SUPPLEMENTAL MATERIAL

## A. Sample Details

Samples dated by U/Pb are represented by **U**, Lu-Hf samples by **H**, and oxygen isotopes in zircon and quartz are **ZO** and **QO**, respectively. Samples with zircon saturation analyses are represented by **T**.

### A 1. Northern Transect (Chihuahua – Hermosillo)

#### 3-20-4

Un-named rhyolite tuff (map-unit *Tv7*; McDowell, 2007), Yecora area, Sonora (28.3303° N, 108.7094° W). Weakly welded ignimbrite. **UHZOQO**

#### BM100305-2

Un-named rhyolite lava, Sierra Guazapares Formation, (map-unit *Tsi*; Murray et al., 2013), Guazapares area, Chihuahua (27.3080° N, 108.2378° W). 5-10% phenocrysts of plagioclase and minor biotite. Sample dated previously to 23.93 Ma by Murray et al. (2013). **UZO**

#### BM100307-1

Cerro Salitrera rhyolite plug, Sierra Guazapares Formation (map-unit *Tsi*; Murray et al., 2013), Guazapares area, Chihuahua (27.3682° N, 108.2579° W). 5-10% phenocrysts of plagioclase and minor biotite. **UHZO**

#### CH01

Gallego Rhyolite (Keller et al., 1982), upper of two rhyolites at Sierra del Gallego area, Chihuahua (29.5366° N, 106.3141° W). ≤50% phenocrysts of oligoclase, sanidine, and augite. Lava or lava-like ignimbrite. **UHZOT**

#### CH03

Bellavista rhyolite welded tuff (McDowell and Mauger, 1994), Bellavista Canyon area, Chihuahua (29.0813° N, 106.3866° W). One of three conformable strongly welded ignimbrites beneath peralkaline volcanic rocks (Acantilado tuff; sample *CH97-7*). Possibly correlates with the Majalca Canyon tuff (sample *MAJ*; McDowell and Mauger, 1994). ~31% phenocrysts of alkali feldspar and sparse quartz, plagioclase, biotite, and hornblende. **UHZO**

#### CH06

Vista Tuff ignimbrite (Swanson and McDowell, 1985; Wark et al., 1990; Wark, 1991; Bryan et al., 2008; McDowell and McIntosh, 2012), Tomóchic area, Chihuahua (28.2611° N, 108.0665° W). Crystal-rich quartz–plagioclase–sanidine–biotite–hornblende-phyric lapilli-tuff erupted from the Las Varas caldera. **UHQO**

#### CH88-13

Chivato rhyolite tuff (McDowell and Mauger, 1994), Palomas area, Chihuahua (28.4684° N, 106.3008° W). Ignimbrite; basal volcanic unit unconformable upon Mesozoic carbonates; below Cañada del Gato rhyolite lava (sample *RED*). **UHZO**

#### CH88-17

Sierra del Nido rhyolite lava (McDowell and Mauger, 1994), Laguna Encinillas area, Chihuahua (29.5232° N, 106.5813° W). **UHZO**

#### *CH97-7*

Acantilado peralkaline rhyolite tuff (Mauger 1981; Keller et al., 1982; McDowell and Mauger, 1994), Bellavista Canyon area, Chihuahua (29.0867° N, 106.4866° W). Moderately to strongly peralkaline rhyolite ignimbrite above Bellavista tuff (sample *CH03*; McDowell and Mauger, 1994). **UHZOQO**

#### CUSI

Un-named rhyolite tuff (McDowell and Mauger, 1994), Cuauhtémoc-Cusihuiriachic area, Chihuahua (28.2137° N, 106.7915° W). Ignimbrite interstratified with intermediate composition lavas above sample *J406*. **UHZO**

#### J406

Bufa rhyolite tuff (McDowell and Mauger, 1994), Cuauhtémoc-Cusihuiriachic area, Chihuahua (28.2274° N, 106.8355° W). Possibly a caldera-filling ignimbrite. **UHZO**

#### MAJ

Majalca Canyon rhyolite tuff (McDowell and Mauger, 1994), Majalca Canyon area, Chihuahua (28.8210° N, 106.4374° W). Probably caldera-filling, very thick ignimbrite disconformable upon Eocene intermediate composition volcanic rocks. Possible correlative with the Bellavista tuff (sample *CH03*; McDowell and Mauger, 1994). **UHZO**

