GEOGRAPHIC VARIATIONS IN CONCENTRATION OF MINERAL INCLUSIONS IN MUONG NONG-TYPE AUSTRALASIAN TEKTITES: IMPLICATIONS REGARDING THE LOCATION OF THE AUSTRALASIAN TEKTITE SOURCE CRATER.

J. D. Dass[1] and B. P. Glass[2], [1]Geology Department, University of Delaware, Newark DE 19716, e-mail: joydeep@udel.edu [2]Geology Department, University of Delaware, Newark, DE 19716, e-mail: billy.glass@mvs.udel.edu

Introduction: Australasian tektites have been found in Indochina, south China, the Philippines, Malaysia, Indonesia, and Australia. Microtektites belonging to this strewn field have been found throughout most of the Indian Ocean, the western equatorial Pacific, and the Philippine, Celebes, and Sulu seas. Altogether, this strewn field covers about 14% of the Earth's surface. It is the youngest of the known tektite strewn fields with an age of only ~0.8 Ma. Based on abundance, shape, size, petrography, and composition of the Australasian tektites, several authors have suggested that the source crater is probably somewhere in Indochina [e.g.,1-4]. Geographic variations in the concentration (number per unit area) of Australasian microtektites is also best explained by a source area in Indochina [5]. However, in spite of the young age and large size of this strewn field, the source crater has not been found.

Large, blocky, layered tektites (called Muong Nong-type tektites) are found primarily in Indochina. Petrographic and compositional data indicate that the Muong Nong-type (MN) tektites formed at a lower temperature than the splash form or ablated tektites [e.g., 6] and are thus found closer to the source crater. Because of their lower temperature of formation, some MN tektites contain coesite and relict mineral inclusions [e.g., 7-9]. Here we report preliminary findings of an ongoing investigation of the geographic variation in the size, kinds, and concentration (number per weight of sample) of mineral inclusions in MN Australasian tektites. The ultimate objective of this research is to determine the geographic location of the source crater.

Methods and Assumptions: Thirty-two MN tektites from 20 known locations in Indochina and China were used in this study (Fig. 1). Each sample was crushed and sieved. The 74-149 µm size fraction was then subjected to a series of heavy liquid separations — see Glass and Barlow [9] for a more complete discussion of the method. Glass fragments with higher specific gravities than the bulk of the glass were studied with a binocular microscope and glass fragments with mineral inclusions were recovered. The inclusions were grouped according to their appearance (i.e., size, shape, color, transparency, and nature of their borders). Selected inclusions from each group were then identified by x-ray diffraction (using a Gandolfi camera) and/or energy dispersive x-ray analysis in order to determine the kinds and abundances of inclusions in each specimen.

It is proposed that geographic variations in the concentration and kinds of inclusions can be used to infer the location of the source crater. We assume that the MN tektites are part of the ejecta and were not formed by melting of surface deposits where they are found and that, therefore, the temperature and pressure (i.e., degree of shock metamorphism) that the MN tektites experienced increases with distance from the source crater. Thus, the degree of shock metamorphism (indicated by the kinds of inclusions) should increase and the concentration of inclusions should decrease with distance from the source crater.

Results: Inclusions were recovered from 19 of the 32 specimens. The number of inclusions per 10 grams of tektite ranges from 0 to 2770. As in previous studies, the inclusions include zircon, a corundum-bearing phase, and rutile. Zircon and a corundum-bearing phase occur in all of the inclusion-bearing specimens, but rutile is rare. The two specimens with the highest concentration of inclusions also contain numerous quartz grains with varying amounts of coesite (see below). The corundum-bearing phase gives an x-ray diffraction pattern for corundum, but has an Al_2SiO_5 composition. It is apparently an Al_2SiO_5 phase, such as kyanite, andalusite, or sillimanite, that has decomposed to corundum plus SiO_2 glass [9].

