$^{40}Ar/^{39}Ar$ ages of Palm Park volcanic rocks, south-central New Mexico

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^{40}AR/^{39}AR AGES OF PALM PARK FORMATION VOLCANIC ROCKS, SOUTH-CENTRAL NEW MEXICO

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Abstract—Volcanic rocks of the Palm Park Formation, exposed in multiple locations throughout south-central New Mexico, are composed of volcanic and volcanoclastic rocks that are lithologically and compositionally variable at scales within individual exposures and between exposures at different localities. ^{40}Ar/^{39}Ar ages of plagioclase and biotite from Palm Park volcanic rocks range from ~43.5 to ~39.5 Ma. These eruption ages can be used to correlate exposures throughout south-central New Mexico and are generally consistent with zircon ages from the same units. Overall, these ages constrain the timing of magmatism related to the Laramide Orogeny as it transitioned to magmatism associated with the ignimbrite flare-up. This is a poorly studied portion of the middle Tertiary magmatic history of southern New Mexico and Palm Park Formation volcanic units provide an excellent opportunity to refine our knowledge of the geologic history of this time interval.

INTRODUCTION

Although the ages of late-Eocene, ignimbrite flare-up-related magmatism have been well documented in south-central New Mexico (e.g., Zimmerer and McIntosh, 2013; Verplanck et al., 1999; Ramos et al., this volume), little is known about the specific ages of middle- to late-Eocene volcanism and volcaniclastic sedimentation that occurred just prior to this time period. Tectonically, the period encompasses the transition between Laramide orogenesis and the onset of late Eocene/early Oligocene bimodal volcanism (prior to initiation of Rio Grande rifting in this region at ~36 Ma) and is reflected in the volcanic and volcaniclastic rocks of the Palm Park Formation.

The Palm Park Formation in south-central New Mexico is composed of an agglomeration of lithologically variable volcanic rocks and volcanoclastic sedimentary rocks, mostly andesitic or dacitic in composition, that are scattered throughout the region. Although lavas within regional stratigraphic sections are local in nature, accompanying ash-fall deposits likely originate from more distal volcanic sources. Overall, these rocks are primarily andesites or dacites and are difficult to stratigraphically correlate across localities.

The oldest exposed section of the Palm Park Formation is marked by a light-colored ash-fall tuff (PALMP(RB/AC)-02) in the Robledo Mountains (Seager et al., 2008) that yields a weighted-mean zircon age of 45.0±0.8 Ma (Creitz et al., this volume). This ash-fall tuff is present in Palm Park strata but may originate from a more distal source and not reflect the same local magmatic sources as most Palm Park Formation volcanic rocks (Ramos et al., this volume). Similarly, the youngest section of the Palm Park Formation is defined by an ash fall tuff (PALMP(SU/BT)-01) in the uppermost Palm Park Formation in the Sierra de las Uvas Mountains that yields a weighted-mean zircon age of 39.6±0.5 Ma (Creitz et al., this volume). This tuff may also originate from a distal magmatic source (Ramos et al., this volume). Intervening strata are, however, related to Palm Park Formation volcanic sources that are local in nature (Ramos et al., this volume).

Here, ^{40}Ar/^{39}Ar ages are determined for a range of Palm Park lithologies that include ash-fall tuffs and andesitic and dacitic lavas exposed in the Doña Ana Mountains, Robledo Mountains, and Sierra de las Uvas Mountains (Fig. 1). These ^{40}Ar/^{39}Ar ages are compared to the zircon ages of Creitz et al. (this volume) that were obtained from the same or similar rocks. In general, Palm Park Formation rocks can be difficult to date because they are commonly altered and thus new ages determined here will ultimately provide a critical temporal foundation in which to correlate and understand the origins of highly disparate and poorly understood exposures of Palm Park Formation rocks scattered throughout south-central New Mexico (e.g., in the Organ, Caballo, Potrillo, and southern San Andres Mountains).

METHODS

Whole rock samples were collected from eight individual sites (Fig. 1, Table 1) encompassing four regional Palm Park exposures including those in the Sierra de las Uvas (Bell Top Mountain), Robledo (Apache and Faulkner Canyons), Doña Ana (Cleofas Canyon), and Organ Mountains (Fillmore Canyon). Two additional samples, one from the basal portion and one from the upper portion of the Palm Park Formation in Cleofas Canyon in the Dona Ana Mountains, collected by Ramos et al. (this volume), will also be discussed. Whole rocks were crushed and sieved to obtain the largest grains available (typically >50 to <300 um). Individual plagioclase feldspars and biotite (from a single dacite from Cleofas Canyon) were hand picked from sieve fractions. Plagioclase crystals were etched in 10% hydrofluoric acid for 5-20 minute intervals, rinsed in distilled water, and sonicated to obtain crystals free of adhering materials. Plagioclases chosen for single crystal analyses ranged from 0.1 to 3 mg. Biotite from the Cleofas Canyon dacite was gently cleaned in water.