#### *N-12* and *N-88*

Quemada rhyolite tuff (map-unit ‘*Mogotabo Unit 5*’; Swanson et al., 2006), San Juanito and Sierra Manzanita areas, Chihuahua (27.5330° N, 107.7954° W and 28.1574° N, 107.4484° W). Strongly welded ignimbrite erupted from Manzanita caldera; overlies Copper Canyon tuff (sample *N-99*). ~10% phenocrysts of plagioclase and biotite. **UHZO**

#### N-63

Un-named rhyolite lava (map-unit *Tfl1*; Swanson et al., 2006), San Juanito area, Chihuahua (28.0075° N, 107.7942° W). **UHZO**

#### N-99

Copper Canyon rhyolite tuff (map-unit ‘*Mogotabo Unit 1*’; Swanson et al., 2006), Divisadero area, Chihuahua (27.5316° N, 107.7933° W). Strongly welded >1 km-thick ignimbrite probably filling a caldera. ≤50% phenocrysts of plagioclase, quartz, biotite, and trace hornblende. **UHZOQO**

#### RED

Cañada del Gato Rhyolite (Cook, 1990; McDowell, 2007), Palomas area, Chihuahua (28.4248° N, 106.2910° W). Lava or lava-like ignimbrite above Chivato tuff (sample *CH88-13*) in unit Tv1 of McDowell (2007). **UHZOT**

#### SJ-3

San Felipe rhyolite tuff (map-unit *Tfst*; Swanson et al., 2006), San Juanito area, Chihuahua (28.0090° N, 107.7030° W). Strongly welded, 300 m-thick with a basal vitrophyre and multiple cooling units. 5 - 13% phenocrysts of quartz and plagioclase with trace alkali feldspar and biotite. Possibly erupted from the San Juanito caldera. **UHZOT**

#### SJ-42

Divisadero Tuff (map-unit *Tdt*; Swanson et al., 2006), Divisadero area, Chihuahua (27.7303° N, 107.7030° W). Strongly welded, crystal-rich lapilli-tuff, locally >300 m-thick and lithic-rich, in multiple cooling units. Crystal modality is variable: biotite and plagioclase with occasional clinopyroxene and quartz.

#### SJ-50

Cerro de la Luna rhyolite lava (map-unit *Tfl2*; Swanson et al., 2006), San Juanito area, Chihuahua (28.0253° N, 107.6926° W). Phenocryst-rich (~18%), quartz and sanidine-bearing lava with sparse plagioclase. **UHZO**

#### SJ-54

Un-named rhyolite lava (map-unit *Tfl2*; Swanson et al., 2006), Sierra Manzanita area, Chihuahua (28.1420° N, 107.5033° W). Phenocryst-rich (~37%), quartz and sanidine-bearing lavas with sparse biotite. **UHZOQO**

### A 2. Central Transect (Parral – Guadalupe y Calvo - Guachochi)

#### SMO13\_03

Cerro El Caracol rhyolite lava, Guadalupe y Calvo area, Chihuahua (26.0830° N, 106.9397° W). Thin lava with 12% phenocrysts of quartz and biotite. **UHQOT**

#### SMO13\_10

La Joya rhyolite lava, Guadalupe y Calvo area, Chihuahua (26.1018° N, 106.7313° W). Near-aphyric lava with sparse biotite and plagioclase. **UHT**

#### SMO13\_17

Un-named rhyolite lava, Turuachi area, Chihuahua (26.2339° N, 106.5353° W). Near aphyric with trace biotite. **UHT**

#### SMO13\_27

Un-named rhyolite lava, El Vergel area, Chihuahua (26.5352° N, 106.3478° W). ~8% phenocrysts with sparse quartz, plagioclase, alkali feldspar, and biotite. **UHT**

#### SMO15\_01

Un-named rhyolite lapilli-tuff, Guachochi area, Chihuahua (26.9755° N, 106.3422° W). ≥10 m-thick, non-welded ignimbrite with 27% phenocrysts of quartz, plagioclase, and sparse biotite. **UHTZO**

#### SMO15\_06

Un-named rhyolite plug, Barranca de Rio Guerachi (Fig. 4), Guachochi area, Chihuahua (26.8726° N, 106.9798° W). 37% phenocrysts of smoky quartz, and sparse biotite and alkali feldspar. Intrudes Cretaceous (?) granitoid and Paleocene-Eocene (?) andesitic breccias. **UHTZO**

