**METHODS**

**LA-MC-ICPMS zircon geochronology**

Zircons were separated at California State University Northridge following standard methods involving crushing, pulverizing with jaw crusher and disk mill, and density separation on a Wilfley gold table and with heavy liquids. Samples were processed through a Frantz isodynamic separator (side tilt = 5°, front tilt = 20°) at 1.5 amps to remove magnetic (non-zircon) minerals. Zircons were poured onto double sided tape and mounted in epoxy, ground and polished. They were then imaged on a Gatan MiniCL detector attached to a FEI Quanta 600 scanning electron microscope.

Uranium-lead ratios were collected at the University of California Santa Barbara in one analytical session in July, 2015 following methods described in Kylander-Clark et al (2013). Analyses were conducted using a Nu Plasma multi-collector inductively coupled plasma mass spectrometer (MC-ICPMS) with a fixed collector array of 12 Faraday cups and four low-mass ion counters. Zircons were ablated using a Photon Machines 193 ArF excimer laser with HelEx cell with a repetition rate of 4 Hz. Spot size for all ablations was ~35 microns. The primary standard, 91500, was analyzed every 10 analyses to correct for in-run fractionation of Pb/U and Pb isotopes. U–Pb isotopic ratios and their uncertainties were calculated using Iolite (Paton et al., 2010). Precision on individual analyses varies by volume and U and Pb concentrations. A typical ablation of 12–26 ng of material yields 1–1.5% for 206Pb/238U ratios and 0.3–1% on 207Pb/206Pb ratios (2SE, using down-hole elemental-fractionation correction; Paton et al., 2010).

Three secondary zircon standards, Plesovice, Temora-2, and GJ-1 were analyzed throughout the analytical session to assess reproducibility of the data. U-Pb analysis of the secondary standards yielded concordant results and 206Pb/238U error-weighted average ages of 341.0 ± 1.5 (n=23; mswd=0.8), 418.8 ± 2.1 (n=1.2; mswd=0.2), and 604.4 ± 2.5 (n=1.1; mswd=0.4) for Plesovice, Temora-2 and GJ-1, respectively. Error weighted average ages for all secondary standards lie within 1% of the accepted values.

U-Pb isotopic data were plotted using Isoplot 3.75 (Ludwig, 2012). Tuffs and rhyolites commonly yield overdispersed zircon dates in which the mean square weighted deviation (MSWD) is >>2 for zircons from a single sample. Data were deconvolved using the Sambridge and Compston (1994) ‘unmix’ algorithm in Isoplot assuming Gaussian distributions of two or three age populations. In most cases, the youngest zircon population is reported as the age of eruption/intrusion, and older populations are considered xenocrystic. The quoted dates in the text and tables are reported at 95% confidence interval and are assigned 2% total (systematic + analytical) uncertainties, except when comparing analyses within the same sample or grain. Total uncertainties are shown in brackets in the text and tables. Geochronologic data are presented in Fig. Xa-b. Sample and standard data are provided in Tables 1-3.

**RESULTS**

**Tuffs**

Zircons from 152 LCJ 06 (Steins Pillar tuff, Wildcat Mountain caldera) are subhedral, and small with typical lengths <100 m. Cathodoluminescence (CL) imaging reveal a significant portion of zircons contain rounded and embayed cores surrounded by oscillatory zoned rims. Core and rim analysis of 25 zircons yielded thirty three spot analyses with 206Pb/238U dates ranging from 53.0 to 39.8 Ma (Fig. 1A; Table 2). Statistical deconvolution of the data assuming three populations yields peaks at 50.1 ± 0.7, 45.8 ± 0.3 and 41.8 ± 0.2 Ma (Fig. 1B).

Sample JM ER-13-4 (Crooked River caldera) contains small (<100 m in length), stubby zircons with well developed crystal faces. In CL images, zircons commonly display dark, embayed cores surrounded by surrounded by lighter rims. Twenty-six zircons were analyzed and 206Pb/238U dates range from 36.5 to 27.9 Ma (Fig. 1C). Deconvolution of the dates yields peak populations at 33.5 ± 0.3 and 29.5 ± 0.2 Ma (Fig. 1D).

Zircons from SRT-SKULL-1, also from the Crooked River caldera, are euhdral and ~100-200 m in length. CL images show minor evidence for distinct core domains. However, analysis of 30 core and rim spot domains yielded overdispersed data with 206Pb/238U dates ranging from 35.3 to 28.3 Ma (Fig. 1E). Statistical deconvolution of the data assuming three populations yields peaks at 34.3 ± 0.4, 31.3 ± 0.3 and 29.3 ± 0.2 Ma (Fig. 1F).

