

DETAILED RESULTS ON ANALYSES OF DEPOSITS OF THE ELTANIN IMPACT, RECOVERED IN SEDIMENT CORES FROM POLARSTERN EXPEDITION ANT-XVIII/5A. Frank T. Kyte¹, Rainer Gersonde², and Gerhard Kuhn², ¹Center for Astrobiology, Institute of Geophysics and Planetary Physics, University of California, Los Angeles, CA 90095-1567, USA (kyte@igpp.ucla.edu). ²Alfred Wegener Institut für Polar- und Meeresforschung, Postfach 120161, D-27515 Bremerhaven, Germany.

Introduction: Deposits of the late Pliocene (2.5 Ma) Eltanin impact are unique in the known geological record. This is the only known example of a km-sized asteroid that impacted a deep-ocean (5 km) basin, and the central portion of the impact region is the most meteorite-rich locality known on Earth. Evidence for this deposit was first discovered as an Ir anomaly in sediments from three cores collected in 1965 [1,2] by the USNS Eltanin. These cores were also found to contain mm-sized shock-melted asteroidal materials and several percent unmelted meteorite fragments [3]. Based on mineral chemistry of unmelted meteorite fragments, and siderophile element concentrations in the impact melt, the parent asteroid is considered to be a low-metal (~4%) mesosiderite [4,5].

In 1995, Polarstern expedition ANT-XII/4 performed the first geological exploration of the impact area [6], and successfully collected three new cores containing ejecta deposits near Eltanin core E13-4. This survey was near the Freeden Seamounts (57.3°S, 90.5°W; we previously called these the San Martin Seamounts but they were officially named Freeden in 1999), and ejecta deposits were found near the top of the seamounts (2.7 km depth), at an intermediate depth (4 km) and in a deep (5 km) basin ~40 km to the north. In addition to detailed mapping and echosounding of sediments in the region, a primary result of this expedition was from the analyses of sediment ages, textures and compositions (size, microfossil, mineralogy, meteorite content), which showed that sediments as old as Eocene, and probably Paleocene were ripped up by the disturbance from the impact and redeposited in three distinct units. The lowermost unit is a chaotic assemblage of sediment fragments up to 50 cm in size. Above this is a laminated sand-rich unit that was deposited as a turbulent flow, and this is overlain by a more fine-grained deposit of silts and clays that settled from a cloud of sediment suspended in the water column. Meteoritic ejecta particles were found to be concentrated near the base of the uppermost unit, where coarse ejecta caught up with the settling sediment following the impact.

This Study: Here we will present our latest results from a new suite of cores collected on Polarstern expedition ANT-XVIII/5a. On March 26

2001, the Polarstern returned to the impact area and, despite severe weather and heavy seas, successfully explored a region of ~80,000 km², collecting 17 new sediment cores that contained sediments of impact age. At least 16 of these cores contained meteoritic ejecta. The known strewn field now extends from core E10-2 (56°S, 82.8°W) in the east to core PS58 280-2 (57.5°S, 93.8°W) in the west, a distance of ~660 km, and from PS2708-1 (57.8°S, 91°W) in the south to PS58 294-1 (55.8°S, 92.1°W) in the north, a distance of ~200 km.

The meteoritic ejecta is most concentrated in cores on the Freeden seamounts, and in the basins to the north, where the amount of meteoritic material deposited on the ocean floor was as much as 3 g/cm². These concentrations drop off to the north and the east to levels as low as ~0.1 g/cm². We were unable to sample the impact south of the seamounts, as the deposit was beyond the reach of our 25 m piston corer. Similar difficulties were encountered to the west, although a very disturbed core at site 280-2 contained abundant large ejecta debris. Our best estimate to date is that ground zero for the impact was in the region just north, or northwest, of the seamounts [7]. Despite the disturbance of sediments, there is no indication that the impactor penetrated the ocean floor and formed a crater, and the composition of the melted ejecta is inconsistent with mixing between projectile and terrestrial materials [5].

