basaltic achondrite. It is probably a eucrite although it could be a howardite or mesosiderite. The Fe/Mn ratio of the pyroxenes in the particles is not consistent with the possibility that the particles could be lunar material. A terrestrial origin is ruled out because of the metal content and the Fe/Mn ratio.

The melted and unmelted projectile materials from the 2.3my sediment are compatible with origin from the hypervelocity impact of a large eucrite onto the surface of the ocean although an air burst cannot be ruled out. In the ocean impact scenario the

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irregular porous melted particles would be impactites generated at the projectile-water interface and the rare unmelted material would be particles which magically escaped melting possibly by high altitude release from the parent meteoroid. The discovery of actual unmelted material from this impact suggests that it may be possible to collect samples of similar events in the sediment record. A unique aspect of this development is the possibility of obtaining samples with terrestrial ages older than the dynamical lifetime of Apollo asteroids.

REFERENCES: 1) Glass, B. P., (1973) *Earth Planet. Sci. Lett.* **a**, 240., 2) Kyte, F. T., Zhou, Z. and Wasson, J. T. (1980), *Nature*, **288**, 651, 3) Blanchard, M. B., Brownlee, D. E., Bunch, T. E., Hodge, P. W. and Kyte, F. T. (1980), *Earth Planet. Sci. Lett.*, **46**, 178, 4) Brownlee, D. F. (1981), in *The Sea*, Vol. 7, Ed. C. Emiliani, Wiley and Sons, 5) Stolper, E., McSween, H. Y. and Hays, J. F. (1979), *Geochim. Cosmochim. Acta*, **43**, 589.

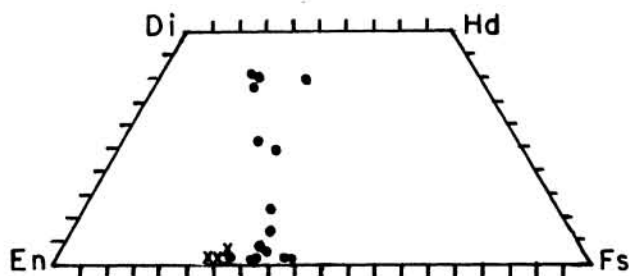


Figure 1. Point pyroxene analyses of the monomineralic particle (dots) Kyte-S4 and the polymineralic particle (crosses) Kyte-S6.

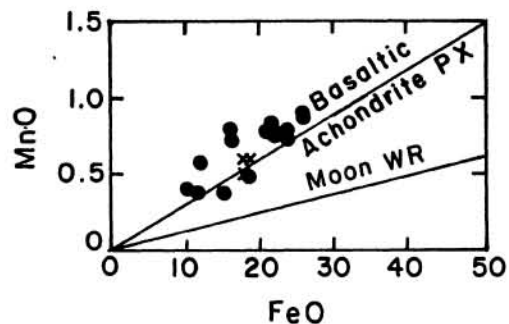


Figure 2. Fe/Mn ratios of the two projectile grains compared with the basaltic achondritic Px line and the moon whole rock (WR) line from Stolper et al. (5).