# ARE IRREGULAR CLASTS OF FORMER SILICATE MELT IN THE CARAWINE DOLOMITE (LATE ARCHEAN, WESTERN AUSTRALIA) THE OLDEST KNOWN TEKTITES ON EARTH?

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**Introduction:** At least 8 different layers rich in sand-size spherules of former silicate melt interpreted as impact ejecta have been identified in early Precambrian successions of South Africa and Western Australia. They have been reported from the early Archean Barberton greenstone belt and Pilbara craton [1,2] and the late Archean to Paleoproterozoic Griqualand West and Hamersley basins [3-5]. Of these spherule layers, only the one hosted by the Carawine Dolomite in the Hamersley basin also contains more irregular clasts of former silicate melt which are more than several millimeters across; their shapes and internal textures suggest they are devitrified tektites. If so, they would be the oldest tektites and the most proximal early Precambrian strewn field yet discovered on earth. It would also indicate that textures in tektite glass can be preserved during diagenetic replacement.

**Sedimentology:** Both the impact spherules and the irregular clasts are restricted to one layer in the Carawine Dolomite [4,5]. This layer is a composite of three debris flow deposits that total ~ 24 meters in thickness and consist mainly of poorly sorted carbonate intraclasts which range in size from sand to slabs over 2 meters long. Tektite candidates are concentrated at the base of the lowest debris flow, whereas spherules are most abundant in the finer-grained sediment at the tops of the flows. We attribute this to hydrodynamic segregation during transport and deposition, so both spherules and irregular clasts are clearly reworked rather than a primary impact deposit. We suspect they have been transported a distance of many tens of kilometers from their original site of deposition.

**Petrography:** Although both consist primarily of fibrous, diagenetic K-feldspar crystals, crystals in the irregular clasts tend to be either randomly oriented or lineated (based on optical response) rather than radial-fibrous as in the spherules. The irregular clasts and spherules differ in many other ways, including their size and shape (Table 1, Fig. 1).

Three internal textures indicate the irregular clasts had a molten origin. First, many of the irregular clasts contain planar to swirling bands elongated parallel to their long axes that resemble flow banding and schlieren (Fig. 1B). Second, ~95% of the clasts contain vesicles that are generally filled with diagenetic quartz crystals. Most vesicles are evenly distributed and circular in cross-section, but larger vesicles are elongated in areas of pronounced flow banding. Third, many of the largest clasts are composites with internal boundaries separating areas with different textures. We interpret such clasts as agglutinates formed by the collision of smaller clasts that were still partially molten. Some of the larger clasts have spherules embedded inside them, indicating they both formed during a single event. Moreover, some of the irregular clasts (especially the more strongly flow banded and vesiculated ones) contain quartz crystals $\leq$ 0.04 mm across as isolated inclusions, and a few of these contain candidates for relict planar deformation features.

| *Parameter* | *Irregular clasts* | *Spherules* |
|---|---|---|
| **Maximum size** | 11 mm | 2 mm |
| **Mean axial ratio** | 0.65 | 0.84 |
| **Shape** | rounded to blocky, some teardrops and dumbbells | mainly spherical to ovoid |
| **Roundness** | 0.1-0.6 (mean = 0.35) | 0.9-1.0 (mean = 0.95) |

TABLE 1. Comparison of average size and shape parameters between spherules and irregular clasts in the late Archean Carawine Dolomite (Hamersley Group, Western Australia).

**Interpretations:** Volcanic processes offer the only alternative to an impact origin for the irregular clasts in the Carawine layer, but three observations make it very unlikely they are resedimented volcaniclasts. First, there are no *bona fide* volcanic materials in either the Carawine spherule layer or the adjacent strata. Second, the rare thin layers of tuff in the Carawine Dolomite do not contain any similar clasts. Third, the only volcaniclasts that approach or exceed 1 cm in diameter in the Carawine Dolomite and associated formations are accretionary lapilli; these consist of fine-grained ash with crude concentric layering rather than pure melt with flow banding. An impact origin for the irregular clasts is further supported by elevated concentrations of iridium and certain other platinum group elements in the Carawine spherule layer [6].

Texturally, Muong Nong-type tektites are a closer match for the irregular clasts in the Carawine layer than the more common splash-form type, as the Muong Nong-type tektites generally have irregular, blocky shapes and are layered [7-10]. Moreover, unlike splash-form tektites, Muong Nong-type tektites contain relict minerals as inclusions, most commonly shocked quartz [7].

The Carawine Dolomite was deposited in the late Archean, based on a Pb-Pb isotopic age of 2548 +26/-29 Ma obtained directly from its carbonates [11] and microprobe dates from single zircons segregated from thin tuffs in associated stratigraphic units [12-13]. If our interpretations are correct, the irregular Carawine clasts would represent both the oldest tektites and the most proximal part of an early Precambrian impact strewn field yet discovered on earth. They would also support the impact interpretation of the associated spherules, about which there are still some questions [14-15]. We have suggested some early Precambrian spherule layers are products of oceanic impacts [6]. The presence of Muong Nong-type tektites in the Carawine layer would signal an impact into continental crust. Lastly, Muong Nong-type tektites are enriched in volatiles relative to splash-form tektites [9]; this could help explain why the internal textures of the irregular clasts were preserved during diagenetic replacement.

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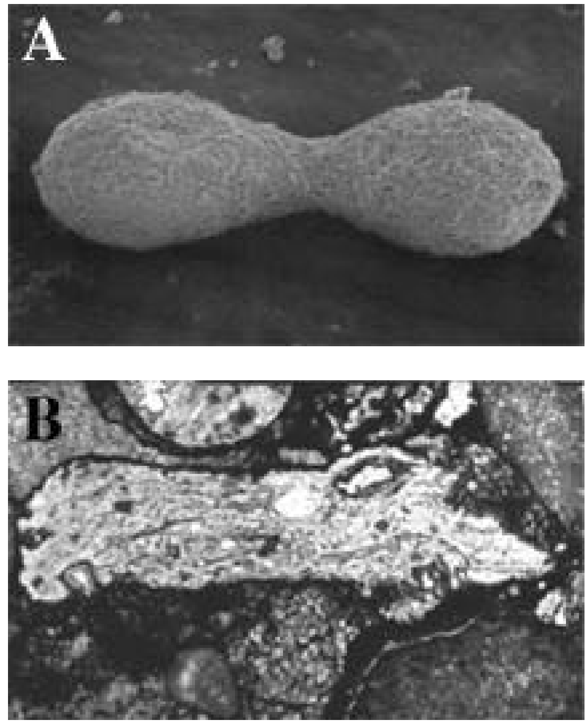


FIGURE 1. A) SEM of a simple splash-form clast from HCl-insoluble residue of a sample of Carawine Dolomite from Ripon Hills; long axis of clast is 2.3 mm. B) Photomicrograph in plane polarized light of an elongated irregular clast which measures 4.98 x 1.24 mm in cross-section and shows longitudinal banding; clear ovals are quartz-filled vesicles, and more irregular lens with dark rim in upper right part of clast is a heterogeneous pocket of quartz crystals, one of which has candidates for relict PDFs. Irregular clast consists mainly of fibrous K-feldspar crystals that are preferentially aligned parallel to banding. Most of surrounding clasts consist of dolomite, but some are also silicate melt clasts, including a spherule (partly visible along top) which measures 1.78 x 1.48 mm in cross-section and consists of radial-fibrous K-feldspar.