#### SMO15\_09

Un-named rhyolite lava, Barranca de Rio Guerachi (Fig. 4), Guachochi area, Chihuahua (26.6934° N, 107.3167° W). ~ 52% phenocrysts of abundant quartz, alkali feldspar, and sparse plagioclase and biotite. **UHTZO**

#### SMO15\_10

Un-named quartz-latite lava, Barranca de Rio Guerachi (Fig. 4), Guachochi area, Chihuahua (26.6934° N, 107.3167° W). ~45% small phenocrysts, of plagioclase, alkali feldspar, and sparse quartz. **UHT**

#### SMO15\_11

Un-named rhyodacite lapilli-tuff, Barranca de Rio Guerachi (Fig. 4), Guachochi area, Chihuahua (26.7285° N, 107.3071° W). Indurated non-welded ignimbrite with mafic lithic clasts and 38% phenocrysts of quartz and plagioclase. **UHT**

#### SMO15\_14

‘San Miguel Arcangel’ rhyolite lapilli-tuff, Barranca de Rio Guerachi (Fig. 4), Guachochi area, Chihuahua (26.7145° N, 107.3138° W). ~120 m-thick, intensely welded ignimbrite with large fiamme, sparse lithics, and 19% phenocrysts of alkali feldspar, plagioclase, and sparse quartz. **UHT**

#### SMO15\_17

Un-named rhyolite lapilli-tuff, Barranca de Rio Guerachi (Fig. 4), Guachochi area, Chihuahua (26.7285° N, 107.3071° W). Moderately welded ignimbrite with 9% phenocrysts of plagioclase, alkali feldspar, and quartz. **UHZOT**

#### SMO15\_23

Un-named rhyolite lava, Guachochi area, Chihuahua (26.8465° N, 106.8198° W). <1% phenocrysts of alkali feldspar. **UHT**

#### SMO15\_32

Un-named rhyolite tuff, Balleza area, Chihuahua (26.9460° N, 106.4792° W). ≥80 m-thick, moderately welded ignimbrite with sparse (~3%) phenocrysts of plagioclase, quartz, and biotite phenocrysts. **UHZOT**

#### SMO15\_35

Un-named rhyolite lapilli-tuff, Balleza area, Chihuahua (26.9603° N, 106.4186° W). Moderately welded ignimbrite with 13% phenocrysts of quartz and sparse alkali feldspar. **UHT**

#### SMO15\_37

Un-named rhyolite lapilli-tuff, Balleza area, Chihuahua (26.8653° N, 106.2717° W). Welded, ignimbrite with 28% phenocrysts of quartz, and sparse alkali feldspar and biotite. Trace plagioclase. **UHZOT**

#### SMO15\_41

Un-named latite lava, Balleza area, Chihuahua (26.8807° N, 106.2625° W). 65% plagioclase, alkali feldspar, hornblende, biotite, and sparse quartz. **UHZOT**

#### SMO15\_42

Un-named rhyolite lapilli-tuff, Balleza area, Chihuahua (26.8951° N, 106.2460° W). Ignimbrite with 29% phenocrysts of smoky quartz and sparse alkali feldspar. Trace hornblende and plagioclase. **UHT**

#### SMO15\_44

Un-named rhyolite lava or lava-like tuff, Balleza area, Chihuahua (26.8893° N, 106.2428° W). ~38% quartz phenocrysts with trace plagioclase. **UHT**

#### SMO15\_46

Un-named rhyolite lapilli-tuff, Balleza area, Chihuahua (26.8747° N, 106.2244° W). Non-welded, phenocryst-poor (~6%) ignimbrite with sparse quartz and trace biotite. **UHZOT**

#### SMO15\_49

Un-named rhyolite lapilli-tuff, Puerto Justo area, Chihuahua (26.8582° N, 106.1178° W). ≥120 m-thick welded ignimbrite with 33% quartz phenocrysts. **UHT**

#### SMO15\_52

Los Baños rhyodacite lapilli-tuff, Puerto Justo area, Chihuahua (26.7205° N, 106.2375° W). Lithic-rich, phenocryst-poor (~16%), quartz-phyric welded ignimbrite. **UHZOT**

#### SMO15\_55

Un-named rhyolite lapilli-tuff, El Tule area, Chihuahua (27.06835° N, 106.2536° W). 15% phenocrysts of quartz and sparse plagioclase. **UHT**

