Scanning Electron Microscopy of Guangdong Tektites Exhibiting Silica-Rich Glass Inclusions and Protrusions. A. Krauss[1], A. Whymark[2] and J.-M. Lange[3], [1]Consultant Engineer (andreas.krauss@krauss-engineering.de), [2]Consultant Wellsite Geologist (aubrey@tektites.co.uk), [3]Sektion Petrographie, Senckenberg Naturhistorische Sammlungen Dresden, Germany (jan-michael.lange@senckenberg.de)

Introduction: Protrusions, originally assumed to be agglutinated microtektites, were noted on the posterior surface of well-preserved Guangdong tektites [1] (Fig. 1). Surface zones with presumed agglutinated microtektites on macrotektites from Guangdong Province, China, were sectioned and analyzed by using scanning electron microscopy. Results of this study suggested an alternative mode of origin.

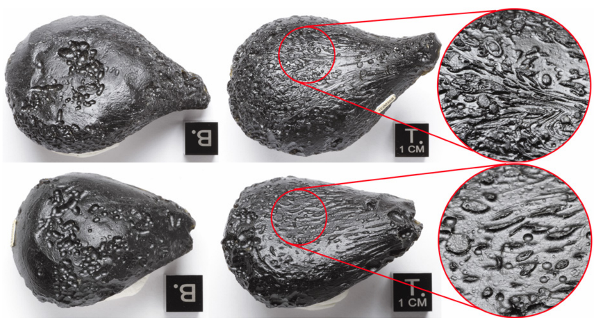

Fig. 1: Protrusions on the posterior surface of two tektites from Guangdong Province. Left: Anterior; Middle: Posterior; Right: Magnified posterior surface. Scale cube = 1 cm.

Description: On well-preserved Guangdong tektites millimeter-sized protrusions were noted. These features are found exclusively on the posterior surface of well-preserved oriented tektites. On the surface, these protrusions are flattened and rounded, oval, or elongated in shape, with the stretching apparently following the deformation of the main tektite body.

Methodology: Samples were taken from two tektites from Guangdong Province, China. Summary process: (1) Clean and mark the protrusions. (2) Make multiple thick sections. (3) Scanning electron microscopy analyses at the Senckenberg Naturhistorische Sammlungen Dresden using (Zeiss EVO 50) with EDX (ROENTEC detector XFlash 3001).

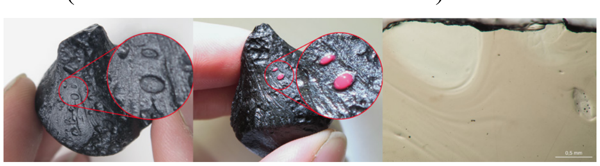

Fig. 2: Example of processing tektite #2 from Guangdong Province, China. Left: Unprocessed state. Middle: Marked. Right: Thick section produced.

Results: The results of investigations on the two tektite samples are similar. Due to space limitations, only the results of tektite #1 are presented here (Fig. 4–6). In the images, brighter colors represent higher abundances of the specified element. This highlights compositional contrasts between the inclusions / protrusions and the bulk tektite.

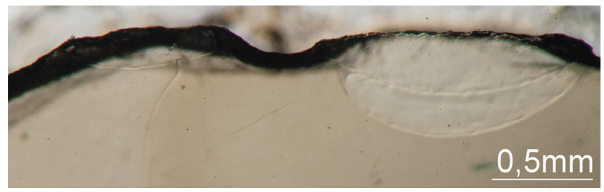

Fig. 3: Thick section of tektite #1, sample #1a.

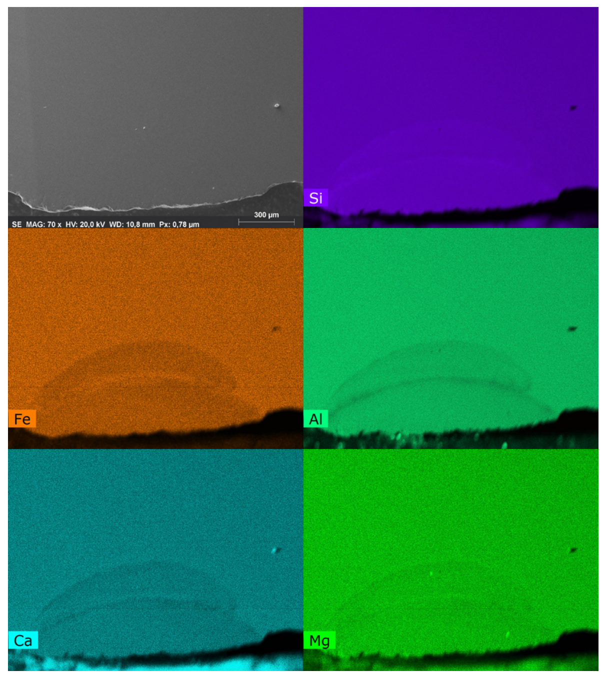

Fig. 4: Element mapping of tektite #1, sample #1a.

Remarkable material differences were noted for Si, Fe, Al, Ca and Mg. Insignificant or barely remarkable material differences were noted for K, Mn, Na and Ti (not shown). The following observations were made: (1) the inclusions / protrusions show a higher Si content and lower Fe, Al, Ca and Mg content compared to the bulk tektite; (2) There is a clear interface between the bulk tektite glass and the inclusions / protrusions, with a higher Si content on the surface of the inclusion at the interface (Fig. 6); (3) The protrusions are flattened in shape (Fig. 4–5); (4) A double protrusion and inclusion (Fig. 4) with the internal inclusion displaying a 'banana' profile apparently wrapped around the internal surface of the protrusion; (5) An elongate inclusion perpendicular to the surface protrusion with poorly defined compositional variation inbetween the surface protrusion and elongate inclusion, suggests that the two bodies may once have been attached (Fig. 7).

