Potential of the young age reference materials: CA-ID-TIMS U–Pb dates of Cenozoic zircons in Japan

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Introduction

Uranium–lead (U–Pb) zircon dating is now becoming one of the most common methods in the field of geochronology. Commonly used analytical techniques for U–Pb dating are chemical abrasion isotope dilution thermal ionization mass spectrometry (CA-ID-TIMS), secondary ion mass spectrometry (SIMS) and laser ablation inductively coupled plasma mass spectrometry (LA-ICPMS). Recently, U–Pb dating techniques have been developed for young zircons on the order of 0.1 Ma that allow precise discussion of formation ages by correcting for initial isotopic disequilibrium (e.g. Sakata, 2018). Dating methods for young zircons (< 2.58 Ma) are being established, but there are few reference (standard) materials to verify them. Therefore, new reference materials are waiting to be evaluated and established for such young zircons. As young rocks and deposits are widely distributed especially in Japan, it is indispensable to evaluate the results of dating for Quaternary samples. We have already reported suitable zircons for U–Pb and (U–Th)/He dating (Nagata et al., 2022; Fukuda et al., 2022). Here we show homogeneous dates of two zircon samples (TRG04 and OGPK), obtained by CA-ID-TIMS.

Samples and Methods

The TRG04 was collected from the upper part of the Utaosa Rhyolite of the Teragi Group, whose formation age has been estimated to be ca. 2.7 Ma, based on biotite K–Ar, zircon fission-track (FT), and U–Pb zircon dates (Uto et al., 1994; Nagata et al., 2022).

The OGPK was collected from the Pink Tuff of the Osaka Group, a Quaternary volcanic ash unit (tephra), erupted on eastern Kyushu Island (Shishimuta Caldera) and spread widely in Japan (Danhara et al., 1997; Maruyama et al., 2017). The eruption timing of the OGPK has been estimated to be ca. 1.05 Ma based on zircon FT dates (Danhara et al., 1997), paleomagnetic results (Hayashida et al., 1996), and oxygen isotopes (Tsuji et al., 2005).

U–Pb dating was performed by LA-ICPMS at the Tono, Geoscience Center (TGC), Japan Atomic Energy Agency (JAEA) and CA-ID-TIMS at the University of British Columbia (UBC).

Dating at the TGC, JAEA was performed using a Neptune-*plus* multiple-collector ICPMS coupled to an Analyte G2 excimer laser-ablation system. The standard-sample bracketing method was applied to correct instrumental bias and differences between various detectors. 91500 zircon reference material (Wiedenbeck et al., 1995) was used as a calibration (external) standard. The OD-3 zircon was used as a secondary reference material, and the weighted average $^{206}Pb/^{238}U$ date of the zircon during analysis was consistent with the reference age (33.0 ± 0.1 Ma; Iwano et al., 2013).

Dating at the UBC was performed using a modified thermal ionization mass spectrometer (TIMS) on a VG354S equipped with Sector 54 electronics and a Daly photomultiplier housed at Pacific Centre for Isotopic and Geochemical Research. Details of the preprocessing and analysis are given in Wall et al. (2016).

Results and Discussions

The obtained U–Pb zircon dates are summarized in Figure 1. The weighted average $^{206}Pb/^{238}U$ date of

the OGPK, obtained by LA-ICPMS, shows 1.06 ± 0.17 Ma (2σ; n = 12; MSWD = 0.33). The weighted average $^{206}Pb/^{238}U$ date of the TRG04 using LA-ICPMS has already been reported (Nagata et al., 2022) and shows 2.65 ± 0.16 Ma (2σ; n = 22; MSWD = 0.13). These dates obtained by LA-ICPMS are not corrected for initial disequilibrium in $^{230}Th/^{238}U$. The weighted average $^{206}Pb/^{238}U$ dates of the TRG04 and OGPK, obtained by CA-ID-TIMS, show 2.6654 ± 0.0016 Ma (2σ; n = 6; MSWD = 0.84) and 1.1266 ± 0.0014 Ma (2σ; n = 6; MSWD = 1.3), respectively. These dates obtained by CA-ID-TIMS are corrected for initial disequilibrium in $^{230}Th/^{238}U$, assuming the Th/U ratio of the parent magma (Th/U_{magma} =2.8 ± 0.1; 2σ).