Low concentrations of inclusions are generally found in MN tektites from Cambodia, southern Vietnam, China (including Hainan), and northern Vietnam (Fig. 1). The highest inclusion concentrations are found in MN tektites from southern Laos and adjacent eastern Thailand with the highest concentration of inclusions (2770 per 10 g of sample) in a specimen from Muong Phin, Laos. There are two obvious anomalies: the high concentration of inclusions (211) in the MN tektite from Da Thein, Vietnam, and the lack of inclusions in specimens from Muong Nong, Laos (just to the east of Muong Phin) (Fig. 1). Otherwise, there appears to be a fairly systematic increase in concentration of inclusions towards the area of southern Laos and adjacent eastern Thailand.

Preliminary studies of a second MN tektite from Muong Phin indicates that it also has a high concentration of inclusions. The inclusion concentrations in the Muong Phin specimens appear to be at least an order of magnitude higher than in any other MN tektites. Additional work needs to be done on the MN tektite specimens, but preliminary data suggest that the major crystalline phase in these specimens consists of quartz with varying amounts of coesite. Numerous large (up to 0.5 mm) white opaque inclusions are visible on fresh interior surfaces of the Muong Phin specimens. Most of these are assumed to be the quartz grains with varying amounts of coesite.

Conclusions and Future Work: The uniform mineral assemblage is consistent with a single source crater with homogeneous surface rocks. Since quartz is a relatively low temperature phase and since coesite is destroyed at high temperatures, the two MN tektites from Muong Phin, Laos, appear to have experienced lower temperatures than the other MN tektites in this study. Therefore, the high concentration of mineral inclusions and the relatively low degree of shock metamorphism (as indicated by the mineral assemblage) indicate that the MN tektites from Muong Phin came from a site closer to the source crater than do the other MN tektites. This suggests that the source crater is in southern Laos or adjoining Thailand or Vietnam. Thus, our preliminary findings are consistent with Schnetzler's [4] conclusion that the source crater is in a limited area near the southern part of the Thailand-Laos border.

A number of additional studies need to be done in order to evaluate our preliminary results. We need to determine the inclusion concentration in additional MN tektites from each of the sites already studied in order to establish the inter-site variability. Preliminary studies of two or more MN tektites from several sites have given mixed results. Part of the problem is that some of the MN tektite specimens may not have been found where they are reported to have come from. We also need to determine the inclusion concentration in several samples from the same MN tektite in order to establish the inter-specimen variability. Present data indicate that individual MN tektite specimens have fairly homogeneous inclusion concentrations. Finally, we need to determine the inclusion concentration and mineral assemblage in MN tektites from several additional sites in order to establish whether or not there is any systematic geographic variability in inclusion concentration and degree of shock metamorphism that will allow us to better define the location of the Australasian source crater.

Acknowledgements: We thank Virgil E. Barnes, Emil P. Izokh, C. C. Schnetzler, and the Smithsonian Institution for the samples used in this study. Yunbin Guyan and Joshua Beggs provided inclusion concentration and some X-ray identification data for 10 Muong Nong-type tektite samples and one sample, respectively. Bryan Eitner did sample processing and heavy liquid processing for two samples. We thank Takako Nagase for X-ray diffraction and scanning electron microscope/energy dispersive analysis of the inclusions.

References: [1] Cohen A. J. (1962) *Space Res.*, 3, 959-973. [2] Stauffer P. H. (1978) In *Proc. of the 3rd Regional Conf. on Geology and Mineral Resources of Southeast Asia, Bangkok, Thailand*, 285-289. [3] Ford R. J. (1988) *Austral. J. of Earth Sci.*, 35, 483-490. [4] Schnetzler C. C. (1992) *Meteoritics*, 27, 154-165. [5] Glass B. P. and Pizzuto J. E. (1994) *J. Geophys. Res.*, 99, 19,075-19,081. [6] Koeberl C. (1992) *Geochim. Cosmochim. Acta*, 56, 1033-1064. [7] Walter L. S. (1965) *Science*, 147, 1029-1032. [8] Barnes V. E. (1963) *Science*, 142, 1651-1652. [9] Glass B. P. and Barlow R. A. (1979) *Meteoritics*, 14, 55-67.