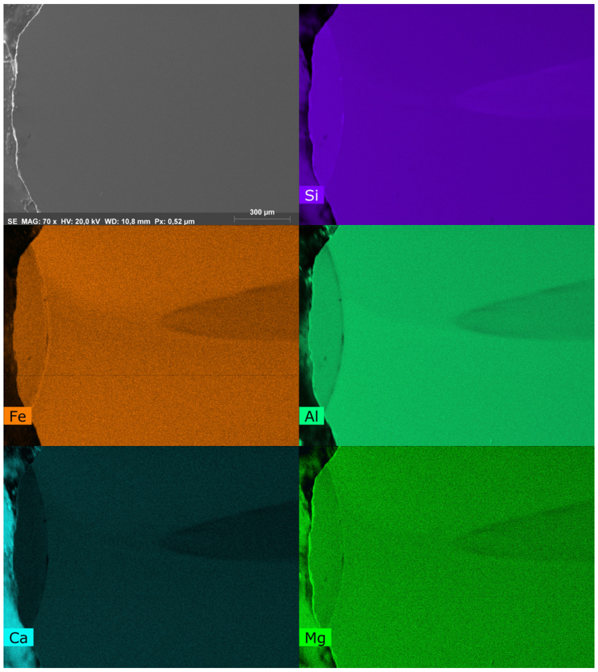

Fig. 5: Element mapping of tektite #1, sample #1b.

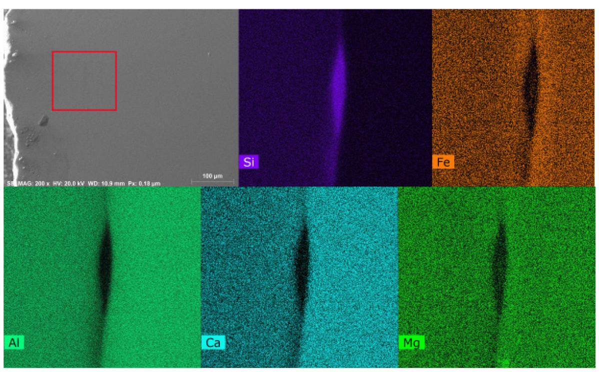

Fig. 6: Magnified region from element mapping of tektite #1, sample #1b.

Discussion: The study commenced with the assumption that, based on morphological considerations, agglutinated microtektites were being investigated. Inconsistencies with this assumption were, however, uncovered: (1) The inclusions / protrusions were higher in silica compared with the bulk tektite. This contrasts with microtektites, 20% of which are bottle-green, assumed condensation products that are lower in silica [2] and 80% of which are normal microtektites that are assumed melt products and have a comparable composition to macrotektites [3]. The idea that normal microtektites may become enriched in silica due to volatile loss was considered, but is not borne out in microtektite chemical analyses [3]; (2) As well as the flattened surface protrusions, perpendicular elongate inclusions were encountered. It was apparent that such features had previously been described from the posterior surfaces of australites as "finger"-type siliceous glass inclusions [4, 5, 6]. These inclusions differ in morphology from the very elongate, twisted, ribbon-like lechatelierite also observed in tektites [7].

An external origin, i.e. accreted and incorporated microtektites, was considered for the silica-rich glass inclusions due to morphological and spatial (posterior only) considerations. Incorporation might be due to collision with a more viscous or solidified microtektite into a molten macrotektite or due to deformation of the surface of the macrotektite as it traversed the atmosphere. The presence of rounded, oval and elongated surface protrusions might be considered as due to deformation of the macrotektite as it traversed the atmosphere, with more circular protrusions being the last to accrete. Unfortunately, the higher silica content of the silica-rich glass inclusions is inconsistent with a microtektite origin, which is expected to have the same or a lower silica content (for condensation products).

An internal origin is therefore considered. The precursor sedimentary rock was probably heterogeneous on a macro- and microscopic scale. Pure quartz clasts would require higher temperatures to melt when compared to bulk tektite source rock. The amorphous silica would have a lower density compared with the bulk density of the tektite. Forces acting to decelerate the molten tektite would result in the less dense, silica-rich inclusion migrating to the posterior surface of the tektite and, if reached, erupting on the surface to form flattened bodies. This migration agrees with observations of parallel "ridges" or flow lines on the surfaces of such inclusions in [5]. Fig. 5 may show a silica-rich glass inclusion that has partially erupted on the surface and, in doing so, has split in two leaving a 'ghost' trail behind it (see Fig. 7). The protrusions of silica-rich glass may be accentuated by acidic waters attacking the alkaline components of the glass, but acting less so on more resistant silica-rich components of the glass.

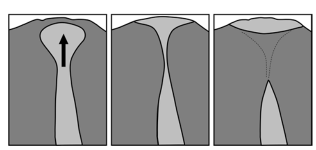

Fig. 7: Possible formation mechanism for silica-rich glass inclusions in Fig. 5.

References: [1] Krauss A. and Whymark A. (2014) *LPS XLV,* Abstract #1081. [2] Glass B. P. (1970) *Earth Planet. Sci. Lett., 9*, 240–246. [3] Cassidy W. A. et al. (1969) *J. Geophys. Res., 74(4)*, 1008–1025. [4] Barnes V. E. (1961) *Sci. Am., 205 (5)*, 58–65 [5] Chao E. C. T. (1963), In: O'Keefe J. A. (ed.) *Tektites: Chicago, University of Chicago Press*, 51–94. [6] Glass B. P. (1974) *Geol. Soc. Am. Bull., 85*, 1305–1314. [7] Knobloch V. et al. (1983) *Chemie der Erde, 42*, 145–154.