Sample 24LCJ06 from the Smith Rock tuff (Crooked River caldera) yielded small (<100m), euhedral zircons. CL imaging shows little obvious evidence for older cores. 206Pb/238U dates for 21 zircons range from 35.8 ± 0.9 to 28.4 ± 0.6 Ma (Fig. 1G). Statistical deconvolution yields nearly identical results to SRT-SKULL-1 with peak populations at 34.3 ± 0.4, 31.3 ± 0.3 and 29.3 ± 0.3 Ma (Fig. 1H).

Sample 1OCJ14, intracaldera fill from the Crooked River caldera, yielded only a few, short stubby zircons <100 m in length. 206Pb/238U dates range from 35.0 ± 1.0 to 28.1 ± 0.7 Ma (Fig. 1I). Deconvolution shows a prominent peak at 30.6 ± 0.3 Ma with minor peaks at 28.3 ± 0.5 Ma (3 zircons) and 33.9 ± 0.5 Ma (5 zircons)(Fig. 1J).

**Rhyolites and dikes**

Sample JB-JM-01 from the Juniper Butte rhyolite yielded suhedral zircons ranging in length from 100-200 mm. No obvious cores were observed in CL imaging. Analysis of 24 zircons yielded dates ranging from 35.8 ± 0.9 to 28.5 ± 0.7 Ma (Fig. 1K), and deconvolved peak populations at 32.1 ± 0.8 and 29.3 ± 0.2 Ma (Fig. 1L).

Sample GSO95-41, the Grey Butte rhyolite, yielded small (<100m), subhedral zircons several of which display distinct core domains in CL imaging. 206Pb/238U dates range from 28.5 ± 0.6 to 36.5 ± 1.0 Ma (Fig. 1M). Statistical deconvolution assuming three populations gives peak populations at 35.7 ± 0.6, 32.9 ± 0.3 and 29.2 ± 0.3 Ma (Fig. 1N). The latter date is statistically identical to a SHRIMP-RG date of 29.6 ± 0.8 from the same sample (Schwartz, unpublished data), but is notably younger than the 40Ar-39Ar date of 28.8 ± 0.2 determined on anorthoclase (Smith et al., 1998).

The Mount Emily rhyolite (912-12-1) yielded very few zircons. CL imaging reveals that many zircons have distinct, bright low U cores, surrounded by dark, high U interiors and rims. Analysis of 12 zircons gave a large range of dates with most ranging from 29.1 to 33.2 Ma (Fig. 1O). Four anomalous older zircons gave dates of 151-205 Ma, and one younger zircon gave a poorly defined date of 14.3 ± 29.7 Ma. Statistical deconvolution of the 29-33 Ma zircons yield populations at 31.3 ± 0.3 and 29.2 ± 0.6 Ma (Fig. 1P).

Sample, PATGR2, the Grizzly Mountain rhyolite, contains 100-200 mm, subhedral zircons. Analysis of twenty zircons gave 206Pb/238U dates ranging from 32.8 ± 1.0 to 28.0 ± 0.7 Ma (Fig. 1Q). Statistical deconvolution shows a prominent peak at 28.9 ± 0.2 Ma and a lesser peak at 31.8 ± 0.6 Ma (Fig. 1R).

Sample SR RH2, an intrusive dike into the Smith Rock tuff, yielded 14 subhedral, oscillatory zoned zircons with little evidence for older core domains. 206Pb/238U dates range from 31.0 ± 0.7 to 28.0 ± 0.7 Ma (Fig. 1S). Unmixing of zircon dates yields two populations at 30.0 ± 0.3 Ma and 28.4 ± 0.3 Ma (Fig. 1T).

**REFERENCES**

Kylander-Clark, A.R.C., Hacker, B.R., Cottle, J.M., 2013, Laser-ablationsplit-stream ICP petrochronology: Chemical Geology, 345, 99-112.

Ludwig, K.R., 2012, Isoplot 3.75: A. geochronological toolkit for Microsoft Excel: Berkeley Geochronology Center Special Publication 5, pp. 1-75.

# Paton, C., Woodhead, J., Hellstrom, J. Hergt, J., Greig, A., Maas, R., 2010, Improved laser ablation U-Pb zircon geochronology through robust downhole fractionation correction: Geochemistry, Geophysics, Geosystems, 11, 10.1029/2009GC002618

Sambridge, M.S., and Compston, W., 1994, Mixture modeling of multi-component data sets with application to ion-probe zircon ages: Earth and Planetary Science Letters, v. 128, p. 373–390, doi: 10.1016/0012-821X(94)90157-0.

Smith, G., Manchester, S.R., Ashwill, M., McIntosh, W.C., Conrey, R.M., 1998, Late Eocene—early Oligocene tectonism, volcanism and floristic changes near Grey Butte, central Oregon: Geological Society of America Bulletin, v. 110, no. 6, p. 759-778.