Rb-Sr AND Sm-Nd OF UPPER EOCENE MICROTEKTITES: A POTENTIAL POPIGAI SOURCE.

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Introduction: Five impact events are known to have occurred towards the end of the Eocene (Popigai, Chesapeake, Mistastin, Logiosk and Wanapitei), several of which are deemed sufficiently large to have produced atmospheric blow-out and global ejecta fields [1]. Glassy and crystalline ejected impact melts, known as microtektites and microspherules, respectively, have been sampled from upper Eocene marine sediments from the Atlantic, Pacific, and Indian Oceans. The number of discrete impact ejecta layers in the marine record based on the existing biostratigraphic data and their major element compositions is still contentious, with authors advocating 2 layers [2], 3 layers [3, 4], or more [5]. Each distinguishable layer implies an origin from a temporally discrete impact structure. The uppermost, glassy tektite and microtektite layer has been linked with the Chesapeake, Virginia, impact structure [6]. This work presents, for the first time, Nd and Sr isotopic signatures of marine microtektites and microspherules. These data enable us to determine the number of isotopically distinct ejecta layers and to assess their provenance by comparing their compositions with impact melts from the known potential source impact structures.

Sampling: We present isotopic data for seven ejecta samples from Deep Sea Drilling Program (DSDP) and Ocean Drilling Program (ODP) cores: microtektite fragments from Site 612, collected from offshore Virginia, near the Chesapeake impact structure; two melanocratic microspherule samples from a 9-13 cm interval straddling two core sections from site 462 in the western central Pacific; and melanocratic, leucocratic, and colourless impact melts from a layer in the eastern Indian Ocean (Site 216). We also present data for a sample of impact melt rock from the Lake Mistastin impact structure, Labrador, Canada. The DSDP/ODP samples were chosen to sample each of the three proposed impact ejecta layers of [3, 4]: Site 612 is representative of the uppermost of these layers, known as the North American (Chesapeake) layer; Site 462 is the middle layer from the *T. cunialensis* biozone (formerly the *T. cerroazulensis* biozone; and Site 216 ejecta, from the lowermost *Po. semiinvoluta* biozone.

Sm-Nd and Rb-Sr isotope results: Studies of Rb-Sr and Sm-Nd in tektites and in microtektites have established that samples from known strewn fields have distinctive radiogenic Sr and Nd isotopic compositions [7, 8]. The $^{143}Nd/^{144}Nd$ compositions are consistent with the provenance of tektites from distinct crustal materials of well-defined mean ages. For Sr, the Rb-Sr model ages may define the time of last significant Rb/Sr enrichment, usually interpereted as being due to sedimentary processes. These Sr and Nd signatures can aid the identification of the provenance of microscopic impact ejecta.

For this work, microtektites and microspherules were handpicked (~130-200 μm in diameter). We have analysed bulk fractions of microspherules and microtektites. Samples consisting of groups of 168-350 microtektites and spherules were leached in dilute acids following [8], in order to remove secondary ferromanganese and iron sulfide coatings. Samples, as small as $\sim 10^{-1}$ mg, were analyzed. The Nd was measured with high sensitivity, as NdO^+. Typical amounts per mass spectrometer analysis were ≤10 ng Nd. Isotopic data for the 2.8 mg bulk sample of microtektite glass fragments from Site 612 (Table 1, Figure 1) are consistent with the data that have been determined for macroscopic 'North American' tektites from the same site [8]. A duplicate Sm-Nd determination for two splits of the melanocratic microspherules from Site 216 indicates good reproducibility. The two microspherule fractions from Site 462 are isotopically similar, which confirms that they are from a single layer, despite the samples straddling two core sections.

Melanocratic microtektites from Site 462 and Site 216 possess Nd model ages (T_{CHUR}) of 1830 to 2100 Ma. The leucocratic and colourless microspherules from Site 216 possess T_{CHUR} of 1720 and 1350 Ma. For these samples the T_{CHUR} model ages are distinct for samples of distinct chemical compositions. The Sr model ages (T_{UR}) are generally much younger than the T_{CHUR} ages and reflect a younger Rb/Sr fractionation process, typically associated with sedimentation. For cases where the chemical fractionation for Rb/Sr ($f_{Rb/Sr}$) is small, or the Sr is non radiogenic, the T_{UR} model ages are not well defined (e.g., Mistastin sample LM57-69).

The melanocratic microtektites from Sites 216 and 462, though from different ocean sites, possess similar εNd (-21.8 to -24) and εSr (+342.1 to +354.0) values;

microtektites from both sites overlap with the values for the Popigai impact melt rocks (Figure 1). The Site 216 leucocratic and colourless microtektites possess less depleted εNd (-20 to -16) and less radiogenic εSr (+187.2 to +209.1) values, but lie outside the North American strewn field range.

Conclusions: The similarity between the isotopic character of Site 216 and Site 462 melanocratic microspherules implies that they have a common source, despite apparently residing in two different biozones. This new evidence supports the contention of [2]: that there are only two discrete ejecta layers (the North American layer and only one underlying microspherule layer). The Archean Nd model ages of the melanocratic microspherules are consistent with their having been derived by impact melting of the Archean Anabar basement gneisses to the ~100 km diameter Popigai impact structure in Siberia. None of the other upper Eocene impact structures appear to be viable sources to these microspherules since melt rocks associated with these other structures display no Nd-isotopic similarity to the microspherules (Figure 1).

