UPPER EOCENE IMPACT EJECTA/SPHERULE LAYERS IN MARINE SEDIMENTS: NEW SITES.
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Introduction: Upper Eocene impact ejecta and/or spherules have been found in at least 19 marine sites and three sites on land[1-6]. The number of upper Eocene spherule layers or impact events is still under debate [7-11]. The purpose of this study is to search for upper Eocene spherule layers at additional sites, and to correlate them with already known spherule layers with the objective of determining the number of upper Eocene spherule layers, their geographic extent, their source craters, and to study the geological and biological effects caused by late Eocene impact events.

Methods: Ocean Drilling Program (ODP) samples (3 cc in volume) were obtained at 20 cm intervals through upper Eocene sections of the appropriate age (based on biostratigraphy) for the purpose of searching for spherules/ejecta. The samples were disaggregated in water using ultrasonics and then wet-sieved. The 63-125 μm and >125 μm size fractions were recovered and examined using a binocular microscope. The spherules were concentrated using heavy liquid separation. Suspected impact ejecta were studied with X-ray diffraction. The major chemical composition of selected microtektites/microkrystites were analyzed by SEM-EDX.

Results: Upper Eocene impact ejecta/spherules have been found from five new sites (Fig. 1): ODP Site 1073A, off New Jersey coast; Site 709C, Western Indian Ocean; Site 699A, Southern Atlantic Ocean; Site 703A, Southern Atlantic Ocean.

Site 1073A. This site is located on the continental slope off New Jersey, 62 km northwest of Site 612, which contains a layer (8 cm thick) of tektites and shock-metamorphosed minerals [12-13]. Rock fragments and minerals were found in core 72, section 3 (72-3), 140 cm through 72-5, 60 cm, but white opaque (shock-metamorphosed) ejecta (> 125 μm) were confined to an interval between 61 cm and 120 cm, in 72-4. Most of the white opaque grains are either shocked quartz with PDFs, or coesite, or mixture of both. No microtektites or cpx spherules (clinoprexene-bearing spherules) were found. Glauconite is present all through the ejecta layer, even below and above, but with a peak that mimics that of the ejecta layer. A peak in calcispheres (calcareous dinocysts?) appears after the ejecta layer. The abundance of planktic foraminifera, benthic foraminifera and radiolarian decrease through the impact layer and resume after the layer, but the variation might due to dilution by impact ejecta. The abundance of three radiolarians (*Thyrsocyrtis bromia, Thyrsocyrtis tetrocatha, Thyrsocyrtis finalis*) decrease through the layer and disappeared just above.

Site 709C. This site is located in the W. Indian Ocean 3353 km away from DSDP 216 in the E. Indian Ocean and which contains abundant spherules [2]. Both microtektites and cpx spherules have been found in an interval between 31X-4, 100 cm and 31X-5, 40 cm. Besides transparent, colorless microtektites, several deeply corroded microtektites with brownish color (larger than 500 μm) were recovered. The major oxide

