THE LARGEST AND HEAVIEST AUSTRALASIAN SPLASH-FORM TEKTITES: DESCRIPTION AND DISCUSSION.
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Introduction: Splash-form tektites are wholly melted bodies in which the molten primary morphology was principally controlled by cohesive forces, most importantly by surface tension and variably opposed by centrifugal forces from non-uniaxisymmetric rotation. Ultimately the majority of splash-form tektites are plastically deformed by atmospheric interaction during the ejection phase and variably heated / ablated then cooled / spalled during re-entry. Muong Nong-type layered tektites can be larger [1] [2]; however, these were not fully molten tektite droplets controlled by surface tension.

Up to 2011, the heaviest splash-form tektite in the Australasian tektite strewn field, and in the world, was from Paracale-Labo, Bicol Region, Philippines and recovered by Prof. Henry Otley Beyer in April 1937 [3]. This tektite was donated to the Corning Museum of Glass in 2000 by Darryl S. Futrell [4]. It is catalogued as '2000.7.4', measures 984 mm maximum diameter, 905 mm minimum diameter [5] and accurately weighed as 1,070.54 grams [4]. The slightly off-spherical tektite is generally smooth with one side slightly more pitted. It has not been X-rayed. Previously, the same specimen has been reported as 1,065 g [6], 1,069 g [7], 1,069.6 g (4″ diameter) [3] and 1,070 g (a little over 4″ diameter) [8] and probably erroneously at 1,080 g [9]. In 2011, remarkably, this record was broken twice with two large tektites found within kilometers of the Beyer tektite: These new tektites are described and discussed.

New Finds: On 5th February 2011 a 1,194.80 gram (± 0.02 g) tektite was found in Talusan Barangay (within ~1 km of 14°14'52"N, 122°46'4"E), Paracale Municipality, Camarines Norte Province, Bicol Region, Philippines. Attempts to acquire this tektite failed and it was exported to Munich, Germany, on 9th February 2011. It was then exchanged for mineral specimens with a dealer in Melbourne, Australia, before reappearing on 16th May 2011. The specimen was purchased by the author and brought back to the Philippines.

The 1,194.80 g tektite has a smooth, locally lightly pitted, surface and is slightly off-spherical with dimensions 111 x 107 x 103 mm. It has a volume of approximately 643 ml and so should weigh 1,575 g. It was therefore concluded that the specimen contained a 66.7 mm diameter bubble. An X-ray taken on 19 September 2011 indicated a bubble of 72 x 71 mm (likely slightly exaggerated due to the X-ray projection onto the film).

Reportedly on 23rd August 2011 a new tektite weighing 1,281.89 g (± 0.02 g) was found. At the time of purchase (24th August 2014) the author was told the specimen was found by a gold panner called Ronnel Canaria who comes from Malatap Barangay (within ~3 km of 14°9'16"N, 122°36'37"E), Labo Municipality, Camarines Norte Province, Bicol Region, Philippines. Later, the author was told by his middle man that the specimen itself came from Magsimalo (often cited as 14°17'0"N, 122°45'0"E, but also the name of a river / stream, probably with 3 km of these coordinates, more likely to the east in the author's opinion), Paracale Municipality, Camarines Norte Province, Bicol Region, Philippines.

The 1,281.89 g tektite has a smooth, locally lightly pitted, surface and is slightly off-spherical with dimensions 105 x 102 x 101 mm. It has a volume of approximately 601 ml and so should weigh 1,472.3 g. It was therefore concluded that the specimen contained a 53 mm diameter bubble. An X-ray taken on 19 September 2011 indicated a bubble of 61 x 60 mm (likely slightly exaggerated due to the X-ray projection onto the film).

Fig 1: Left: 1,281.89 g tektite. Right: 1,194.80 g tektite from Paracale, Camarines Norte, Bicol, Philippines.

To the authors knowledge, in December 2014, the 1,281.89 g specimen is the heaviest known splash-form tektite and the 1,194.80 g specimen is the largest known splash-form tektite, by volume, and the second heaviest.

Discussion: The three heaviest splash-form tektites in the world, alongside many other exceptionally sized specimens, have all been found in a geographically confined area in the Paracale to ?Labo Municipalities.

Transportation and reworking have concentrated tektites from this area into gravel deposits. These placer deposits have been worked for gold, often using manual techniques which are suited to the recovery of tektites. Miners know that tektites are associated with gold bearing layers and are aware of their worth. Recovery is efficient in Paracale, but still does not explain the high abundances and often large sizes of tektites found here.

