^{10}BE IN MUONG NONG-TYPE AUSTRALASIAN TEKTITES: CONSTRAINTS ON THE LOCATION OF THE SOURCE CRATER.

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Introduction: Although it is generally agreed that Australasian tektites formed from terrestrial rocks melted by meteorite impact(s) in Indochina during the early-mid Pleistocene (~ 0.8 Ma), there is still much controversy over the crater location. Several impact sites have been proposed, but none of them has been confirmed [1-3]. Many people believe that, relative to other tektites, the Muong Nong-type or layered tektites were formed at lower temperatures and remained closer to the crater. Based on the spatial distribution of Muong Nong-type tektite sites and the chemical characteristics of the objects, Schnetzler [3] has suggested that the source region is in a limited area near the Thailand/Laos border. More recently, Dass and Glass [4] have investigated the occurrence of mineral inclusions in the Muong Nong-type Australasian tektites and suggested that the Muong Nong-type tektites from Muong Phin, Laos came from a site closer to the source crater than do other Muong Nong-type tektites. The geographic variation of ^{10}Be contents in Australasian tektites may also provide clues to the location of the source crater. Muong Nong-type tektites contain less ^{10}Be than other types. Aggrey et al. [6] gave an average concentration of 57±12 (10^6 atom ^{10}Be/g) for five Muong Nong-type tektites, only one-third and one-half the concentrations reported for Australian tektites (150×10^6 atom/g) and splash-form indochinites (100×10^6 atom/g), respectively [7]. Here we report some new results for ^{10}Be in Muong Nong-type tektites from SE Asia (Vietnam, Laos, Thailand, and Southern China). Our purpose was to examine the relationship between ^{10}Be contents and mineral inclusions and possible implications regarding the location of the source crater.

Experimental Methods and Results: Eighteen Muong Nong-type tektites collected from Southeast Asia were chosen for ^{10}Be measurements. All these samples had previously been searched for mineral inclusions [4]. We processed 500–1000 mg of each tektite to extract ^{10}Be by means of standard anion and cation ion exchange procedures. ^{10}Be measurements were done by accelerator mass spectrometry at PRIME lab, Purdue University. Samples of a powder prepared from the Dhurmsala meteorite, for which the ^{10}Be/^{9}Be ratio is well known, were also processed and measured as a reference. The ^{10}Be concentrations in Dhurmsala were found to be consistent within 5% with the values measured elsewhere [8]. The ^{10}Be/^{9}Be blank for the chemical procedure was less than 7×10^{-15} (atom/atom).

The ^{10}Be contents (10^6 atoms/g) for all the Muong Nong-type tektites analyzed lie in a range between 40 and 105 (Table 1), mostly with statistical uncertainties of 3-5%. The concentrations (number/10 g) of mineral inclusions are also listed.

Table 1: ^{10}Be content [10^6/g] and concentration of mineral inclusions (MI) (number inclusions /10 g) in Muong Nong-type tektites from Southeast Asia.

SampleID	Location	^{10}Be	MI
MP-26	Muong Phin, Laos	49.9±2.0	2770
TT-30-6	Nakhon Phanom, Thai	42.4±2.3	80
TT43	Kan Laung Dong, Thai	52.4±2.1	24
A65	Danang, Vietnam	60.2±2.9	22
TK27	Nam Dan, Vietnam	71.0±3.3	22
VC-10	Dalat, Vietnam	75.6±3.4	14
TK1	Saigon, Vietnam	74.9±3.0	10
VC1	Da Thein, Vietnam	102.9±3.4	210
TU-3	Ubonratchathani, Thai	75.5±2.3	0
TT-41	Phang Daeng, Thai	79.2±2.6	6
TK-26	Nam Dam, Vietnam	68.9±3.1	0
C2	Muong Nong, Laos	73.8±6.5	0
VC9	Dalat, Vietnam	72.5±2.3	0
CG1	Guangdong, China	96.0±6.7	3
A82	Vinh, Vietnam	59±20	0
CNC-1	Hainan, China	101.0±3.1	3
MN3	Muong Nong, Laos, Site 3	83±53	N.D.

Discussion: Glass [5] has reported that the relict grains of zircons in the Muong Nong-type Australasian tektites, unlike those found in moldavites from Jakule, Czech Republic [9] and in Georgia tektites, did not break down to baddeleyite plus silica. It seems 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 moldavites and Georgia tektites. Dass and Glass [4] have also found that there is a fairly systematic increase in concentration of inclusions towards the area of southern Laos and adjacent eastern Thailand.

