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GEOCHRONOLOGY OF PROTEROZOIC ROCKS OF THE SANDIA-MANZANO-LOS PINOS UPLIFT: IMPLICATIONS FOR THE TIMING OF CRUSTAL ASSEMBLY OF THE SOUTHWESTERN UNITED STATES

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Abstract—New U-Pb zircon geochronologic data from plutons in the Sandia-Manzano-Los Pinos uplift are in agreement with older data that there were two major plutonic episodes, one at 1.66-1.65 Ga and the other at 1.46-1.45 Ga. These plutons are manifestations of a regional polyphase tectonic evolution for New Mexico during the Mazatzal and Picuris orogenies, respectively. Paleoproterozoic magmatism involved a bimodal rhyolite-basalt section of the basal Manzano Group; a new U-Pb zircon ICPMS age of 1665±16 Ma on the Sevilleta Metarhyolite Ma agrees with published ID-TIMS ages of 1662±1 Ma for the Sevietta Metarhyolite and 1662±2 Ma for interlayered mafic volcanic rocks. New ICPMS ages of 1655±14 Ma for the Manzanita, 1661±17 Ma for the Ojito, and 1662±14 Ma for the Los Pinos plutons, combined with older U-Pb dates, suggest these plutons overlap in age across the entire uplift. The 1.65-1.66 Ga plutons are interpreted to represent a magmatic arc system where plutons were intruding their own volcanic edifice and also intruding developing syn-contractional, arc-related sedimentary basins. New ICPMS U-Pb zircon ages from Mesoproterozoic plutons yield 1453±12 Ma for the Sandia and 1456±13 Ma for the Priest pluton. These plutons overlap in age, are about 20 Ma older than previously thought, and were emplaced syntectonically during the Picuris orogeny. $^{40}Ar/^{39}Ar$ data from coarse-grained muscovite crystals associated with these plutons yield complementary geochronologic information. In some cases, the muscovite ages are more precise than those obtained from zircon. Paired with our refined zircon ages, cooling ages obtained from muscovite provide insight into the secular thermal architecture of the Sandia-Manzano-Los Pinos uplift.

INTRODUCTION

The Proterozoic crust of the southwestern U.S. has been interpreted to have formed during protracted convergent margin tectonism from 1.8-1.0 Ga (Fig. 1) (Karlstrom et al., 2004; Whitmeyer and Karlstrom, 2007). Paleoproterozoic metamorphism and penetrative fabric development in central and southern New Mexico have been attributed to the accretion of arc terranes and associated basins during the Mazatzal orogeny (Karlstrom and Bowring, 1988; 1993; Karlstrom et al., 2004; Amato et al., 2008), whereas widespread granitic plutonism, deformation, metamorphism, and thermal overprinting from 1.45-1.35 Ga have traditionally been attributed to intracratonic tectonism (Nyman et al., 1994; Williams et al., 1999, Karlstrom et al., 2004; Shaw et al., 2005). The regional significance of the 1.45-1.35 Ga Mesoproterozoic event has been the subject of debate for many years (Grambling and Dallmeyer, 1993; Karlstrom et al., 1997; Williams et al., 1999; Karlstrom et al., 2004; Daniel and Pyle, 2006). The recent discovery of Mesoproterozoic ash layers and detrital zircon grains in the uppermost portions of sedimentary packages previously thought to be entirely Paleoproterozoic (Jones et al., 2011; Doe et al., 2012; 2013) has reinvigorated this debate (Daniel et al., 2013). In northern New Mexico, this sedimentary succession is now called the Trampas Group (Daniel et al., 2013), and its apparently conformable contact relations with the underlying Hondo Group have led some workers to propose a dramatically different tectonic setting for 1.49-1.45

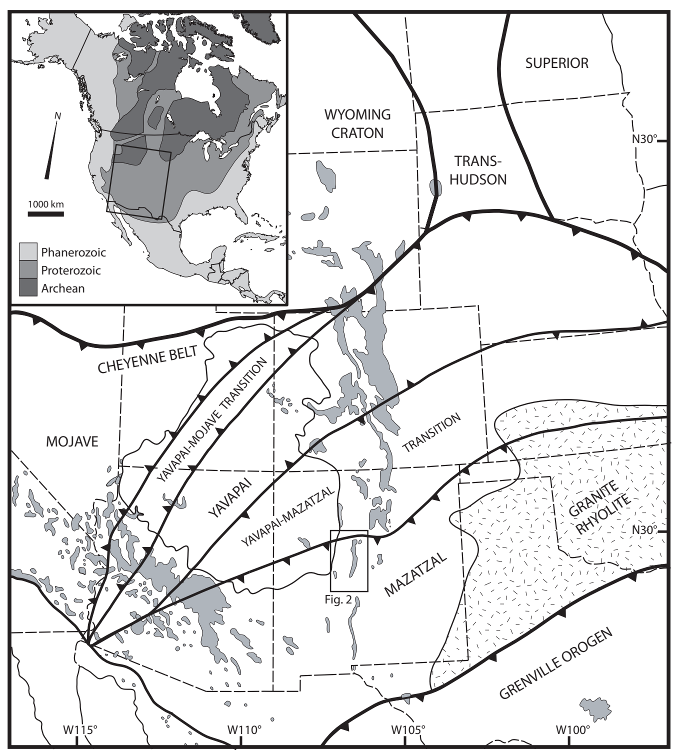

FIGURE 1. Simplified geologic map of the western United States modified after Karlstrom et al. (2004). Proterozoic crustal provinces are shown along with basement exposures of Proterozoic crust (in gray). The box shows the area of Figure 2.