### A 3. Southern Transect (Durango – Mazatlán)

#### 1-70-1

Las Adjuntas rhyolite dome (Wahl, 1973; McDowell and Keizer, 1977), La Ciudad - El Salto area, Durango (23.7506° N, 105.5118° W). Crystal-rich (quartz-sanidine-plagioclase) and flow-banded.206Pb/238U weighted mean age of 29.5 ± 0.3 Ma (MSWD = 1.3, *n* = 15; Ferrari et al., 2013). **UZO**

#### 2-71-1

Santaurio Tuff (McDowell and Keizer, 1977; Swanson et al., 1978), Durango City, Durango (24.0409° N, 104.6683° W). Moderately welded, crystal-rich (25 - 50 %), lapilli-tuff with sanidine (~15 %), plagioclase (~10 %), quartz (~5 %), and hornblende (~2 %). Uppermost formation of the Carpintero Group erupted from the Chupaderos caldera near Durango. **UHQO**

#### 3-71-2

El Salto rhyolite lapilli-tuff (Wahl, 1973; McDowell and Keizer, 1977), La Ciudad - El Salto area, Durango (23.7900° N, 105.3700° W). Strongly welded, thin, plagioclase, sanidine, and quartz-phyric ignimbrite. **UHZO**

#### 3-71-7

Un-named tuff (‘*plateau units*’; McDowell and Keizer, 1977), La Ciudad - El Salto area, Durango (23.6584° N, 105.7403° W). Thin, strongly welded lapilli-tuff. **UZO**

#### K-LP-T

Aguila rhyolite tuff, Carpintero Group (map-unit *Ta*; McDowell and Keizer, 1977; Swanson et al., 1978), Durango City area, Durango (24.0088° N, 104.3970° W). Thick, strongly welded ignimbrite with ≤50% phenocrysts of sanidine, quartz, plagioclase, and pyroxene. Erupted from the Chupaderos caldera (Swanson et al., 1978). **UHZOQO**

#### SL-41

Agua Nueva dome (map-unit *Tan*; Aguirre-Díaz and McDowell, 1991), Nazas – San Luis del Cordero area, Durango (25.3496° N, 104.1521° W). Porphyritic rhyolite with plagioclase (18 - 25 %), hornblende (9 - 20 %), biotite (3 - 5 %), and trace clinopyroxene and quartz in a groundmass of plagioclase, oxides, clinopyroxene, and devitrified glass. **UZOQO**

### A 4. References

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## B. U-Pb Geochronology Data

See separate MS Excel file – “UPb data table.xlsx”. Contains two tabs: *WSU LAICPMS*, and *UCLA SIMS*.

## C. EarthChem Database References

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## D. Lu-Hf Data

See separate MS Excel file – “Hf DATA TABLE.xlsx”. Contains two tabs: *WSU* and *AZLaserChron*.

## E. Oxygen Isotope Data

See separate MS Excel file – “Oxygen DATA TABLE.xlsx”. Contains three tabs: *d18O WiscSIMS*, *d18O UCLA*, and *d18O quartz*.

## F. Zircon Saturation Temperature Data

|  |  |  |
| --- | --- | --- |
|  | **Zircon saturation temperature** |  |
| **sample name** | **SiO2 (wt.%)** | **Zr (ppm)** | **M (atom-1) 12** | **TZircsat (°C) 12** | **references** |
| ***Chihuahua Transect*** |  |  |  |  |
| CH01 | 70.71 7 | 633 7 | 1.62 | 634 | 7,8 |
| RED | 71.32 5 | 258 5 | 1.43 | 653 | 5,8 |
| SJ-3 | 70.88 5 | 227 5 | 1.28 | 667 | 3,5,6 |
| ***Parral Transect*** |  |  |  |  |
| SMO13\_03 | 69.77 | 165 | 1.11 | 685 | 11 |
| SMO13\_10 | 73.26 | 200 | 1.20 | 675 | 11 |
| SMO13\_17 | 72.84 | 233 | 0.97 | 700 | 11 |
| SMO13\_27 | 74.12 | 248 | 1.24 | 672 | 11 |
| SMO15\_01 | 72.90 | 116 | 1.04 | 692 | 11 |
| SMO15\_06 | 76.23 | 81 | 1.08 | 689 | 11 |
| SMO15\_09 | 76.66 | 75 | 1.23 | 673 | 11 |
| SMO15\_10 | 65.07 | 182 | 1.64 | 632 | 11 |
| SMO15\_11 | 72.74 | 73 | 1.21 | 675 | 11 |
| SMO15\_14 | 71.95 | 333 | 1.44 | 652 | 11 |
| SMO15\_17 | 71.25 | 286 | 1.29 | 667 | 11 |
| SMO15\_23 | 75.06 | 193 | 1.27 | 668 | 11 |
| SMO15\_32 | 79.97 | 177 | 1.22 | 674 | 11 |
| SMO15\_35 | 75.24 | 177 | 1.16 | 680 | 11 |
| SMO15\_37 | 75.02 | 127 | 1.09 | 687 | 11 |
| SMO15\_41 | 70.53 | 139 | 1.66 | 631 | 11 |
| SMO15\_42 | 76.69 | 264 | 1.06 | 691 | 11 |
| SMO15\_44 | 79.30 | 184 | 1.19 | 677 | 11 |
| SMO15\_46 | 70.17 | 194 | 0.96 | 701 | 11 |
| SMO15\_49 | 76.66 | 231 | 1.21 | 675 | 11 |
| SMO15\_52 | 68.84 | 219 | 1.18 | 678 | 11 |
| SMO15\_55 | 76.47 | 244 | 1.29 | 666 | 11 |

