

Supporting Information for

[Tracking voluminous Permian volcanism of the Choiyoi Province into central Antarctica][Demian A. Nelson^{1*} and John M. Cottle¹][¹*Department of Earth Science, University of California, Santa Barbara, California 93106–9630, USA (demian@ucsb.edu) *corresponding author*]**Zircon U-Pb geochronology**

U-Pb measurements were made on a Nu Plasma high-resolution multi collector-inductively-coupled plasma-mass spectrometer (MC-ICP-MS) (Nu Instruments, Wrexham, UK) at the University of California, Santa Barbara. A 193 nm ArF excimer laser (Teledyne Cetac, USA) was used to ablate domains 25 μm in diameter, and ^{238}U , ^{232}Th , ^{208}Pb , ^{207}Pb , ^{206}Pb , and $^{204}(\text{Pb} + \text{Hg})$ were measured. Laser energy was typically 3–4 mJ and the ablation repetition rate 4 Hz. Analyses were conducted over 30 second ablation periods with 20 second washout periods between measurements to return signal to background. Isotopes ^{204}Pb , ^{206}Pb , ^{207}Pb , and ^{208}Pb were measured on secondary electron multipliers, while ^{232}Th and ^{238}U were measured on Faraday cups equipped with 10^{11} ohm resistors.

U-Pb data were collected during two analytical sessions. A primary reference material, ‘91500’ zircon (1065.4 ± 0.3 Ma $^{207}\text{Pb}/^{206}\text{Pb}$ ID-TIMS age and 1062.4 ± 0.4 Ma $^{206}\text{Pb}/^{238}\text{U}$ ID-TIMS age, Wiedenbeck et al., 1995, 2004) was used to monitor and correct for mass bias as well as Pb/U fractionation. To assess data accuracy, two secondary reference zircon ‘GJ-1’ (608.5 ± 0.4 Ma $^{207}\text{Pb}/^{206}\text{Pb}$ ID-TIMS age; Jackson et al., 2004 and 601.7 ± 1.3 Ma $^{206}\text{Pb}/^{238}\text{U}$ ID-TIMS age; Condon, personal commun.) and ‘Plešovice’ (337.13 ± 0.37 Ma $^{206}\text{Pb}/^{238}\text{U}$ ID-TIMS age Sláma et al., 2008) were analyzed concurrently (typically once everyone 8-10 unknowns) and mass bias- and fractionation- corrected based on measured isotopic ratios of the primary reference material. Analyses of the GJ-1 secondary reference zircon over all of the analytical sessions yield a mean $^{206}\text{Pb}/^{238}\text{U}$ age of 606 ± 11 Ma (2 SE; $n = 182$; 2 points rejected; MSWD = 0.7). Analyses of the Plešovice secondary reference zircon over all of the analytical sessions yield a mean $^{206}\text{Pb}/^{238}\text{U}$ age of 338 ± 6 Ma (2 SD; $n = 180$; 0 points rejected; MSWD = 1.1). Data reduction, including corrections for baseline subtraction, instrumental drift, mass bias, down-hole fractionation, and primary-reference normalization was carried out using Iolite v2.5. Full details of the data reduction methodology can be found in Paton et al. (2010, 2011).

Uncertainties on individual analyses are quoted at the 95% confidence or 2σ level and include contributions from the external reproducibility of the secondary reference material for the $^{207}\text{Pb}/^{206}\text{Pb}$ and $^{206}\text{Pb}/^{238}\text{U}$ ratios. Weighted $^{206}\text{Pb}/^{238}\text{U}$ averages were calculated using Isoplot version 3.00 (Ludwig, 2003). Uncertainties on weighted mean ages are quadratic additions of the internal precision on the measurements and the long-term external reproducibility of GJ-1 and Plešovice ($\sim 1.7\%$ 2 SE).

Zircon Hf isotopes

Hf isotopes in zircon were measured *in situ* by LA-MC-ICP-MS at UCSB. Methods used in this study are similar to those used by Hagen-Peter et al. (2015). Ablation spots were placed over the original U–Pb analysis spots to obtain Hf compositions that correspond to the measured U–Pb date of the zircon. A laser spot size of 50 μm , 4 mJ laser energy at 100%, and a pulse rate

of 8 Hz were used to ablate samples for 50 s, with a 30 s delay between analyses to allow washout. Masses 171–180 inclusive were measured on 10 Faraday cups at 1 a.m.u. spacing.

Data were reduced using Iolite v2.31 (Paton et al., 2011). Natural ratios of $^{176}\text{Yb}/^{173}\text{Yb} = 0.786847$ (Thirlwall and Anczkiewicz, 2004) and $^{176}\text{Lu}/^{175}\text{Lu} = 0.02656$ (Chu et al., 2002) were used to subtract isobaric interferences of ^{176}Yb and ^{176}Lu on ^{176}Hf . The Yb mass bias factor was calculated using a natural $^{173}\text{Yb}/^{171}\text{Yb}$ ratio of 1.123575 (Thirlwall and Anczkiewicz, 2004) and was used to correct for both Yb and Lu mass bias. A natural $^{179}\text{Hf}/^{177}\text{Hf}$ ratio of 0.7325 (Patchett and Tatsumoto, 1980, 1981) was used to calculate the Hf mass bias factor.

To assess accuracy and precision, natural reference material zircons ‘91500’ ($^{176}\text{Hf}/^{177}\text{Hf} = 0.282308 \pm 6$; Blichert-Toft, 2008), and ‘Plešovice’ ($^{176}\text{Hf}/^{177}\text{Hf} = 0.282482 \pm 13$; Sláma et al., 2008), and ‘MunZirc1’ ($^{176}\text{Hf}/^{177}\text{Hf} = 0.282135 \pm 7$; Fisher et al., 2011) were analyzed between every 8 sample analyses. The weighted mean corrected $^{176}\text{Hf}/^{177}\text{Hf}$ values ($\pm 2\text{SD}$) obtained for the secondary reference materials were 0.282308 ± 7 ($n = 46$) for 91500, 0.282484 ± 6 ($n = 44$) for Plešovice, and 0.282143 ± 5 ($n = 51$) for MunZirc1.

Zircon trace elements

Trace element concentrations in zircon were obtained simultaneously with U-Pb isotope measurements by the ‘split stream’ approach of (Kylander-Clark et al., 2013) using an Agilent 7700 S Q-ICP-MS system; laser settings, ablation periods, and washout times used for trace elements measurements were therefore identical to those for U-Pb. Trace element data were reduced using the ‘trace elements’ data reduction scheme in Iolite v2.5 (Paton et al., 2011). Zircon standard ‘GJ1’ was used as the primary reference material for most trace elements in zircon samples [see Liu et al. (2010) for trace element reference values]. Secondary trace element reference materials used are the same as the primary U-Pb reference materials. These standardization schemes reproduced values in the secondary reference materials to within 10% or less for most trace elements.

Dataset S1. Zircon U-Pb and trace elements for zircon.

Dataset S2. Zircon Hf isotope data for zircon.

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