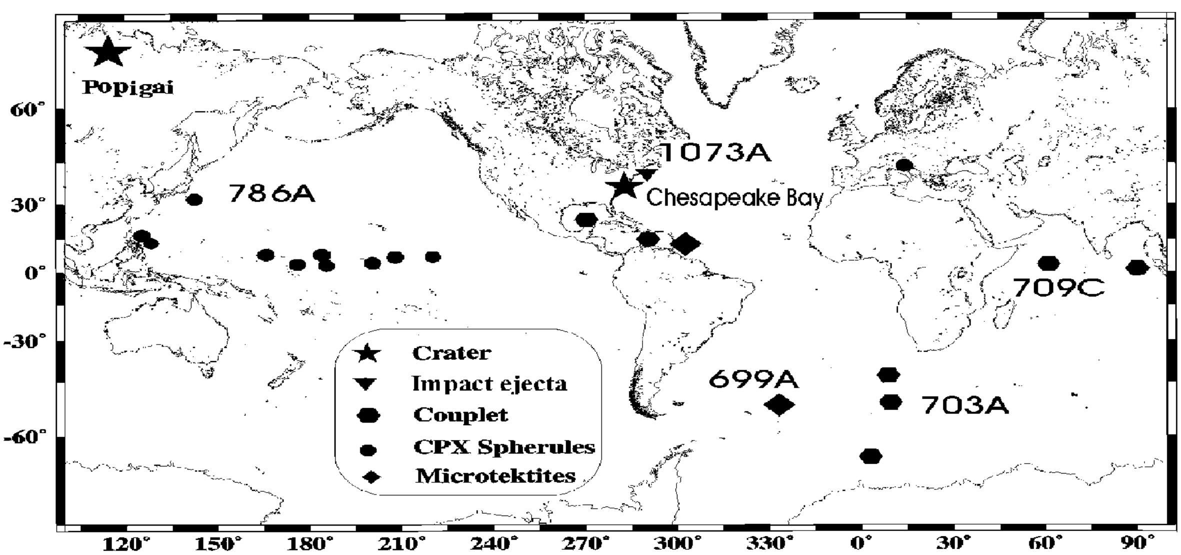

Fig. 1. Locations of new ODP sites where upper Eocene impact ejecta/spherule layer have been found. Impact ejecta means unmelted impact jecta; couplet means the site contains both microtektites and cpx spherules.

composition of these microtektites is similar to that of the North American (N. A.) tektites. There are more light-colored cpx spherules than dark-colored spherules; about half of the light-colored cpx spherules are fragments, while <5 % of dark-colored cpx spherules are fragments.

The peak abundance of microtektites (>125 μm) is about 47/gram, compared to that of the cpx spherules (854/gram). There is no separation of the peak abundance between microtektites and cpx spherules.

Site 699A. Site 699A is located on the NE flank of the NE Georgia Rise in the South Atlantic Ocean, ~2420 km away from Site 689 in the Weddell Sea, where both upper Eocene microtektites and cpx spherules were discovered [5-6]. Microtektites have been found from a narrow interval between 70 and 90 cm in core 35, section 4. The microtektite-bearing sediment is confined to the *Isthmolithus recurvus* Subzone [14]. Microtektites are scattered through the interval, but no cpx spherules have been found. The abundance of microtektites is less than 5 /gram (>63 μm).

Site 703A. This site is located on Meteor Rise in the South Atlantic, 467 km to the south of Site 1090B, and 1966 km to the north of Site 689B. A few microtektites and one cpx spherule were found in sample 15-3, 35-36 cm. The spherule-bearing sediment is confined to the *Isthmolithus recurvus* Subzone [14].

Site 786A. This site is located in the center of the Izu-Bonin forearc basin in the Western Pacific Ocean, about 4765 km from Popigai crater, and is thus the closest marine site to Popigai crater. Calcium-rich cpx spherules are recovered between 35-40 cm, in core 11, section 2, at Site 786A. Those cpx spherules have a creamy color, and are different from those from 709C in terms of appearance and composition.

Discussion: Based on calcareous nannofossils, core 72X of Site 1073A is assigned an age of 35-36 Ma, within Zone CP15 [15]. The ejecta-bearing sediment at Site 1073 is stratigraphically correlated with the spherule/ejecta layer at nearby sites 612, 903, 904 [12,16-17]. The Chesapeake Bay structure, which is estimated to have an age of 35.5 Ma, has been suggested as the source crater for the North American microtektite [18]. It has been suggested that the tektite layer of Site 612 is not coeval with the microtektite layer of Barbados [10], however, the radiolarian data for Site 1073A implies that they are the same layer, since the impact layer at Hole 1073A lies close to the *C. bandyca* and *C. ornata* zonal boundary as observed at Barbados [3].

According to radiolarian data, at Hole 709C [19] the spherule layer is associated with five radiolarian extinction, the same as that of at sites 216 and 1073A and at Barbados. No separation of the peak abundance between microtektites and cpx spherules was observed at Hole 709C. Both microtektites and cpx spherules have been recovered from Site 216, and it has been suggestion that the microtektites belong to the N. A. tektites strewn field [20]. Sr-Nd analysis of the large brownish microtektites and bottle green microtektites will help to correlate them either with N. A. strewn field or Popigai event, or other events.

Though Hole 699A is close to Site 689 and Hole 1090B, the abundance of microtektites is far less than that of Site 689 and Hole 1090B [5,6]. Like the spherule layer at sites 689 and 703, the microtektite-bearing sediment lies in the *I. recurvus* subzone [14]. But the scarcity of microtektites without a well-defined peak at Site 699 remains to be explained.

Conclusion: The impact ejecta layer from Site 1073A is correlative with the previously described microtektite/ejecta layer found on Barbados and in three DSDP/ODP sites off New Jersey coast and Barbados. Cpx spherules and microtektites from 709C are similar in appearance, composition, and abundance to those found at Site 216. Large brownish corroded and/or fragmented microtektites found at this site have major oxide compositions similar to N. A. microtektites and may belong to the N. A. strewn field.

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