The date of the TRG04 obtained from this study is consistent with radiometric dates (*e.g.* K–Ar, FT, and U–Pb) reported in previous studies (Uto et al., 1994).

On the other hand, the obtained date of the OGPK is slightly older than the reported dates (Danhara et al., 1997). The depositional timing of the OGPK has been correlated to the Jaramillo event (1.07–0.99 Ma) because its remanent magnetization shows the normal polarity chron (Hayashida et al., 1996). The ca. 80,000-year age difference may indicate the storage time of the OGPK zircons in magma. To estimate accurate date of the OGPK, it is necessary to determine the Th/U_{magma} analysis of melt inclusions for initial disequilibrium correction. Although further study is required regarding the OGPK, the TRG04 is expected to serve as the age reference material.

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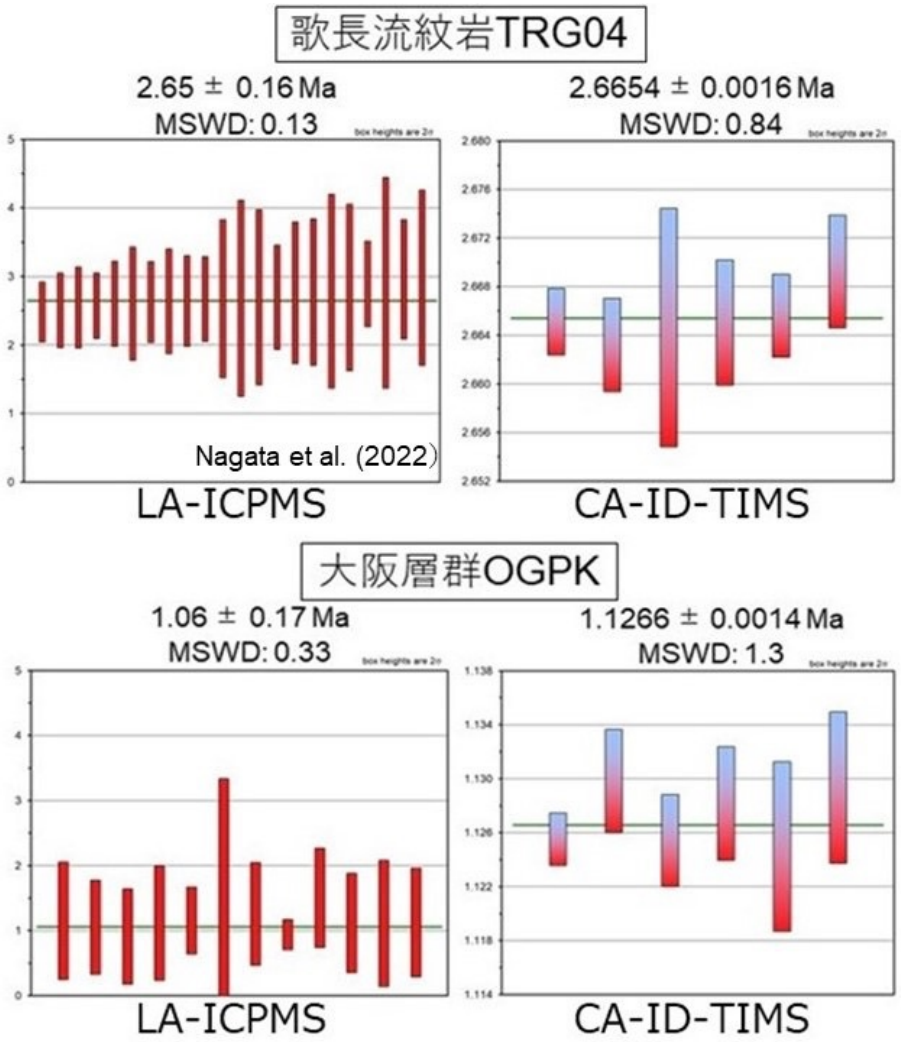

Fig. 1 U–Pb zircon dates from the TRG04 and OGPK
図1　本研究のジルコン（TRG04とOGPK）より得られたU–Pb年齢