New x-ray radiographs of impact deposits reveal details that were not seen in earlier cores. The uppermost unit of the impact deposit is well-preserved in several cores, found as much as 50 cm from the seamounts to the east, north, and west of the seamounts, where at least 25 cm of this unit is preserved. At greater distances burrowing organisms have mixed the sediments so if this unit did exist, it was too thin to survive bioturbation. These fine-grained sediments are clearly laminated, and show alternating layers of low- and high-density sediments (the latter largely meteoritic), consistent with ripple formation in an energetic flow regime. In one core, climbing ripples are clearly seen.

The meteoritic content of the ejecta deposit is examined by geochemical analyses of Ir and other elements (e.g., Cr, Ni, Fe) and by separation and analysis of coarse particles from sieved sediments. The total mass of meteoritic material deposited is estimated using an Ir concentration of 188 ng/g,

which is an average value found in melt-rock particles [5]. To date 435 samples have been analyzed for Ir and 921 samples have been sieved and separated into clay, silt, and fractions >63, >125, >250, >500, >1000, and >2000 microns. All size fractions >500 μm have been hand picked and separated into terrestrial, impact melt rock, and unmelted meteorite fractions. These samples have yielded 34.6 g of meteoritic impact melt rock and 3.1 g of unmelted meteorite fragments. Additionally a 9 g, 2.2 cm meteorite was recovered during opening of core PS58 281-1. A large fraction of the recovered meteoritic material came from two cores – PS58 297-1 (13 g melted, 0.5 g unmelted), from near the summit of the seamounts, and PS58 281-1 (9 g melted, 0.7 g unmelted), just to the northwest of the seamounts. In core 297-1, we found abundant remains arenaceous foraminiferans – benthic protozoans that construct shells from sediment sand grains. In this core, these forams constructed their shells nearly entirely with meteoritic ejecta, as this component dominated the clastic, non-carbonate, portion of the sediments.

At most sites, the meteoritic ejecta is confined to the uppermost portion of the impact deposit, as the fallout from the impact appears to settle into the top of the sediment flows. Occasionally, fragments of meteoritic ejecta have been found meters below this layer, but we cannot rule out the possibility that particles were disturbed downcore by the coring process. One exception to this rule appears to be core PS58 281-1, where low concentrations of meltrock and a few meteorite fragments were found consistently in samples as much as 3.5 below the main fallout layers. We suspect that this implies early arrival of fallout, or direct injection of meteoritic material into the sediment flows at this site. This might imply that site PS58 281 was nearest to the actual impact site.

The observation that ~8% of the coarse ejecta is unmelted meteorites is consistent with earlier work [8]. This phenomenon may be a characteristic of deep-ocean impacts. This may have significance for delivery of organic matter to the early Earth by small impacts into a primordial ocean. Computer simulations [9] have been used to show that organics can survive small impacts. Our results show that actual meteorite fragments survive in significant amounts. However, a large portion of the meteoritic debris is buried rapidly by the sediments disturbed by the impact.

References: [1] Kyte, F.T. et al. (1981) *Nature* 292, 417-420. [2] Kyte, F.T. et al. (1988) *Science* 241, 63-65. [3] Kyte, F.T. and Brownlee, D.E. (1985) *GCA* 49, 1095-1108. [4] Kyte F.T. (2002a) *Deep Sea Res. II* 49, 1029-1047. [5] Kyte F.T. and Gersonde

R., (2003) *MAPS* A118. [6] Gersonde, R. et al. (1997) *Nature* 390, 357-363. [7] Gesrone et al. (2003) *Large Met. Impact III*, abs#4095. [8] Kyte F.T. (2002b) *Deep Sea Res. II* 49, 1049-1061. [9] Pierazzo E. and Chyba C.F. (1999) *MAPS* 34, 909-918.