Ga tectonism, which posits collision of the Mazatzal terrane at 1.45 Ga during the Picuris orogeny (Daniel et al., 2013). These new results highlight the continued importance of deciphering the histories of poly-deformed and metamorphosed terranes, as well as the vital importance of geochronology in the ongoing effort to understand the Proterozoic tectonic history of North America.

The Sandia-Manzano-Los Pinos uplift of central New Mexico is located on the eastern flank of the Rio Grande rift (Ricketts et al., 2015), and exposes a ~100-km cross-strike transect of the Proterozoic orogenic belt (Karlstrom et al., 2004). The purpose of this paper is to present new geochronologic data for Proterozoic rock units of the Sandia-Manzano-Los Pinos uplift and update the previous compilation (Karlstrom et al., 2004). We present new detrital zircon U-Pb ages for rhyolites of the Manzano Group metasedimentary succession, and refined ages for the Paleoproterozoic and Mesoproterozoic plutons that intrude the Manzano Group. When interpreted in the light of previous field and microstructural studies, these new ages improve our regional constraints on the timing of the Paleoproterozoic and Mesoproterozoic tectonic pulses.

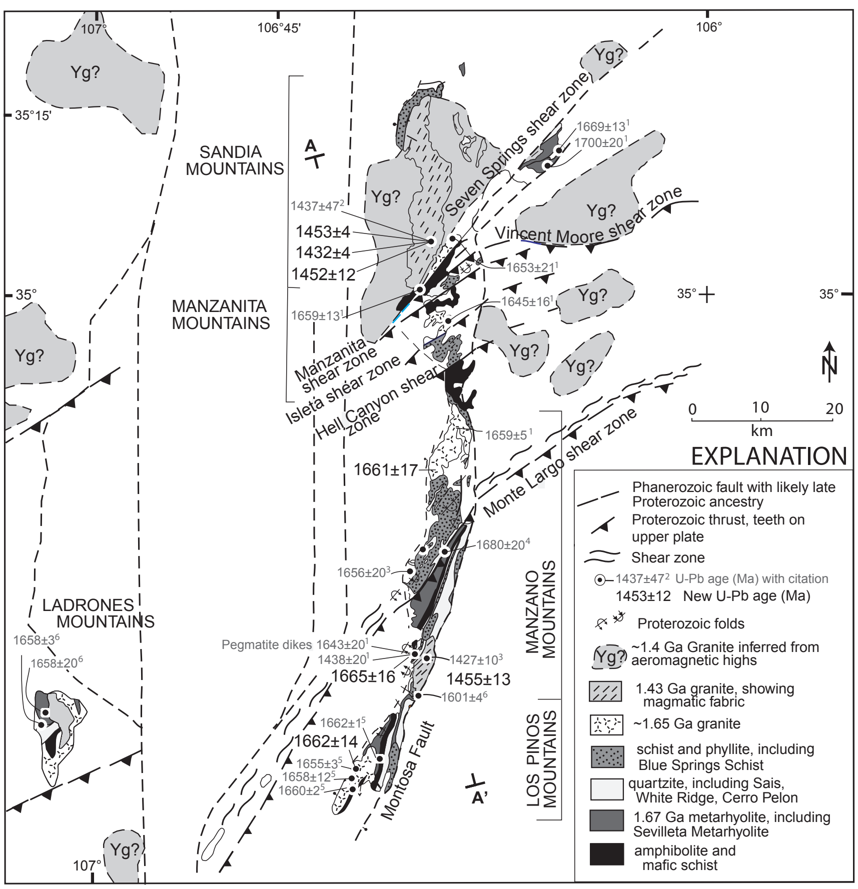

FIGURE 2. Simplified geologic map of Sandia-Manzano-Los Pinos uplift in central New Mexico modified after Karlstrom et al. (2004). Previously summarized geochronologic data are shown along with their appropriate citation: [1]Unruh, unpublished data presented in Karlstrom et al., 2004; [2]Kirby et al., 1995; [3]Bauer et al., 1993; [4]Bowring et al., 1983; [5]Shastri, 1993; [6]Luther, 2006. New data are shown in black text, previous ages in gray. Line of section A-A' denotes the approximate trend of the cross section shown in Figure 3. In Color Plate 4, a larger geologic map of the area is provided.

