TONGUES AND RINGS: EXTRUDED MOLTEN MATERIAL FROM TEKTITE INTERIORS.
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Introduction: There has been some discussions on the origin of special features on proximal Indochinite tektite surfaces known as ‘tongues’ which are surrounded by ‘navels’ or ‘rings’. Herein the term ‘ring’ is applied instead of ‘navel’ (navels, *sensu stricto,* are etched Hertzian cones forming in solidified medial tektites, such as Philippinites, during re-entry). Previous discussion was marked by three main explanations of origin: a) Impact and agglutination of a smaller more solidified body to a hotter, softer, larger body [1] [2], b) the tongue being a bulge formed by a bubble trying to escape the viscous melt [2] and c) the tongue being extruded molten tektite glass through a surface break or rupture [2] [3]. Today there are many more examples of tongues and rings. In this abstract different forms of these features are presented and origin is discussed.

Observations: The basic shape of the rings are round or oval u-grooves. Although probably of different origin to Philippinite navels [4], the secondary acidic ground water etching of circular lines of weakness to circular u-grooves is the same process.

With reference to Figures 1 and 2 one will note that the tongues and rings often occur on flattened, less etched, surfaces similar in nature to ‘bald spots’ which are spalled surfaces on the anterior margin. Sometimes they occur on clearly broken surfaces (see Figure 1).

Within the ring, different stages of tongue formation are observed. Preliminary stages of tongues are small bulges or proto-tongues (Figure 1). Typically, the ring is deeper than the regular surface of the tektite. The radius of the ring is significantly greater than the elevation of the tongue.

Fig. 1: Preliminary stages of tongue formation, termed proto-tongues (from Guangdong Province, China).

Next, in classic examples of the tongue and ring morphology (Figure 2) the rings are often more circular than oval. The radius is frequently comparable to the elevation of the tongue, which is usually hemispherical.

Fig. 2: Hemispherical tongues (from Guangdong Province, China; disk bottom right is from Yen Bai Province, Vietnam).

As the sequence progresses (Figure 3), tongues are more ellipsoidal or oval than hemispherical. The elevation of the tongue can be higher than the radius of the ring. These are termed elongate tongues.

Fig. 3: Elongate tongues (from Guangdong Province, China).

Further along the sequence, the tongue can become very elongate and even separate to form a secondary droplet (Figure 4). Secondary drops, made of molten material extruded from inside of tektites, are very rare. The drop in Figure 4 is the single known tektite presumed to be of that kind. The extruded drop differs from the primary drop form is that it appears much smoother, apparently a primary feature and not due to subsequent water abrasion.

Fig. 4: Very elongate tongue and a presumed secondary drop or "tongue-drop" (from Guangdong Province, China).

Two of the specimens described thus far are associated with bubbles (Figure 5). One observes non-spherical bubbles apparently beneath the tongue. Furthermore, the examples in Figure 1 are also likely bubble related. Not all specimens are believed to contain bubbles.

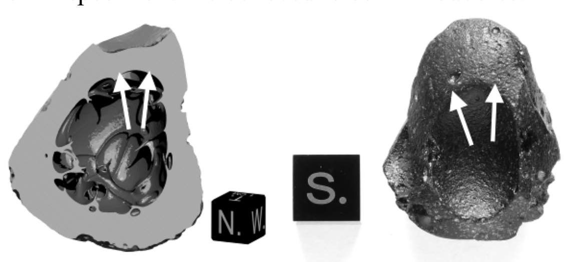

Fig. 5: Left: X-ray CT of bottom left tektite in Fig. 1; Right: Photo of the back of top left tektite in Fig. 3

Conclusions on formation mechanism: The critical observation is that the tongue and ring, on reasonably preserved specimens, always occurs on a flatter and smoother spalled or broken surface.

It is proposed herein, and in agreement with [3], that the sequence of events leading to tongue and ring formation is as follows:

a) The primary tektite morphology forms at altitude, within the atmosphere. It is immediately distorted and flattened through atmospheric interaction, all the time cooling. A hard exterior shell is formed. At this point the atmospheric pressure, at that altitude, is locked in.

b) The tektite suffers a break in its solidified exterior. This may be due to collision with another tektite, collision with the ground or thermal shock. Probability of failure may be enhanced by the presence of weaknesses, such as bubbles. The ring, effectively an annulus, may form by point pressure through impact or thermal crack propagation occurring in the presence of exit / re-entry body forces: Basically the same process as in Philippinite navel formation, but due a hot and non-brittle interior a Hertzian cone cannot form.

c) The previously 'locked in' molten interior is now exposed to a new exterior pressure. At greater altitude than the exterior solidification point, the air pressure will be lower. The tektite interior will then expand. This process would be far more pronounced if the tektite contained a bubble. The degree of tongue extrusion will likely be related to pressure differential and time taken to re-solidify. External forces, e.g. centrifugal forces or gravity may act on molten material extruded.

d) The body solidifies and is preserved.

e) Over geological time the ring (a weak point) is etched by ground water to produce circular u-grooves.

Figure 6 demonstrates the varying stages of tongue formation. The shape and characteristics of the tongue, which may eventually detach, being controlled by: a) The differential pressure between inside and outside the tektite at the time of the break. b) The temperature / viscosity of the melt and time taken for the tongue to cool. c) External forces such as centrifugal forces acting on the body in the same way as in primary bodies, drawing the tongue out.

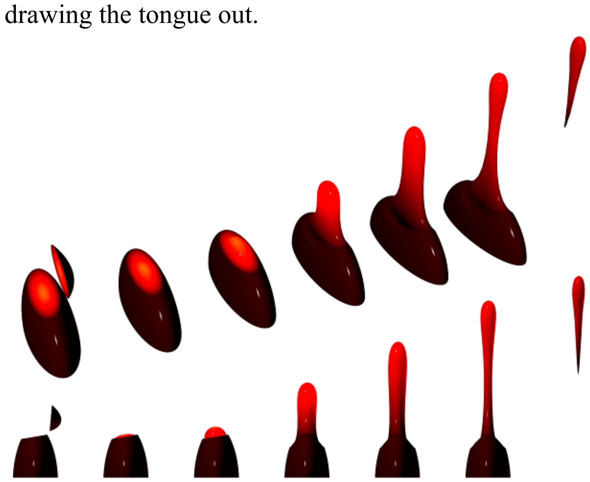

Fig. 6: Possible sequence of tongue generation.

References: [1] Harris, P. (2003) *Meteorite Times Magazine, March 1, 2003.* [2] Tobin, J. (2006), *Meteorite Times Magazine*, June 1, 2006. [3] Murray, S. (2011) *Meteorite Times Magazine, August 1, 2011.* [4] Whymark A. (2013) *LPS XLV*, Abstract #1032.