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Transantarctic Mountain microtektites: Geochemical affinity with Australasian microtektites

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Abstract

We extended the petrographic and geochemical dataset for the recently discovered Transantarctic Mountain microtektites in order to check our previous claim that they are related to the Australasian strewn field. Based on color and composition, the 465 microtektites so far identified include two groups of transparent glass spheres less than ca. 800 μm in diameter: the most abundant pale-yellow, or normal, microtektites, and the rare pale-green, or high-Mg, microtektites. The major element composition of normal microtektites determined through electron microprobe analysis is characterized by high contents of silica ($SiO_2 = 71.5 \pm 3.6$ (1σ) wt%) and alumina ($Al_2O_3 = 15.5 \pm 2.2$ (1σ) wt%), low total alkali element contents (0.50–1.85 wt%), and MgO abundances <6 wt%. The high-Mg microtektites have a distinctly higher MgO content >10 wt%. Transantarctic Mountain microtektites contain rare silica-rich (up to 93 wt% SiO_2) glassy inclusions similar to those found in two Australasian microtektites analyzed here for comparison. These inclusions are interpreted as partially digested, lechatelierite-like inclusions typically found in tektites and microtektites. The major and trace element (by laser ablation – inductively coupled plasma – mass spectrometry) abundance pattern of the Transantarctic Mountain microtektites matches the average upper continental crust composition for most elements. Major deviations include a strong to moderate depletion in volatile elements including Pb, Zn, Na, K, Rb, Sr and Cs, as a likely result of severe volatile loss during the high temperature melting and vaporization of crustal target rocks. The normal and high-Mg Transantarctic Mountain microtektites have compositions similar to the most volatile-poor normal and high-Mg Australasian microtektites reported in the literature. Their very low H_2O and B contents (by secondary ion mass spectrometry) of 85 ± 58 (1σ) μg/g and 0.53 ± 0.21 μg/g, respectively, evidence the extreme volatile loss characteristically observed in tektites. The Sr and Nd isotopic compositions of multigrain samples of Transantarctic Mountain microtektites are $^{87}Sr/^{86}Sr \approx 0.71629$ and $^{143}Nd/^{144}Nd \approx 0.51209$, and fall into the Australasian tektite compositional field. The Nd model age calculated with respect to the chondritic uniform reservoir (CHUR) is $T^{Nd}_{CHUR} \approx 1.1$ Ga, indicating a Meso-Proterozoic crustal source rock, as was derived for Australasian tektites as well.

Coupled with the Quaternary age from the literature, the extended dataset presented in this work strengthens our previous conclusion that Transantarctic Mountain microtektites represent a major southward extension of the Australasian tektite/microtektite strewn field. Furthermore, the significant depletion in volatile elements (i.e., Pb, B, Na, K, Zn, Rb, Sr and Cs) of both normal and high-Mg Transantarctic Mountain microtektites relative to the Australasian ones provide us with further confirmation of a possible relationship between high temperature–time regimes in the microtektite-forming process and ejection distance.

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1. INTRODUCTION

We recently reported the discovery of microtektites (microscopic impact glass spheres) on the tops of the Victoria Land Transantarctic Mountains (Folco et al., 2008) during the 2003 and 2006 Italian *Programma Nazionale delle Ricerche in Antartide* (PNRA) expeditions. Microtektites, as well as 1000s of micrometeorites up to 2 mm in size, were found trapped within the fine-grained, local detritus accumulated in weathering pits, joints and fractures (hereafter micrometeorite traps) of glacially eroded summits (~2600 m a.s.l.) of Miocene age (Folco et al., 2008; Rochette et al., 2008). These include Miller Butte, Frontier Mountain, a nunatak in the Timber Peak area (now officially named Pian delle Tectiti), and Mistake Peak. Their geographic distribution extends latitudinally for ca. 520 km in Victoria Land (Fig. 1).

