Tektites, minitektites and microtektites from the Kalgoorlie region, Western Australia

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Introduction

About 790 ka (Schneider *et al*. 1992), an asteroid or comet impacted in southeast Asia, melting crustal rocks (and regolith) and producing glassy impact debris, known as tektites or australites, which are found over more than 10% of the Earth's surface (Schnetzler & McHone 1996), including much of Australia and surrounding oceans (Fig. 1). The tektites formed as molten "splash" material cooled during high-velocity movement through the air and range in size from spheres less than 1 mm (microtektites, found mainly in deep sea cores) to irregular blocks weighing up to more than 20 kg (Muong Nong tektites in SE Asia). The distribution, size and concentration of tektites in the Australasian strewn field indicate a likely impact site somewhere in southern Laos, northern Cambodia or eastern Thailand, but the location of the impact site has not yet been discovered.

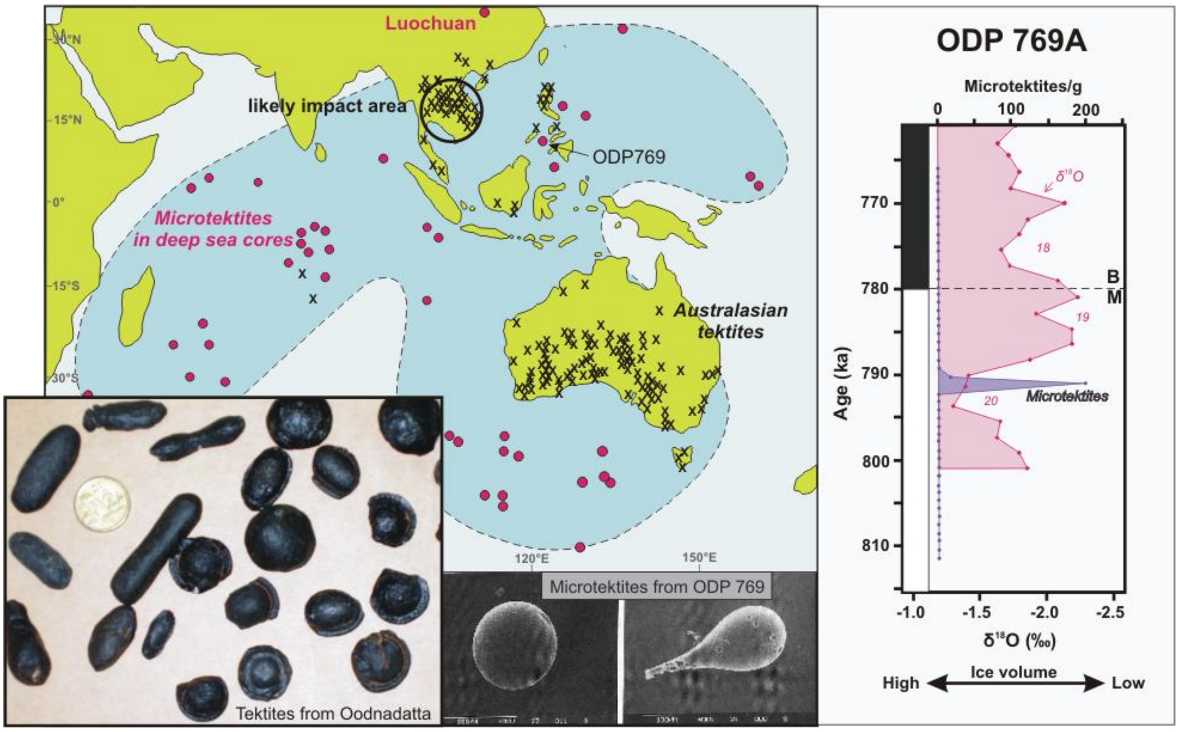

Figure 1: Map of the Australasian tektite strewn field (modified from Prasad *et al*. 2003). Insets (left to right) show (1) tektites from Oodnadatta area (coin is ~20 mm diameter) from the ANU collection, (2) Microtektites in ODP core 769A (Schneider *et al*. 1992) and (3) Position of microtektite layer in ODP core 769 (Schneider *et al*. 1992).

Although there has been considerable debate concerning the age of the Australasian tektites, their age is firmly established through magnetostratigraphy of deep sea cores in which microtektites occur just prior to the Matuyama/Brunhes polarity transition (Schneider *et al*. 1992), as well as direct laser fusion $^{40}Ar/^{39}Ar$ dating of tektite glass (Izett & Obradovich 1992). Previously, a number of field studies supported a late Pleistocene age in the range 5 to 25 ka (e.g. Gill 1970; Lovering *et al*. 1972), but these occurrences are now considered to represent reworking into younger sediments (e.g. Fudali 1993; Shoemaker & Uhlherr 1999). There has long been speculation that the impact may have triggered the Matuyama/Brunhes reversal (e.g. Glass & Heezen 1967). However, the estimated time (12-15 ka) between the impact and the reversal appears to be too long for a causal link between the two events (Schneider *et al*. 1992).

