RELICT ZIRCON INCLUSIONS IN MUONG NONG-TYPE AUSTRALASAIN TEKTITES: IMPLICATIONS REGARDING THE LOCATION OF THE SOURCE CRATER. B. P. Glass, Geology Department, University of Delaware, Newark, DE 19716, USA (bglass@udel.edu)

Introduction: Over the last thirty years we have recovered crystalline inclusions from approximately forty Muong Nong-type tektites from the Australasian tektite strewn field in order to learn more about the nature of the parent material and the formation process [e.g., 1, 2]. More recently we have used geographic variations in concentration (number/gm) of crystalline inclusions to indicate the possible location of the source crater [3]. The purpose of this abstract is to summarize all the presently available data regarding relict zircon inclusions recovered from Australasian Muong Nong-type tektites and to discuss implications regarding the possible location of the source crater which has still not been found.

Method: The tektite samples were thoroughly cleaned, crushed, and sieved. The sieved glass fragments (generally the 74-149 µm size fraction) were then subjected to heavy liquid separation in order to recover the grains containing the crystalline inclusions. The inclusions were then counted and representative ones were identified with X-ray diffraction (XRD) using Debye-Scherrer or Gandolfi cameras [2]. Some of the crystalline inclusions were also studied with a petrographic microscope and scanning electron microscope (SEM) with an attached energy dispersive X-ray analyzer.

Results: Approximately 60% of Muong Nong-type Australasian tektites were found to contain crystalline inclusions. Silica-rich Muong Nong-type tektites (i.e., those with refractive indices <1.503) are more likely to contain crystalline inclusions [2]. The crystalline phases found so far are corundum, zircon, rutile, chromite, monazite, quartz, coesite, and perhaps baddeleyite. Zircon, rutile, chromite, monazite, and quartz appear to be relict phases and all show evidence of shock metamorphism. The corundum appears to be a decomposition product of an Al_2SiO_5 phase and coesite is a high-pressure phase formed by shock metamorphism of quartz [2,4].

Relict zircon inclusions have been identified in 28 out of the 33 (~85%) Muong Nong-type Australasian tektite samples from which we have identified inclusions; however, not all of the recovered inclusions have been identified by XRD. Based on appearance, the percent of inclusion-bearing specimens containing zircon is probably 100% or very close to it. Nearly all the zircons are opaque white and their X-ray patterns show extreme X-ray asterism. However, of the 28 zircons identified by X-ray diffraction, only two (both from the same specimen whose place of origin is unknown) produced X-ray diffraction patterns indicating that baddeleyite may be present. The X-ray patterns from these two grains contained the two strongest lines for baddeleyite and one of them contained a few additional lines that closely match those for baddeleyite. Scanning electron microscope images of the polished sections of twelve of the zircons generally show some evidence of disaggregation; and most have granular textures similar to the textures observed in zircons which have completely broken down to baddeleyite plus SiO_2 glass. An attempt to recover zircons (from a specimen known to contain zircons) by dissolving the glass using dilute hydrofluoric acid failed. A grain containing a zircon was placed in a plastic cavity slide with a drop of dilute hydrofluoric acid and observed with a microscope. When the glass was dissolved, the zircon collapsed into powder, suggesting that the zircon grains are composed of crystallites in a glassy matrix (i.e., they have polycrystalline textures) [5].

Discussion: Crystalline inclusions have been recovered also from a Muong Nong-type moldavite from Jakule in the Czech Republic [6] and from a Muong Nong-type Georgia tektite [7]. In both cases the only crystalline phases present were zircon or its decomposition product baddeleyite. The inclusions have the same appearance and structure as the zircons recovered from the Muong Nong-type Australasian tektites; however, in these specimens many or most of the zircons have broken down to baddeleyite plus SiO_2 glass. Why didn't the zircons in the Muong Nong-type Australasian tektites also break down to baddeleyite plus silica glass? The most obvious answer would appear to be that the Muong Nong-type Australasian tektites were not as severely shock metamorphosed and thus were not heated to as high a temperature as the Muong Nong-type moldavite and Georgia tektite. This is supported by the fact that zircon and baddeleyite were the only phases found in the moldavite and Georgia specimens. Since the average degree of shock metamorphism is inversely related to distance from the source crater, we can assume that the Muong Nong-type Australasian tektites were found closer to their source crater than were the Muong Nong-type moldavite and Georgia tektite specimens. The Muong Nong-type moldavite was found about 300 km from the Ries crater (believed to be the source crater for the moldavites) and the Georgia tektite was found about 750 km from the Chesapeake Bay structure (believed to be the source crater for the North American tektites). The fact that the zircons in the Muong Nong-type Australasian tektites did not break down to baddeleyite plus silica suggests that the Muong Nong-type Australasian specimens were all found within 300 km of the Australasian tektite source crater. But, there is no possible crater location that is within 300 km of all the zircon-bearing Muong Nong-type tektite sites if we include the southernmost site (near Saigon in southern Vietnam) where only one zircon has been identified by X-ray diffraction. Additional zircon inclusions from the southernmost sites need to be X-rayed in order to determine if most zircons in this part of the strewn field show evidence of breakdown to baddeleyite. If they do, then the zircon data would support a source crater location in southern Laos or adjacent Thailand or Vietnam as previously proposed [e.g., 3, 8]. If zircons recovered from Muong Nong-type tektites from southern Vietnam don't show evidence of breakdown to baddeleyite, then the zircon data would be more consistent with cometary impact that melted surficial deposits over a large area as proposed by Barnes and others [e.g., 9, 10]. However, such a hypothesis does not appear to be able to explain the rather small range in major, trace, and isotopic compositions of the Australasian tektites [11]. Alternatively, the observed lack of baddeleyite associated with the zircons in the Muong Nong-type Australasian tektites may be due to the larger sizes of these tektites that resulted in slower cooling which may have allowed the zircons to recrystallize. If this is the case, then some of the Muong Nong-type Australasian tektites may be farther than 300 km from the source crater without the zircon inclusions showing evidence of breakdown to baddeleyite. Severe heating of the zircons is indicated by U-Pb isotopic data (obtained during an attempt to date eight zircons from Muong Nong-type Australasian tektites) that show that the zircons experienced extreme lead loss and exchange of lead with the adjacent molten glass [12].

Conclusion: The apparent widespread distribution of Muong Nong-type Australasian tektites containing zircons that do not exhibit evidence of breakdown to baddeleyite plus silica is difficult to explain. However, the southern limit of this distribution is based on a single X-ray diffraction pattern. If additional studies show that there are Muong Nong-type Australasian tektites containing zircons which have broken down to baddeleyite plus silica, then their geographic distribution should help define the location of the source crater.

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