GEOLOGIC BACKGROUND

The Sandia-Manzano-Los Pinos uplift is a 100-km-long cross strike transect through Proterozoic middle crust of central New Mexico (Figs. 2-3). The entire transect has been well mapped at 1:24,000 and/or 1:12,000 scale (Ferguson et al., 1996; Karlstrom et al., 1994; Chamberlin et al., 1997; Karlstrom et al., 1999; Karlstrom et al., 2000; Baer et al., 2004; Scott et al., 2005; Luther et al., 2005; Allen et al., 2014), allowing for regional correlation of map units. The Sandia-Manzano-Los Pinos uplift is underlain by a complex assemblage of poly-deformed and metamorphosed supracrustal and intrusive rocks, which over a 20-year effort, have been characterized by various structural, geochronologic, geochemical, and thermochronologic studies (Shastri, 1993; Bauer et al., 1993; Kirby et al., 1995; Thompson et al., 1996; Karlstrom et al., 1997; Marcoline et al., 1999; Brown et al., 1999; Baer, 2004; Luther, 2006; Gaston, 2014).

The oldest rocks in the Sandia-Manzano-Los Pinos uplift are bimodal metavolcanic and minor intercalated metasedimentary deposits locally exposed throughout the transect. The oldest metavolcanic deposits may be as old as 1700 Ma (Fig. 2), but the most precise dates are from the 1662±2 Ma Sevilleta metarhyolite (Shastri, 1993; Luther, 2006), which consists of a thin lower unit interlayered with 100- to 125-m-thick amphibolite layers, and a >1-km-thick upper metarhyolite layer (thicknesses refer to the rocks as exposed in the Los Pinos Mountains and described by Luther, 2006). Overlying the Sevilleta metarhyolite is the Abajo Formation, which consists of meta-lithic arenite at its base grading upward into cleaner micaceous quartzite and meta-quartz arenite, and finally the White Ridge quartzite (Baer, 2004). The White Ridge quartzite is a clean quartzite capped by a distinctive aluminous horizon. Overlying the White Ridge quartzite is the Estadio Schist, a garnet + staurolite + biotite schist that preserves multiple deformational fabrics (Thompson et al., 1996). The micaceous Sais quartzite overlies the Estadio Schist. Finally, the Blue Springs Formation consists of interbedded quartzites, garnet + chlorite + quartz + muscovite schist, and the 1601±4 Ma Blue Springs rhyolite (Luther et al., 2005).

Several Paleo- and Mesoproterozoic granitic bodies intrude the Manzano Group along the Sandia-Manzano-Los Pinos uplift (see Grambling et al., this volume for compositional data). Paleoproterozoic intrusive bodies are variably penetratively deformed. The margins of the Manzanita and Ojito plutons display contact aureoles that elevate the regional greenschist facies metamorphism to amphibolite grade near the pluton margins (Brown et al., 1999;

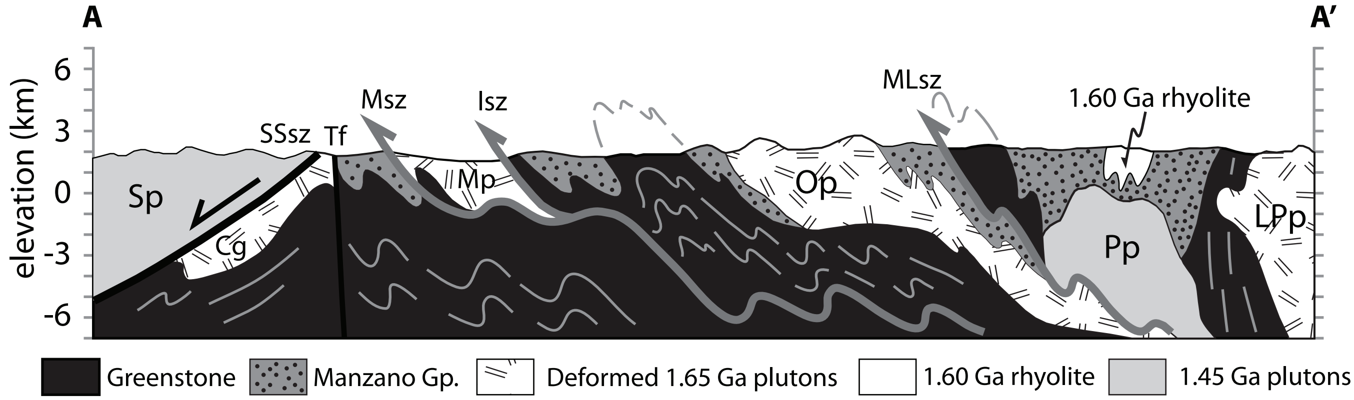

FIGURE 3. Schematic cross section of the Manzano thrust belt showing major lithologies and structural features. Sp=Sandia pluton, Cg=Cibola gneiss, SSsz=Seven Springs shear zone, Tf=Tijeras fault, Msz=Manzanita shear zone, Mp=Manzanita pluton, Isz=Isletta shear zone, Op=Ojito pluton, MLsz=Monte Largo shear zone, Pp=Priest pluton, LPp=Los Pinos pluton. Also see Color Plate 12.