Tektites have been found in abundance at numerous sites across Australia, particularly southern Australia (Fig. 1), where Fudali *et al*. (1991) estimated that finds must number in the tens of thousands. The reason(s) why very few finds have been reported from north of 25°S is (are) unclear. Indeed, it might be expected that there should be a general tendency for increasing size and number of tektites in northwestern Australia as the impact source in southeast Asia is approached. Most tektites in southern Australia have been found on bare, usually wind-deflated surfaces, so their apparent rarity in northern Australia may be a function of a general lack of exposure at the surface.

Kalgoorlie field setting

Tektite occurrences are widespread in the Kalgoorlie region. Typically, tektites are found in surface exposures where recent erosion has removed finer material and left larger material as a lag; they are also found as bedload lags in small streams and gullies, and in shoreline deposits of saline lakes (Cleverley 1988, 1994). In most cases, therefore, the tektites are not *in situ*, but have been redeposited from their original fall position. At Menangina Station, north of Kalgoorlie, exquisitely preserved flanged button tektites (Fig 2) may be found on the surface of an iron and silica cemented hardpan, often referred to as the Wiluna Hardpan (Bettenay & Churchward 1974). More often than not, however, the tektites are found as fragments of an originally larger piece.

Figure 2: Flanged button tektite from Menangina Station

Two tektite specimens in the Kalgoorlie School of Mines collection are from lithified sediments, one of which occurs in ferricrete and one of which occurs in silcrete (Fig 3). These specimens were described by Cleverley & Kirsch (1984): The first (SM 12 015), was found embedded in the surface of coarse ferruginous grit in the bed of Davis Creek, Mt Remarkable Station ~140 km NE of Kalgoorlie. The second (SM 12 102) was found embedded in silcrete on the shore of Lake Lefroy ~60 km SE of Kalgoorlie. As noted by Cleverly & Kirsch (1984), tektites embedded in lithified material are very rare – they knew of only 5 reported cases in more than 100 years.

Figure 3: Tektites embedded in ferricrete (left, exposed length 35 mm) and silcrete (right, exposed length 20 mm) from the collection held at the Kalgoorlie School of Mines and described by Cleverly & Kirsch (1984).

At one site east of Kalgoorlie, microtektites (<1 mm) and minitektites (1-5 mm) occur in sandy beach sediments on the eastern side of a small saline lake known informally as Lake Kuchel (McColl & Hitchcock in press). The tektites (Fig 4) only occur on the east side of the lake and appear to have a localized source in sediments that are being eroded by wave action and surface wash from adjacent, older exposures. This is the first known on-land site in Australia to yield microtektites and one of only three reported on-land sites from the Australasian tektite strewn field, the other two being in Antarctica (Folco *et al*. 2008) and China (Zhou & Shackleton 1999). Our investigations of tektites at Lake Kuchel are focusing on their source and reasons for their preservation at this site. Adjacent small lakes have been carefully searched but no microtektites have been found.

Figure 4: Minitektites and microtektites from Lake Kuchel, ~200 km east of Kalgoorlie (smallest spheres are ~1 mm in diameter).

Discussion

It is unfortunate that while most museums and many private mineral collectors in Australia have tektites in their collections, the provenance of the overwhelming majority of specimens is poorly documented. Most commonly, location will be stated as "Adelaide region", or something similarly broad, with no details of stratigraphic setting. In our current study, we are aiming to carefully document the regolith stratigraphy of tektite occurrences in the Kalgoorlie region and to apply dating techniques such as paleomagnetism and optically stimulated luminescence (OSL) to determine the ages of regolith materials associated with the tektite occurrences. We are also undertaking detailed geochemical analyses of the tektites by LA-ICPMS and XRF, as well as fission track dating, to verify that they belong to the Australasian tektite strewn field.

Arguably, the best field-documented specimens in Australia are from the Port Campbell area of Victoria, where Shoemaker & Uhlherr 1999) carefully described the stratigraphic setting of nearly 4000 tektites and tektite fragments. According to Shoemaker & Uhlherr (1999), the majority of the tektites in the Port Campbell area occur as a lag deposit at the basal contact of the Late Pleistocene to Holocene Sturgess Sand, where they have been reworked from the underlying Hanson Plain Sand (Plio-Pleistocene). However, no detailed regolith dating has been carried out at the Port Campbell tektite sites.

In regolith deposits where reworking is suspected, the presence of tektites provides a maximum age of 790 ka for the enclosing sediment. For example, waterworn tektites have been found in diamond-bearing alluvial gravel terraces some 25 km downstream of the Argyle diamond mine in northwestern Western Australia (Fudali *et al*. 1991; Fudali 1993), indicating a maximum age of 790 ka for the terraces. By using a combination of field stratigraphy, geochemistry and regolith dating methods, we aim to better document the occurrences of tektites in the Kalgoorlie region and ultimately, to undertake similar studies in other parts of Australia

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