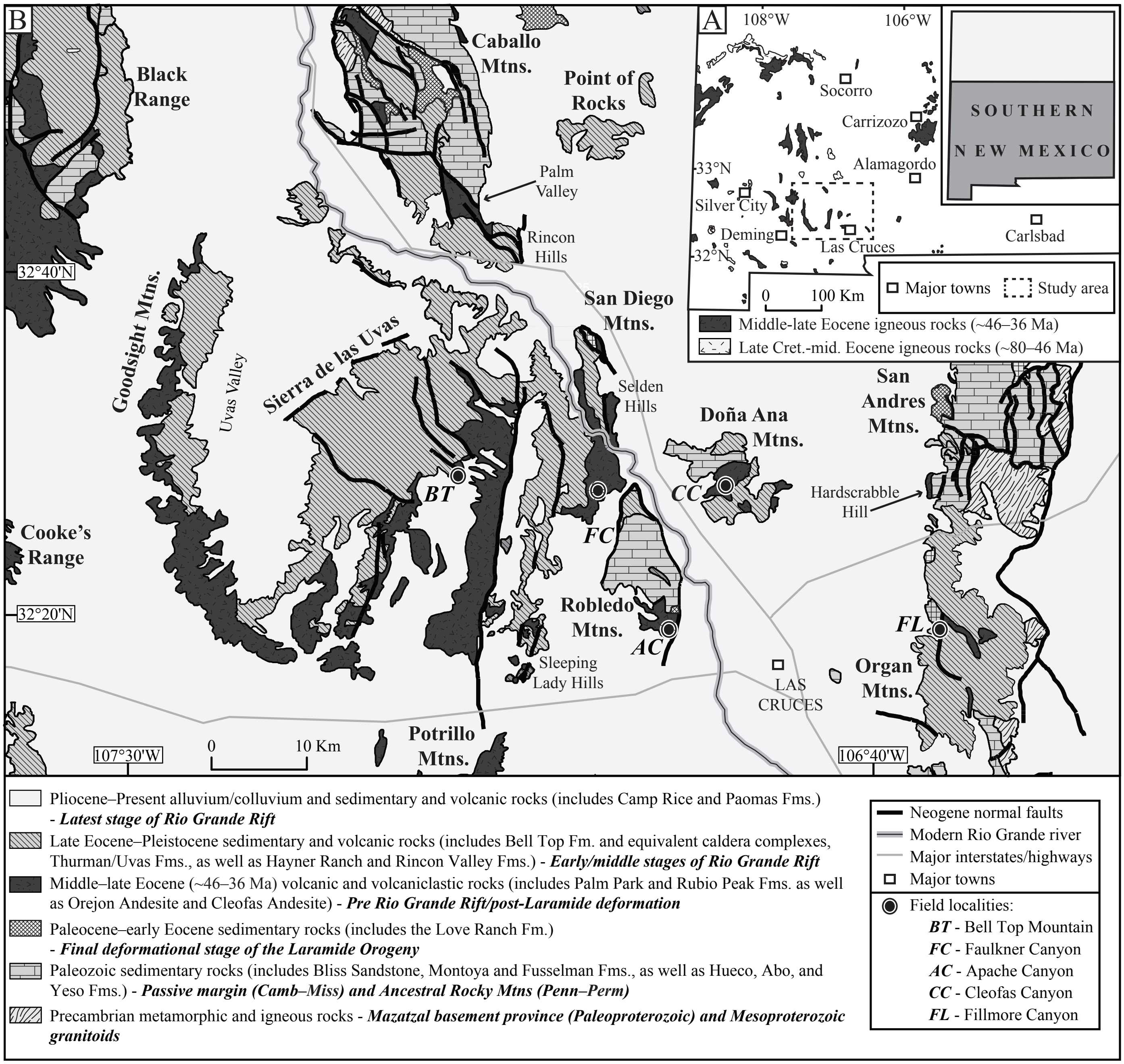

FIGURE 1. Regional map of south-central New Mexico showing sample locations of whole rocks collected for this study. Palm Park Formation air-fall tuffs were collected from Apache Canyon (Robledo Mountains) and Bell Top Mountain (Sierras de las Uvas Mountains). Andesitic and/or dacitic lavas were collected from Cleofas Canyon (Doña Ana Mountains) and Faulkner Canyon (Robledo Mountains). Location map modified from Creitz et al. (this volume).