*Table F 1. Zircon saturation temperatures (Watson and Harrison, 1983; Boehnke et al., 2013) calculated for selected SMO samples.*

## G. Assimilation – Fractional Crystallization Modeling

### G 1. Methodology

Modeling of coupled assimilation and fractional crystallization (AFC) processes follows the methodology of DePaolo (1981), specifically equation 15a. All simulations were made with constant (i) hafnium partition coefficient (*D*) of 1, (ii) assimilation-crystallization ratio (*r*) of 1:2, and (iii) 5 % increments. Four mantle and three lower crustal end-members were examined using the parameters in Table G 1 and references therein.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **end-member** | **Hf (ppm)** | **O (ppm)** | **εHf35** | **δ18OWR ‰** |
| depleted mantle (DM35) | 0.157 1 | 4353 2 | 15.5 3 | 5.5 3 |
| enriched mantle I (EMI35) | 8 4 | 4353 2 | -7.5 5 | 5.71 6 |
| enriched mantle II (EMII35) | 8 4 | 4353 2 | 5.5 5 | 6 6 |
| high δ18OWR EMII35 | 8 4 | 4353 2 | 5.5 5 | 9.3 7 |
| La Olivina intermediate orthogneiss | 3.2 8 | 5000 8 | -7.47 3 | 8.25 3 |
| La Olivina paragneiss | 6 8 | 5000 8 | -15.36 3 | 12.6 3 |
| Potrillo paragneiss | 6 8 | 5000 8 | -10.74 3,9,10 | 13.2 3 |

*Table G 1. Modeling Parameters*

1 – Workman & Hart (2005)

2 – Drew et al. (2013)

3 – Cameron et al. (1989)

4 – Willbold & Stracke (2006)

5 - Zindler & Hart (1986)

6 – Eiler (2001)

7 – Liu et al. (2014) – calculated from δ18Oolivine data

8 – Cameron et al. (1992) – Hf concentration calculated based on measured Zr divided by 36.4 (see text)

9 – Ruiz et al. (1988a)

10 – Ruiz et al. (1988b)

The four mantle end-members are: depleted mantle, enriched mantle I (EMI), enriched mantle II (EMII), and high δ18O arc mantle (adapted from Liu et al., 2014). The three lower crustal end-members are estimated from xenoliths collected adjacent to the SMO: intermediate orthogneiss from La Olivina (Ruiz et al., 1988a; Cameron et al., 1992), sillimanite-paragneiss from La Olivina (Ruiz et al., 1988a; Cameron et al., 1992), and sillimanite- / kyanite-paragneiss from Potrillo (Ruiz et al., 1988a; 1988b). Whole-rock hafnium concentrations in the crustal end-members were calculated using the equation

Hf = Zr / 36.4

where Zr is the zirconium concentration in parts per million and 36.4 ±4.5 (1σ) is the mean Zr/Hf ratio for 118 SMO rhyolites (Mahar et al., 2019 (*n* = 10); unpublished data (*n* = 108)). Epsilon hafnium values were calculated from published epsilon neodymium data using the terrestrial array equation of Vervoort et al. (2011). All epsilon hafnium values are calculated for 35 Ma. Whole-rock δ18O values (δ18OWR) in SMO samples were recalculated from δ18Ozircon using an equilibrium temperature of 800 °C and Δ18O(melt-zircon) of 1.8 ‰ (Bindeman et al., 2007).

### G 2. References

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