Tektite occurrence is not random. Paracale appears to be situated on a very prominent easterly butterfly ray. The concept of tektites being concentrated in rays and large specimens being found along these rays is well established in the up-range rays of Australia [10]. In the Philippines strong evidence of rays also exists (Fig. 2) and the strongest case in the Philippines is in a line running from southern Zambales, through the northern part of Metro Manila, the northern shore of Laguna de Bay, Paracale, Siruma, Panganiban and out into the Pacific Ocean through drill sites V28-238 and ODP 804C [11].

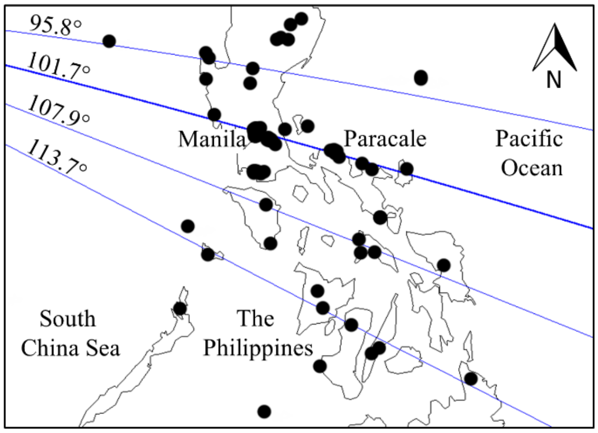

Fig. 2: Philippine tektite occurrence (●) & possible rays emanating from suggested Gulf of Tonkin Crater [12].

In order to understand the size distribution of tektites along these rays one must review the atmospheric passage and interaction of the molten tektite droplet. The degree of atmospheric interaction is dependent on the energy imparted to the target rock in terms of temperature and inherited velocity, plus the angle of ejection.

Distally ejected tektites formed from the first formed, highest temperature, lowest viscosity, melts. These melts readily cascade into smaller bodies. Proximally ejected tektites formed from the last formed, lower temperature, more viscous, melts which resist disruption and cascading and form larger bodies.

Distally ejected tektites formed from the highest velocity melts. The last formed, proximally ejected, tektites formed from the lowest velocity melts. The higher the velocity / momentum, the greater the amount of atmosphere is traversed prior to the melt sheet being disrupted into isolated droplets. With insufficient velocity some proximal bodies will not achieve atmospheric exit.

Distally ejected tektites had the lowest ejection angle in the oblique Australasian impact event. This meant that more atmosphere needed to be traversed in the ejection process. Proximally ejected tektites had the highest ejection angle and most direct route of atmospheric exit.

At a point between proximal and distal forms, medial forms such as philippinites are found, with the large tektites of Paracale probably representing the peak manifestation. These largest tektites probably formed from the melts disrupted at the highest altitudes: A combination of the optimum ejection velocity and angle (= quickest atmospheric transit time) and melt viscosity.

Only at the highest altitudes (combined with higher viscosities) can larger (non-equilibrium, less stable) molten droplets resist the aerodynamic flattening of a sphere towards a discoidal shape [13] and subsequent cascading. Furthermore, during re-entry, spheroidal tektites tumble or roll, but non-spheroidal forms orient, focusing heating then cooling on one surface and increasing thermal effects and therefore spallation. A spheroidal, balanced, body can achieve atmospheric re-entry with minimal spallation. A further limiting factor on spallation is that the largest tektites falling in Paracale would have had insufficient time to fully cool before reentry. They cooled sufficiently to resist deformation, but retained enough heat to resist significant brittle failure / spallation. Minor low pressure spallation (indochinite-like with no Hertzian cones) is evident on these large tektites, represented by smoother, less pitted, surfaces.

Finally, a tektite sphere in excess of 1 kg exceeds the thermal stress limits of the glass [14]. Many fragmented large tektites have been found in Bicol. It is probably no coincidence that the two largest complete splash-form tektites contain unusually large bubbles. The presence of a central bubble increases stability as crack propagation usually commences in the central region of the tektite sphere [14]. The central bubble also reduces the thickness of the glass and should thus increase stability.

One might expect to find similarly large tektites on the western butterfly ray southwest of the Malay Peninsula, possibly in the Andaman Sea. Interestingly, two large tektites were questionably [15] found in Kelantan [16] or Pahang [8] of the Malay Peninsula. This is on a westerly up-range ray, but at a practically identical distance from the possible Gulf of Tonkin source crater (17°45'20"N, 107°50'30"E) [12] to Paracale. Theoretically, even larger spheroidal dumbbells may exist.

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