Multidisciplinary Methods of Finding and Verifying Abyssal Impact Craters: Results and Uncertainties

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Because they are vulnerable to erosion and deformation that obscures and removes them, only about 1/6 of the impact craters that formed during the last 120 Ma have been discovered [1]. Until recently, all of these craters were found on land or on the continental shelf. This left 59% of the Earth [2] (the abyssal ocean basins) with no known impact craters. Abyssal impact craters form on true oceanic crust, typically at water depths of 2000 meters or greater. Because they are covered by water and are on strong oceanic lithosphere, abyssal impact craters are less vulnerable to erosion and deformation than continental impact craters. Thus, abyssal impact craters should preserve a nearly complete ejecta blanket and impact melt body that could potentially provide great insight into impact processes. Another issue is the importance of Ir in identifying impact layers. Although there are a number of strewn tektite fields with an inferred or known submarine source crater, only the Eltanin impact layer has a documented Ir anomaly [3] and an inferred abyssal source crater. In this abstract, we present evidence for the presence of two previously unknown abyssal impact craters, a prospective source crater for the late Pliocene Eltanin impact layer and the late Miocene Ewing impact layer. With exception of previously published work on the Eltanin impact layer, all of the research is unpublished. Because the water and sediment of the oceanic crust reduce the topographic expression of the crater [4], abyssal impacts are difficult to verify from topography alone. Instead, we use a suite of geochemical, geological and geophysical indicators: 1) magnetic anomalies, 2) seismic reflection characteristics, 3) severe sediment erosion, 4) impact spherule bearing ejecta layers in sediment cores, 5) tektites in ejecta layers, 6) Ir anomalies in ejecta layers, and 7) topography. The topographic relief of an abyssal impact crater is modest, only a few hundred meters at most. The rims of the larger craters (Ewing, 150 km [5] and Eltanin, 132 km [6]) appear as a set of evenly spaced conical hills in a ring. This rim structure is the result of movement of the water into the crater, which produces severe erosion of the crater walls. Due to more extensive erosion, the downslope portion of the crater rim is nearly absent. The central uplift appears as a partial ring (Ewing) or a small central hill (Eltanin). Outside the edge of the continuous ejecta blanket, the bottom sediments are completely denuded and/or extensively reworked by impact induced water movements [6]. Extensive sediment reworking is evident on seismic lines at distances of up to 500 or 600 km away from the center of both craters. Abyssal impacts melt red clay and basaltic crust, both of which have high Fe contents. As a result, the magnetic anomalies from impact melt bodies should be very large [7]. The Ewing crater has two large magnetic anomalies from impact melt ponded in topographic lows in the southern part of the crater [5]. There is no marine magnetic data from the Eltanin crater. Outside the crater rim, impacts produce a continuous ejecta blanket that extends out roughly one crater diameter from the crater rim. Seismic lines show a clear ejecta blanket about the Eltanin crater. The ejecta blanket from the Ewing crater is less obvious, perhaps due to the poor quality of the older single channel seismic data from the area. The distal impact layers show up in cores as layers with a high magnetic susceptibility. The upper portions of the high susceptibility layers derived from the Ewing structure contain impact spherules and magnetite grains. Some of these high susceptibility layers contain tektites. We now have enough data on impact spherules and tektites from the Ewing impact (about 12 ejecta layers from 12 different cores) to show a rough pie shaped slice of tektite distribution in the ejecta layers with the Ewing crater at the center of the pie. Searching through LDEO cores, we found four new high susceptibility layers with a late Pliocene age that is (within error) the same age as that of the Eltanin impact layer. These high susceptibility layers contain impact spherules. Two of these cores (RC17-211 and RC12-228) contain tektites. Ten samples for Ir analyses were selected from three cores (RC17-211, RC12-230, and RC18-33) which, based on previous magnetic susceptibility measurements, were inferred to have potential meteoritic debris. The samples were analyzed using isotope dilution by high resolution ICP-MS (ThermoFinnigan Element1), after aqua regia digestions in sealed carius tubes. Abundances of Ru, Ir and

Pt were obtained from six samples with the highest magnetic susceptibility in RC17-211 and RC 12-230, and range from 200-500 ppt Ir with Pt/Ir ratios of 14-23xCI. These data are consistent with PGE abundances in marine clays and do not indicate a significant contribution of meteoritic debris in this portion of the Eltanin ejecta blanket. This result could mean that the crater we have found is not the source crater for the Eltanin impact layer. Alternatively, the impactor that formed the crater may have broken up as it came through the Earth's' atmosphere or may have come in at a low angle. Low angle impacts decrease the amount of melting of the projectile [8]. In both cases, the areas of most pronounced meteorite enrichment within the Eltanin impact layer should lie along the incoming trajectory of the meteorite. We feel confident that we have found two new abyssal impact craters. More work will be required before we can fully understand how the prospective Eltanin crater is related to the nearby Pliocene age, impact ejecta layers that both lack and contain Ir anomalies. In the future, mapping of large amplitude sediment waves (antidunes?) or erosional troughs may provide clues that will help us to determine the sequence of events during the formation of the Eltanin and Ewing impact craters.

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