The leucocratic and colourless microspherules from Site 216 display more Nd and Sr isotopic variability than their melanocratic counterparts. The leucocratic melts were probably derived through bulk melting of target rocks with a different, more variable isotopic composition. The simplest explanation is that the felsic microspherules were derived by impact melting of the 1 km thick sedimentary rocks that overly the Anabar shield gneisses in the Popigai region. These sediments would have an isotopic character distinct to the Anabar basement shield owing to their external provenance [9].

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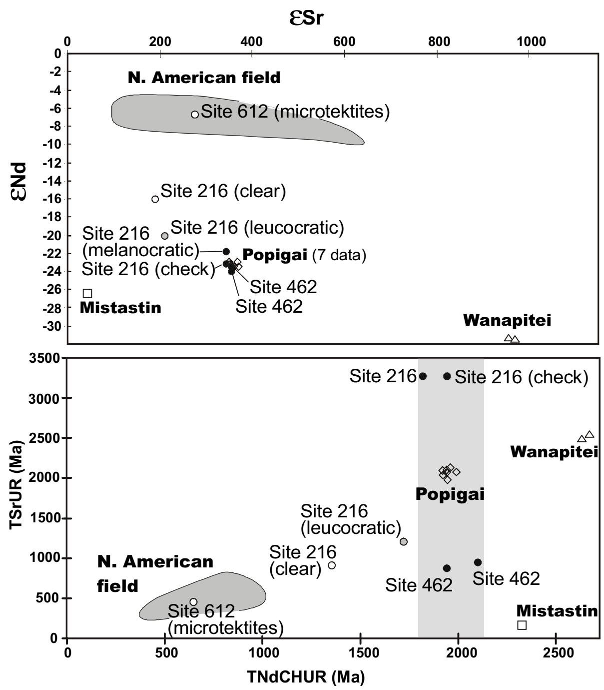

Figure 1. Nd and Sr isotopic compositions of upper Eocene impact melt ejecta. Data sources: Popigai melt rocks [8, 10]; N.American field [8, 11, 12]; Wanapitei [13].

Table 1

Site-core-section, depth	Note	Weight (mg)	Rb (ppm)	Sr (ppm)	Nd (ppm)	Sm (ppm)	$^{143}Nd/^{144}Nd$	$^{147}Sm/^{144}Nd$	ε Nd	+/-	f(Sm/Nd)	T^{Nd}_{CHUR} (Ma)	+/-	$^{87}Sr/^{86}Sr$	$^{87}Rb/^{86}Sr$	ε Sr	+/-	f(Rb/Sr)	T^{Sr}_{UR} (Ma)
612-21-05, 115-117 cm	VF	2.80	43.1	41.1	11.09	2.12	0.51151	0.11550	-6.6	*0.4*	-0.4126	640	*40*	0.72383	3.041	274.4	*1.0*	35.77	460
462-36-01, 145-147 cm	MS	0.97	85.2	127.8	24.14	4.37	0.51065	0.10940	-23.4	*0.5*	-0.4440	2100	*50*	0.72944	1.932	354.0	*1.8*	23.40	990
462-36-02, 6-8 cm	MS	1.18	84.1	117.0	21.77	3.66	0.51062	0.10150	-24.0	*0.7*	-0.4839	1970	*60*	0.72944	2.084	354.0	*1.1*	25.20	880
216-16-02, 5-7cm	MS	2.98	nd	81.2	14.18	2.43	0.51073	0.10357	-21.8	*0.5*	-0.4735	1830	*50*	0.72860	nd	342.1	*0.7*	nd	nd
216-16-02, 5-7cm *	MS	2.51	42.3	81.0	13.85	2.36	0.51066	0.10320	-23.2	*0.4*	-0.4754	1940	*40*	0.72845	1.514	340.0	*1.0*	17.30	1180
216-16-02, 5-7cm	LS	9.31	39.9	122.7	15.25	2.67	0.51082	0.10570	-20.0	*0.5*	-0.4625	1720	*50*	0.71923	0.942	209.1	*0.6*	10.39	1210
216-16-02, 5-7cm	CS	2.16	64.1	168.7	22.21	3.82	0.51103	0.10410	-16.0	*0.4*	-0.4710	1350	*30*	0.71769	1.101	187.2	*1.0*	12.31	910
Mistastin LM57-69	IS	29.50	271.7	599.1	52.76	9.36	0.51049	0.10720	-26.5	*0.6*	-0.4548	2320	*60*	0.70746	2.262	42.0	*1.1*	14.88	170

VF - Vesicular, pale green, transparent glass fragments
MS - Melanocratic, holocrystalline microspherules
LS - Leucocratic, holocrystalline microspherules
CS - Colourless, transparent, holohyaline microspherules
MF - Melanocratic, holocrystalline to holohyaline fragments
LF - Leucocratic, holocrystalline fragments
IS - In-situ melt from the Mistastin impact structure
* - Sm-Nd data for a second split of Site 216 mafic microspherules.
nd - not determined