TABLE 1. Table showing formations, localities, sample identifiers, ages, and coordinate locations.

Formation	Palm Park	Palm Park	Palm Park	Palm Park	Palm Park	Palm Park
Locations	Robledo Mtns.	Dona Ana Mtns.	Dona Ana Mtns.	Robledo Mtn.	Robledo Mtn.	Sierra de Las Uvas Mtns.
	Apache Canyon	Cleofas Canyon	Cleofas Canyon	Faulkner Canyon	Faulkner Canyon	Bell Top Mtn.
Sample ID	PALMP (RB/AC)-02	DAA	DAD	PALMP (RB/FC)-01	PALMP (RB/FC)-08	PALMP (SU/BT)-01
Age	45.22±0.03 Ma	43.1±0.2 Ma	43.1±0.2 Ma	42.08±0.06 Ma	42.3±0.06 Ma	39.4±0.3 Ma
Latitude	32.348	32.462	32.457	32.460	32.478	32.486
Longitude	-106.881	-106.839	-106.853	-106.971	-106.948	-107.120

Plagioclase and biotite separates were loaded into machined Al discs and irradiated in two packages (NM-288, NM-293) for 8 hours at the USGS TRIGA Reactor in Denver (CO). Fish Canyon Tuff sanidine (FC-2) was used as a flux monitor and assigned an age of 28.201 Ma (Kuiper et al., 2008). The ^{40}K total decay constant of 5.463e^{-10}/a was used (Min et al., 2000). Argon isotopes for the plagioclases were measured using a ThermoScientific ARGUS VI mass spectrometer (Jan) while the biotite was analyzed using a Helix MC plus mass spectrometer (Felix). The multi-collector configuration used for the ARGUS VI analyses was: ^{40}Ar-H1, ^{39}Ar-Ax, ^{38}Ar-L1, ^{37}Ar-L2, and ^{36}Ar-L3. Amplifiers used for H1, AX, and L2 Faradays were 1e^{13} Ohm, the L1 Faraday was 1e^{14} Ohm, and L3 used a CDD ion counter with a deadtime of 14ns. For the Helix, the configuration was ^{40}Ar-H2, ^{39}Ar-H1, ^{38}Ar-AX, ^{37}Ar-L1, and ^{36}Ar-L2. Amplifiers used for H2, H1, AX, L1 Faradays were 1e^{12} Ohm, L2 used a CDD ion counter with a deadtime of 20ns. Feldspars were step-heated or fused for 30-40 seconds using a 75W Photon Machines CO_2 laser whereas the biotite was heated with a 50W Photon Machines diode laser (see appendix). Reactive gases were removed with various combinations of SAES NP-10, GP-50 and D50 getters. Mass spectrometer sensitivity for the ARGUS VI is 8e^{-17} mol/fA and for the Helix 4e^{-16} mol/fA. Typical total system blank and backgrounds were 5±20%, 0.2±10%, 0.05±12%, 0.25±5%, and 0.04±10%, x 10^{-17} moles for masses 40, 39, 38, 37, and 36, respectively for the ARGUS VI runs and 20±2%, 0.4±100%, 0.6±60%, 0.5±75%, and 0.08±5%, x 10^{-17} moles for masses 40, 39, 38, 37, and 36, respectively for the Helix runs. Correction factors for interfering reactions were determined by analysis of K-glass and CaF_2. J-factors were determined to precisions of ~±0.02% and used CO_2 laser fusions of at least 6-crystals from multiple radial positions around irradiation trays. All ages are reported at 2σ analytical uncertainty and do not include errors associated with the flux monitor standard or decay constant.

RESULTS

Seventy-six individual plagioclase crystals from 4 samples along with one biotite separate from an additional sample were dated using $^{40}Ar/^{39}Ar$ geochronology (Table 2). Plagioclase and biotite crystals originated from a range of lithologies collected from the lower, middle, and uppermost (Table 1) parts of regional Palm Park Formation exposures in south-central New Mexico (Figs. 1 and 2). An additional sixteen plagioclase crystals from a Palm Park andesitic lava flow in Cleofas Canyon were dated by Ramos and Heizler (this volume) and are included in this study as well. Most $^{40}Ar/^{39}Ar$ ages determined here are compared to the zircon ages of Creitz et al. (this volume). The age comparison is evaluated at 2σ precision and does not factor in uncertainties related to decay constants for either method or for the age of the Fish Canyon sanidine standard used to determine $^{40}Ar/^{39}Ar$ ages.