Karlstrom et al., 1999). Mesoproterozoic plutons that intrude the Manzano Group include the Sandia Granite, previously dated as 1437±47 Ma (Kirby et al., 1995), which dominates the northern part of the uplift (the Sandia Mountains). The Priest pluton, previously dated as 1427±10 Ma (Bauer et al., 1993), is located in the southern Manzano Mountains. Mesoproterozoic pluton interiors are largely undeformed, but intense fabrics are locally present in their margins (Kirby et al., 1995). Contact aureoles around both Mesoproterozoic plutons contain intensely strained rocks, and porphyroblast-matrix relationships in the contact aureoles have been interpreted to record synchronous deformation of the Manzano thrust belt and pluton emplacement (Thompson et al., 1996).

METHODS

U-Pb geochronology of zircon grains separated from the main intrusive and metasedimentary lithologies in the Sandia-Manzano-Los Pinos uplift was conducted via laser ablation-inductively coupled-plasma mass spectrometry (LA- ICP-MS) at the Arizona Laserchron Center (ALC) at the University of Arizona in Tucson, AZ. Two samples were analyzed via LA-ICP-MS at the Geochemical Evolution and Metalogeny of Continents (GEMOC) Key Centre at Macquarrie University in Sydney, Australia. Both laboratories employ similar analytical methods, and yield comparable results (Holland et al., 2015). Details of the analytical methods for the ALC (Gehrels et al., 2008; Gehrels and Pecha, 2014; Pullen et al., 2014), and GEMOC Key Centre (Belousova et al., 2001; Griffin et al., 2004; Jackson et al., 2004) are available in the literature, and a brief summary of these methods is given below.

U-Pb Geochronology at the ALC

U-Pb isotopic analyses at the ALC are conducted using a Photon Machines Analyte-G2 ArF 193 nm excimer laser ablation system with a HelEx sample cell coupled to a Thermo Element2 single-collector ICP-MS. Because the Element2 is a single-collector, a time-resolved analysis is used so that each measured mass is scaled relative to the dwell time on that mass. The total counts are determined from the sum of counts relative to dwell time from each measurement cycle. Uncertainties for each analysis are calculated using Poisson counting statistics and propagated in quadrature together with the systematic errors to yield the final uncertainties; these are typically ~1-2% (Pullen et al., 2014).

Data reduction is conducted using the in-house excel macro AgeCalc (Gehrels, 2009). This macro is responsible for applying fractionation corrections, propagating uncertainties, and excluding analysis that are discordant (>20%), reverse discordant (>5%), yield high common Pb, or >10% uncertainty in U-Pb ages.

U-Pb Geochronology at the GEMOC Key Centre

U-Pb geochronology at the GEMOC Key Centre was conducted in-situ using an HP 4500 inductively coupled plasma quadrupole mass spectrometer (ICP-MS) paired with a custom-made UV laser ablation microprobe (LAM) that incorporates a petrographic microscope for detailed sample scrutiny. Samples and standards were ablated also in a custom-made chamber and transported to the ICP-MS with He carrier gas in order to minimize U/Pb fractionation. In addition, the laser was focused above the sample in order to further minimize fractionation effects; laser conditions were rigorously maintained throughout the duration of sample analysis.

Samples were compared to the zircon standard 02123, with four standard analyses completed before and after every 12 unknowns. The 02123 standard is a gem quality zircon from a Norwegian syenite that yields a perfectly concordant age of 295±1 Ma determined by isotope dilution thermal ionization mass spectrometry (ID-TIMS) (Ketchum et al., 2001). Isotope ratios for both standards and unknowns are determined from background-subtracted signals; the uncertainties in both the background and signal are added in quadrature.

Masses 206, 207, 208, 232, and 238 were measured, and all isotopic ratios were calculated using the in-house on-line data reduction software GLITTER. Mass 204 was not measured due to large isobaric interference from Hg. Common Pb correction was therefore conducted after Andersen (2002), using $^{206}Pb/^{238}U$,

$^{207}Pb/^{235}U$, and $^{208}Pb/^{232}Th$ ratios to solve mass-balance equations and correct the data in three-dimensional concordia space.

RESULTS

Igneous Zircon Geochronology

We obtained new U-Pb geochronologic data from zircon grains separated from the main intrusive bodies in the Sandia-Manzano-Los Pinos uplift, as well as the Sevietta metarhyolite near the base of the Manzano Group. A summary of our new geochronologic data is shown in Figures 4 and 5.