Our new results not only have confirmed the lower ^{10}Be contents in Muong Nong-type tektites relative to other tektites, but also revealed a decrease in ^{10}Be contents towards the area of southern Laos and adjacent eastern Thailand. The lower ^{10}Be contents strongly suggest, although they do not prove, an origin in older and deeper layers. In most sedimentary formations and soil columns, ^{10}Be contents decrease with increasing depth [10]. The reason is that most of the ^{10}Be is produced at a more-or-less constant rate in the atmosphere, comes down to Earth with rain, and then quickly sticks to solid grains at the surface. With the passage of time, material bearing fresh ^{10}Be covers the old surface and ^{10}Be in the underlying layers continues to decay.

Figure 1 shows an inverse relationship between the ^{10}Be content and the concentration of mineral inclusions in the Muong Nong-type tektites. Tektites A82 and MN30 for which the uncertainties in ^{10}Be are large have been omitted. The geographic distribution patterns of ^{10}Be (Figure 2) and of mineral inclusions (see [4]) in tektites show that the tektites with low ^{10}Be contents ($<60\times10^6$ atom/g) and high mineral inclusion concentrations (>20/10 g) are most numerous in a region near the Thailand/Laos border, close to an area which has been proposed for the source region [3].

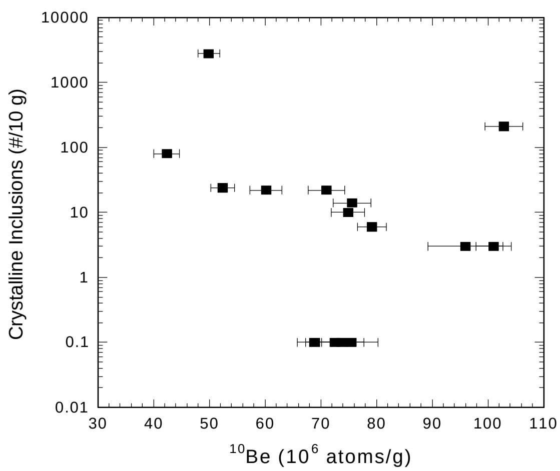

Figure 1.

Schnetzler [3] and Koeberl [11] conclude from major and trace element data, respectively, that all Australasian tektites came from a single impact event. Blum et al. [12], based on Sm-Nd and Rb-Sr isotopic measurements, have suggested that all Australasian tektites were derived from a single sedimentary formation with a narrow range of stratigraphic ages close to 170 Ma. Four candidate structures in this area had been identified from an examination of a digital topographic data set and Landsat imagery, but no evidence of impact origin could be found for these structures [1]. Our new measurements and previously published results [6,7] show that all the Muong Nong-type tektites contain appreciable amounts of ^{10}Be, and that the target materials had been at the surface within 10 My of the time of melting. A near-surface location is consistent with Barnes' [13] proposal that the projectile was a low density comet that melted surficial deposits over a large area.

The inner contour in Figure 2 (^{10}Be=60 $\times$ 10^6 atom/g) is not closed to the northeast for lack of tektite samples along the coast of Vietnam. Perhaps the crater is located somewhere in Gulf of Tonkin. Interestingly, one tektite sample from Hainan, China, contains low ^{10}Be (58×10^6 atom/g [6]).

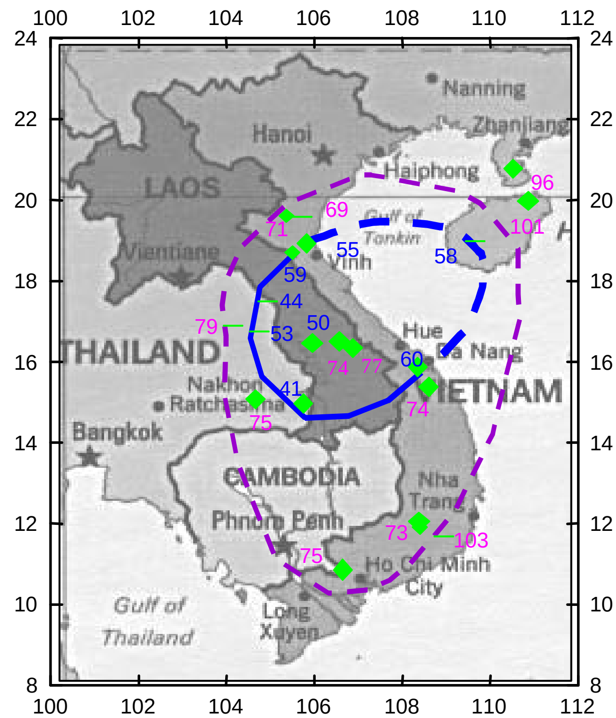

Figure 2. ^{10}Be contents (10^6 atom/g) in Muong Nong-type tektites vary with recovery location (diamonds). Within the interior boundary (^{10}Be=60), 8 of 10 samples (this work, [6]) have ^{10}Be contents <60. The outer contour (^{10}Be=80) may extend further in all directions except northeast.

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