The ~130 microtektites extracted from the host detritus by Folco et al. (2008) consist of transparent glass spheres (and a small number of oblate spheroids and lenses) in the 400–800 μm size range with a characteristic transparent pale yellow color (Fig. 2). The preliminary major and trace element compositional data (from 39 and 6 microtektites, respectively) showed a good match with the Upper Continental Crust composition. Comparison with microtektites from the three already known Cenozoic North American (ca. 35 Ma old), Ivory Coast (ca. 1.1 Ma old) and Australasian (ca. 0.8 Ma old) strewn fields (e.g. Glass et al., 2004; Simonson and Glass, 2004) revealed a good compositional match with only some (i.e., the MgO <6 wt% normal-type microtektites; see Glass et al., 2004, for definition) Australasian microtektites, particularly for refractory element ratios. Furthermore, ^{40}Ar–^{39}Ar total fusion analyses of 25 individual spherules provided an isochron age of 1.4 ± 1.5 (2σ) Ma with a trapped initial $^{40}Ar/^{36}Ar = 409 \pm 28$ (2σ), and multi-grain stepwise heating ^{40}Ar–^{39}Ar analysis of 11 spherules provided a "Plateau-Isochron" age of 0.76 ± 0.98 (2σ) Ma with an initial $^{40}Ar/^{36}Ar = 422 \pm 18$ (2σ). The ^{40}Ar–^{39}Ar age of Transantarctic Mountain microtektites, although poorly resolved, is essentially Quaternary and compatible with the 0.76 ± 0.05 (2σ) Ma ^{40}Ar–^{39}Ar ages for the Australasian strewn field (Izett and Obradovich, 1992). Based on this data set, Folco et al. (2008) suggested that the Transantarctic Mountain microtektites define the southern extension of the Australasian strewn field. However, due to the uncertainty in the ^{40}Ar–^{39}Ar age, Folco et al. (2008) could not rule out that the Transantarctic Mountain microtektites could identify a new strewn field of Quaternary age.

There would be a number of fascinating implications should the Transantarctic Mountain microtektites indeed belong to the Australasian strewn field. The margin of the Australasian tektite/microtektite strewn field would be shifted southward by approximately 3000 km (Fig. 1b), thereby bringing the maximum distance of microtektite distribution from the putative parent impact site in Indochina (e.g., Glass and Pizzuto, 1994; Lee and Wei, 2000; Ma et al., 2004; Glass and Koeberl, 2006; Prasad et al., 2007) to more than 10,000 km in a southeastward direction. This would emphasize its asymmetry and the paradox that the parent crater of the largest (more than 10 percent of the Earth's surface) and youngest tektite strewn field discovered on Earth is still unidentified. Furthermore, it would raise important issues regarding the microtektite formation mechanism and the physics involved in ejecting microtektites to more than 10,000 km from the source crater. Similarly, there would be significant implications for the collisional history of our planet, should the Transantarctic

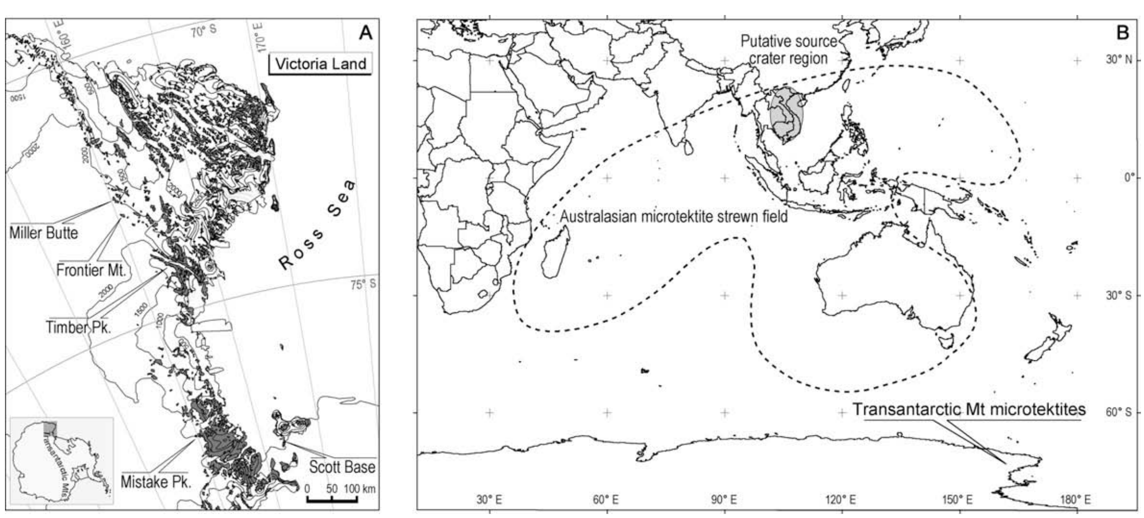

Fig. 1. (A) Sketch map of Victoria Land showing the locations of Frontier Mountain, Miller Butte, Pian delle Tectiti (Timber Peak area) and Mistake Peak, where Victoria Land Transantarctic Mountain microtektites were found (modified after Folco et al., 2008). Shaded areas represent exposed bedrock. (B) Map showing the Transantarctic Mountain microtektite find location in Victoria Land, Antarctica, relative to the Australasian tektite strewnfield (dashed line; modified after Glass and Koeberl, 2006). The latter is outlined by tektite finds on land and microtektite finds in cored deep-sea sediments. The gray area marks the region where the hypothetical source crater of the Australasian tektites is likely located according to Glass and Pizzuto (1994), Glass and Koeberl (2006) and Prasad et al. (2007).