K15-SEV-RHY-ES

A sample of the Sevilleta Metarhyolite was collected from near the base of the Abajo formation at the mouth of Estadio Canyon. We obtained 19 near concordant ages from this sample (Fig. 4D). A weighted mean of all 19 ages yields an age

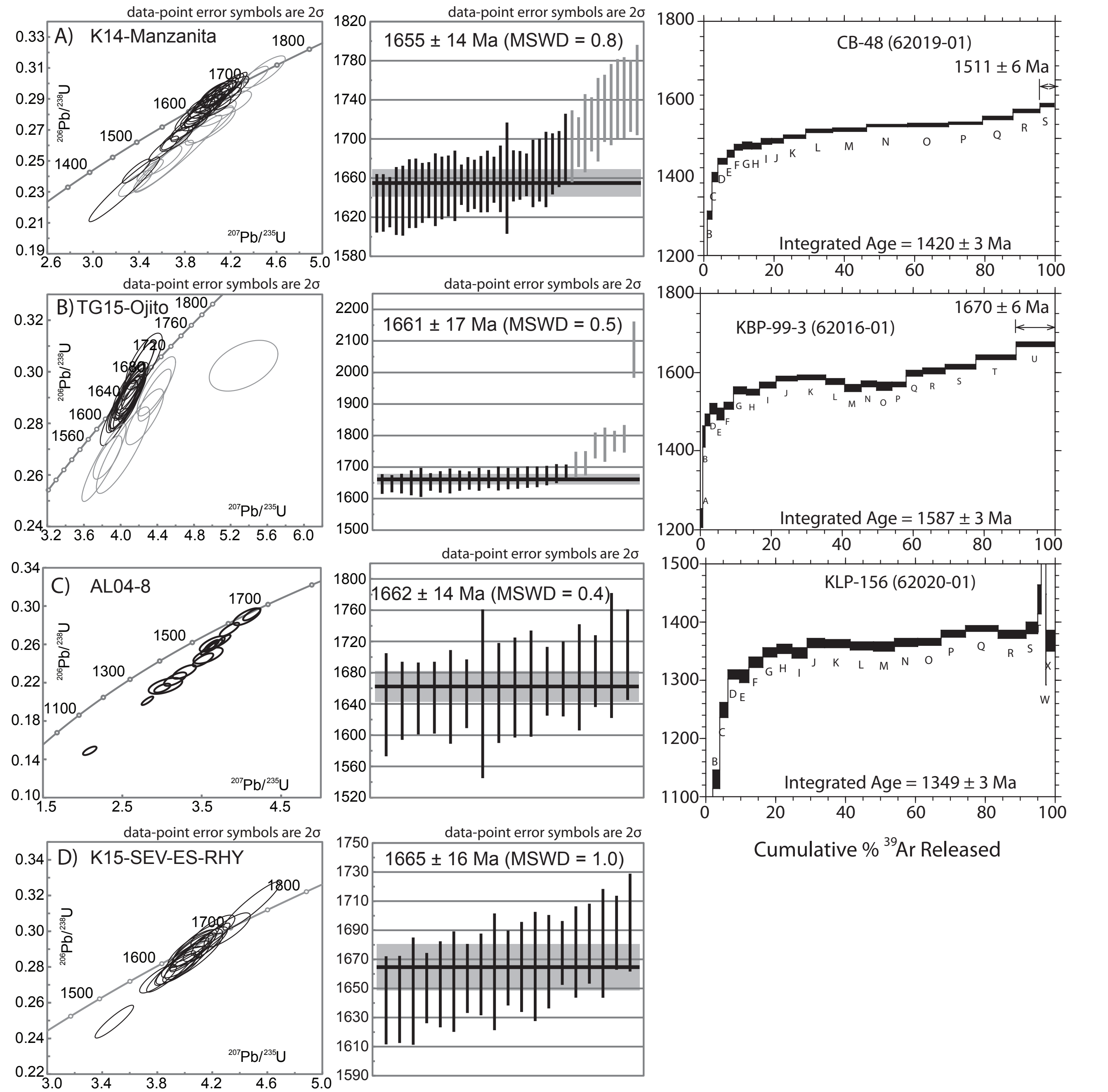

FIGURE 4. Zircon U-Pb and muscovite $^{40}Ar/^{39}Ar$ geochronologic data for Paleoproterozoic plutons and associated pegmatites in the Sandia-Manzano-Los Pinos uplift. Data from each sample are represented by a Wetherill concordira diagram (left), weighted mean (center), and an Ar release spectrum (right). For the zircon data, all points that passed the data reduction process are plotted, however data shown in gray were not included in the weighted mean calculations. Lettered steps on the $^{40}Ar/^{39}Ar$ age spectra show the age of gas evolved from muscovite crystals with progressive heating. The height of each box represents the uncertainty of each step, expressed at 2-sigma. The $^{40}Ar/^{39}Ar$ geochronologic data are reported in Gaston (2014).

of 1665±16 Ma (MSWD = 1.0). This age is in good agreement with the more precise ID-TIMS age presented by Shastri (1993) of 1662±1 Ma.

AL04-8

Sample AL04-8 was taken from the Los Pinos pluton and analyzed at the GEMOC Key Centre. We obtained 16 ages ranging from 1639±66 to 1703±58 Ma, and weighted mean of all 16 analyses yields an age of 1662±14 Ma (Fig. 4C). This new age is in good agreement with the 1655±3 Ma age presented by Shastri (1993).

TG15-OJITO

A sample of the Ojito pluton was taken from near the southern margin of the intrusion. We obtained 27 ages ranging from 1646±35 to 2073±91 Ma (Fig. 4B). A weighted mean of the 20 youngest ages yields an age of 1661±17 Ma. This age is in good agreement with the ID-TIMS age from Dan Unruh of 1659±5 Ma presented by Karlstrom et al. (2004). The older population of grains were not obtained from texturally distinct zircon domains, however they were excluded from our age determination based on a marked change in concordance towards more discordant (<90% concordant) ages. It is possible that these xenocrystic grains were derived from the presence of older rocks in the lower crustal melt source region. However, the >2.0 Ga age is likely from assimilated detrital grains within the Manzano Group. Regionally, Nd isotopic data suggest that the Mazatzal province is largely juvenile (Bennett and DePaolo, 1987; Amato et al., 2008), and is therefore unlikely to contain appreciable volumes of pre-2.0 Ga older lower crustal components.

K14-MANZANITA

A relatively undeformed sample of Manzanita Granite was collected from within the Manzanita shear zone. We obtained 41 ages ranging from 1750±48 to 1634±33 Ma (Fig. 4A). A weighted mean of the 30 youngest grains yields an age of 1655±14 Ma (MSWD = 0.8). This age is in good agreement with the unpublished age of 1645±16 age from Dan Unrue ID-TIMS dating as reported in Karlstrom et al. (2004). The older population of grains was excluded based on a marked change in concordance towards more discordant (<90% concordant) ages. Similar to the Ojito pluton, these ages were not obtained from textural distinct zircon domains, but are interpreted as xenocrystic. Inherited zircon may represent detrital grains assimilated by the pluton during emplacement. Alternatively, these grains may be derived from an older lower crustal substrate.

H13-MAN

Sample H13-MAN was taken from the Priest pluton in Estadio Canyon. We analyzed 40 zircon grains from this sample, yet only 11 grains passed the data reduction process. Many analyses yielded highly discordant (>20%) ages and very high common Pb, which is consistent with the blotchy and disturbed internal textures revealed by CL imaging. The ages obtained from these grains range from 1673±55 to 1452±14 Ma (Fig. 5B). Four of the youngest and most concordant ages yield a weighted mean age of 1455±13 Ma (MSWD = 1.2), which is interpreted as the age of crystallization of the Priest pluton. One slightly older and more discordant grain yielded an age of 1484±57, which we exclude from the weighted mean calculation due to its discordance and large uncertainty.

Four concordant Paleoproterozoic ages obtained texturally distinct zircon cores yield a weighted mean age of 1658±21

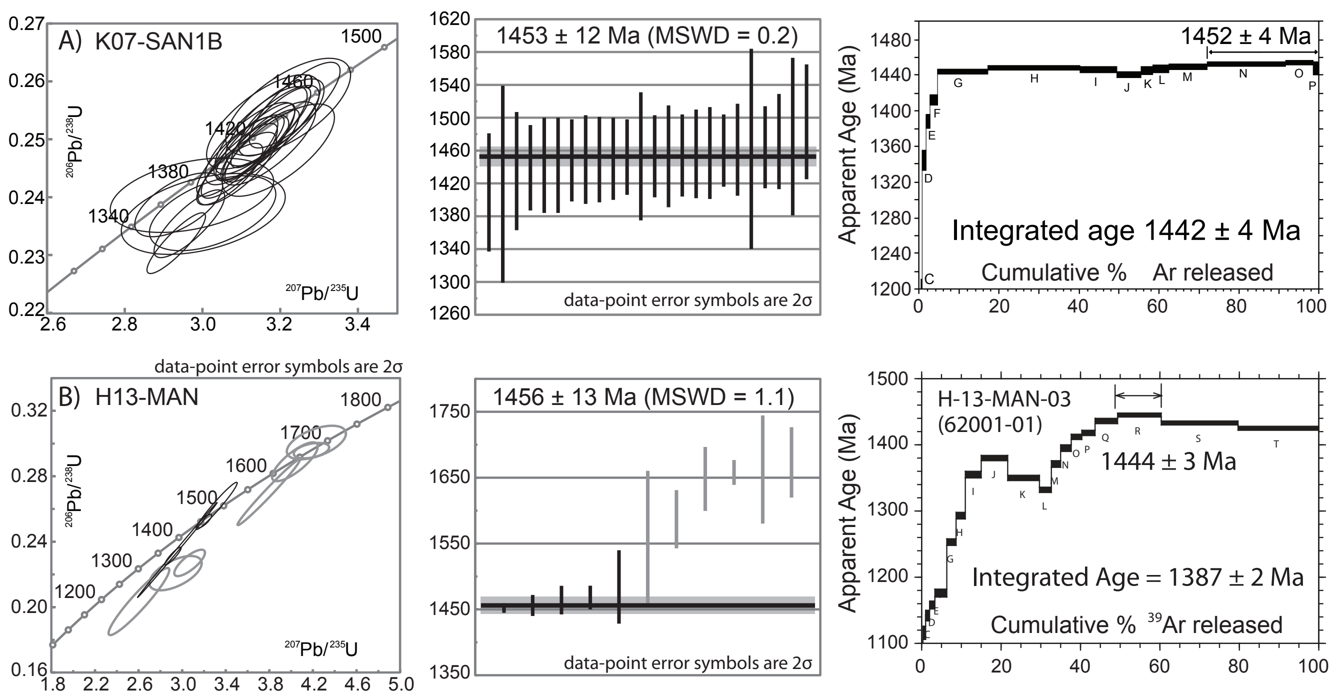

FIGURE 5. Zircon U-Pb and muscovite $^{40}Ar/^{39}Ar$ geochronologic data for Mesoproterozoic plutons in the Sandia-Manzano-Los Pinos pluton. Data from each pluton is represented as in Figure 4.

Ma (MSWD = 0.2), and two discordant ages of 1558±103 and 1587±46 Ma are interpreted as geologically meaningless mixed ages. The Paleoproterozoic zircon cores are similar in age to the age of a thin 1643±20 granite dike in Estadio Canyon and also similar in age to other ~1660 Ma Paleoproterozoic plutons, so these are interpreted as inherited zircon grains.

K07-SAN1B

Sample K07-SAN1B was taken from the Sandia Granite and analyzed at the GEMOC Key Centre. We obtained 24 ages ranging from 1409±72 to 1495±70 Ma (Fig. 5A). A weighted mean of all analyses yields an age of 1453±12. This is within error of the 1437±47 Ma age presented by Kirby et al. (1995), but more precise and is likely a more robust estimate of the age of crystallization. Interestingly, the $^{40}Ar/^{39}Ar$ age reported by Gaston (2014) may be the most precise age for the Sandia pluton (see the following discussion and Fig. 5A).

DISCUSSION

New geochronologic data from the plutons in the Sandia-Manzano-Los Pinos uplift are in agreement with older data indicating that there were two major plutonic episodes, one at 1.66-1.65 Ga and the other at 1.45-1.46 Ga. These were separated by a long interval from 1.60-1.50 Ga of tectonic quiescence referred to as the "tectonic gap" (Karlstrom et al., 2004). These new dates have importance for the recently revitalized debate over the timing of regional tectonism by providing refined ages for a polyphase tectonomagmatic history of the basement rocks.

Initiation of deposition of the Manzano Group is best constrained by the ID-TIMS ages of 1662±1 Ma for the Sevietta Metarhyolite and 1662±2 Ma for interlayered mafic volcanic rocks near the base of the section (Shastri, 1993). Our new ICPMS age of 1665±16 Ma is in agreement with these ages. The older reported ages of 1700±20 Ma and 1680±20 Ma for more northerly outcrops of presumed the Sevilleta Metarhyolite could be of varied significance. For example, these older ages could reflect temporal and spatial migration of volcanism leading to real differences in depositional age of the Manzano Group, or they could be the result of mixing between unrecognized inherited components in the older ID-TIMS analyses. Monazite U-Pb ages discussed in Karlstrom et al. (this volume) are as old as 1690 Ma, which may support an older depositional age for the lower Manzano Group. However, these older ages were obtained from monazite cores in the Abajo Formation, which are overgrown by younger ~1660 Ma rims (Karlstrom et al., this volume). Thus, our preferred interpretation is that these monazite grains are detrital in origin, and that similarly aged inherited components contributed to older age determinations for metavolcanic deposits to the north (Fig. 2).

The bimodal rhyolite-basalt section of the Manzano Group is intruded by granodiorite plutons that yield consistent ages of ~1.65 and 1.45 Ga in all parts of the uplift, and these are similar to ages seen in the Ladron Mountains across the rift to the west (Karlstrom et al., 2004). The close similarity in ages between the Paleoproterozoic volcanic rocks and the intrusive rocks (e.g., within 5 Ma for the most precisely dated Los Pinos samples of Shastri, 1993) suggests a magmatic arc system where plutons were intruding their own volcanic edifice and associated arc-related sedimentary successions at 1.65-1.66 Ga. Previous studies of pluton contact aureoles suggest that Paleoproterozoic intrusions in the Sandia-Manzano-Los Pinos uplift were emplaced at 2-3 kbar pressure conditions (7- to 10-km depths) and locally elevated regional temperatures from regional greenschist conditions (300-500°C) to ~600°C (Brown et al., 1999). A comprehensive review of contact metamorphism in the Sandia-Manzano-Los Pinos uplift is presented by Grambling et al. (this volume).

Deposition of the 1.66 Ga Sevietta Metarhyolite and subsequent intrusion of 1.66-1.65 Ga plutons at mid-crustal levels requires rapid burial of the Manzano Group. This burial was likely facilitated by thrust faulting in an accretionary tectonic setting. This deformation is recorded by matrix-porphyroblast relationships in aureoles around the 1.66-1.65 Ga plutons (Brown et al., 1999), and suggests that deformation was accommodated in the Manzano thrust belt synchronously with pluton emplacement. The presence of a 1601±4 Ma rhyolite at the top of the Manzano Group (Luther, 2006) constrains deposition of the Manzano Group to have lasted ~60 Ma, but it is unknown whether there was semi-continuous deposition versus significant (10s of Ma) unconformities in the section. The three new samples of Paleoproterozoic granites that intrude the Manzano Group range in age from 1662±14 to 1655±14 Ma. The combined data are compatible with either a rapid pulse of short-lived magmatism (~1.66-1.65 Ga), or a maximum duration of magmatism over 35 Ma. Field and microstructural studies of the granites sampled in this study suggest that they were emplaced syn-tectonically with the formation of the penetrative S_2 subvertical foliation throughout the Sandia-Manzano-Los Pinos uplift (Shastri, 1993; Brown et al., 1999; Baer, 2004; Luther, 2006).

Regional Mesoproterozoic magmatism was active from 1.45-1.35 Ga (Karlstrom et al., 2004). However, our new data yield overlapping ages of 1453±12 and 1456±13 Ma for the Sandia and Priest plutons, respectively. These new ages are older than those previously published for each pluton, and restrict the timing of Mesoproterozoic magmatism in the Sandia-Manzano-Los Pinos uplift to one of the earliest phases of regional magmatism at ~1.45 Ga.

Unpublished $^{40}Ar/^{39}Ar$ thermochronologic data from Gaston (2014) provide insight into the thermal history of the Sandia-Manzano-Los Pinos uplift throughout the Paleo and Mesoproterozoic. Coarse muscovite crystals were sampled from both Paleoproterozoic plutons or associated pegmatite dikes (Fig. 4), as well as Mesoproterozoic plutons (Fig. 5). Muscovite sampled from the Los Pinos pluton yields a climbing age spectrum with an integrated age of 1349±3 Ma (Fig. 4C) recording cooling through muscovite closure ~300 Ma after pluton emplacement. In contrast, muscovite crystals sampled from the Ojito and Manzanita plutons preserve older ages (Fig. 4A-B). Muscovite from the Ojito pluton yields a climbing age spectrum with a terminal age of 1670±7 Ma, which is analytically indistinguishable from our new zircon age of 1661±17 Ma. Also, muscovite sampled from the Manzanita pluton yields a climbing age spectrum with a terminal age of 1511±6

Ma. This age likely represents partial Ar loss due to either slow cooling after emplacement, incomplete resetting related to 1.45 Ga magmatism, or deformation-induced Ar loss.

Coarse muscovite sampled from the Mesoproterozoic Sandia and Priest plutons yield very different age spectra (Fig. 5). The Sandia pluton yields an essentially flat age spectrum that gives an age of 1452±4 Ma, which is analytically indistinguishable from our new zircon age of 1453±12 (Fig. 5A), and requires rapid cooling to ambient temperatures of <450°C after emplacement of the Sandia pluton. The apparently simple Ar systematics and excellent agreement between muscovite and zircon ages suggests that the $^{40}Ar/^{39}Ar$ age of 1452±4 Ma may be the best age of emplacement of the Sandia pluton. In contrast, the age spectrum obtained from the Priest pluton is irregular, with a maximum age of 1444±4 Ma, yet a younger integrated age of 1387±2 Ma. These data provide insight into the enigmatic thermal architecture of southwestern Laurentia at ~1.4 Ga (Karlstrom et al., this volume), and combined with previous $^{40}Ar/^{39}Ar$ thermochronologic compilations (Shaw et al., 2005) support reactivation of the Manzano thrust belt synchronously with Mesoproterozoic plutonism (Karlstrom et al., 2004).

CONCLUSIONS

New U-Pb ICPMS ages on rhyolites and plutons from the Sandia-Manzano-Los Pinos uplift are in agreement with older data in showing two magmatic episodes that affected central New Mexico. Paleoproterozoic tectonism is attributed to the Mazatzal orogeny: magmatism was concentrated during a relatively short tectonic and magmatic interval (1.66-1.65 Ga) that involved extrusion of bimodal volcanic rocks and the burial of these supracrustal to mid-crustal levels so that they were intruded by Paleoproterozoic granitic plutons. Deformational and metamorphic rocks in the aureoles of several of the 1.66-1.65 Ga plutons are compatible with syn-contractional emplacement.

Following a period of tectonic quiescence, the 1.6-1.5 Ga “tectonic gap” of Karlstrom et al. (2004), a second pulse of magmatism took place at 1.45 Ga. New dates on these plutons suggest that the 1453±12 Ma Sandia and 1456±13 Ma Priest plutons overlap in age, and are about 20 Ma older than previously thought. New $^{40}Ar/^{39}Ar$ data may provide the most precise ages for plutons that cooled quickly below the 450°C closure temperature of Ar in coarse muscovite crystals. Mesoproterozoic plutons were also emplaced syn-tectonically, as indicated by the intense fabric development recorded in their contact aureoles. This second contractional event, now termed the Picuris orogeny, began with the syntectonic deposition of the Trampas Group about 1.49 Ga, involved thrust deformation such as reactivation of the Monte Largo shear zone, and synchronous emplacement of Mesoproterozoic plutons at middle crustal levels.

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