Although samples were collected from four regional Palm Park Formation exposures, only three yielded plagioclases or biotite that could be dated as many samples are too altered. All plagioclase from the Palm Park Formation in Fillmore Canyon in the Organ Mountains and plagioclase from two of four samples in Cleofas Canyon in the Doña Ana Mountains were too degraded to yield accurate ages. We thus focus on mineral ages originating from the remaining samples from the Doña Ana, Robledo, and Sierra de las Uvas Mountains (i.e., excluding the Organs Mountains) and discuss resulting ages in an older to younger context as determined by zircon age analyses (Creitz et al., this volume).

In general, plagioclase $^{40}Ar/^{39}Ar$ ages are summarized and shown in comparison with zircon ages from the same samples for the different Palm Park Formation exposures. For context (and further addressed in the Discussion), plagioclase dates have significant scatter for individual samples with maximum and minimum values spanning ~1 to 5 Ma. The primary cause for scattering to older ages likely results from inherited grains. Thus, we typically regard the youngest distribution of ages as the most accurate in the results described below.

Apache Canyon, Robledo Mountains

Seventeen single plagioclase crystals from PALMP(RM/AC)-02 were analyzed from an ash-fall tuff located in the basal portion of the Palm Park Formation in Apache Canyon. One crystal was analyzed in 3 steps, whereas the rest were fused in a single step. Dates range from ~43.2 to 44.5 Ma (Fig. 3e), with the 5 youngest analyses yielding a somewhat scattered distribution and weighted-mean age of 43.52±0.18 Ma. This age is somewhat younger than the full zircon distribution that has a weighted-mean age of 45.0±0.8 Ma.

Cleofas Canyon, Doña Ana Mountains

Sixteen, single to 3 crystal aliquots of plagioclase from a lava flow in the lower portion of the Palm Park Formation in Cleofas Canyon (sample DAA) were step-heated in 3 increments (Fig. 3d and Ramos and Heizler, this volume). Thirteen aliquots yielded flat age spectra with plateau ages between ~41.6 and 46.9 Ma with 10 yielding a normal distribution and weighted mean age of 43.05±0.28 Ma. An attempt to date sanidines from a dacitic lava (DAD) in the upper portion of the Palm Park Formation in Cleofas Canyon (i.e., to the west) was unsuccessful because the crystals were too altered, but biotite from this dacite (sample DAD) yields an age spectrum with climbing ages over the first ~25% of ^{39}Ar released (first 7 steps) and a flat part for the remaining 75% (last three steps) of the spectrum with a plateau age of 43.35±0.05 Ma (Fig. 4). This dacite lies stratigraphically above the two samples dated by Creitz et al. (this volume) that yielded zircon ages of 41.3±0.7 and 41.6±0.7 Ma (PALMP(DA/CC)-01 and PALMP(DA/CC)-05), respectively.

Faulkner Canyon, Robledo Mountains

Twenty-two single plagioclase crystals from a Palm Park Formation lava flow in the lower portion of Faulkner Canyon in the Robledo Mountains were either fused in one step (n=11) or step-heated (n=11) using 2 or 3 steps (PALMP(RB/FC)-08).

TABLE 2. $^{40}Ar/^{39}Ar$ results of plagioclase.

Run ID	Method	Age	Error (1s)
PALMP(SU/BT)-01 Plagioclase			
66088-11	TF	38.80	0.26
66088-13	Plateau	39.29	0.42
66088-02	TF	39.93	0.29
66088-12	Plateau	40.29	0.60
66088-04	TF	40.60	0.31
66088-10	TF	41.06	0.26
66088-09	TF	41.72	0.35
66088-08	TF	42.08	0.17
66088-07	TF	42.38	0.17
66088-14	Plateau	42.45	0.84
66088-01	Plateau	42.80	0.40
66088-03	TF	46.42	0.17
66088-06	TF	52.44	0.28
66088-06	TF	191.30	0.32
Weighted mean erupiton age (2s)		**39.67±0.71 Ma**	MSWD = 5.72

Run ID	Method	Age	Error (1s)
DAA Plagioclase			
65470-17	Plateau	41.63	0.45
65470-11	Plateau	42.47	0.37
65470-13	Plateau	42.61	0.49
65470-15	Plateau	42.64	0.22
65470-12	Plateau	43.01	0.30
65470-08	Plateau	43.12	0.23
65470-09	Plateau	43.19	0.29
65470-05	Plateau	43.22	0.28
65470-19	Plateau	43.34	0.80
65470-18	Plateau	43.66	0.54
65470-07	Plateau	44.32	0.43
65470-01	Plateau	45.00	0.45
65470-14	Plateau	46.85	0.30
65470-04	TGA	103.96	0.29
65470-16	TGA	186.0	1.0
65470-10	TGA	1324	47
Weighted mean erupiton age (2s)		**43.05±0.28 Ma**	MSWD = 1.95

Run ID	Method	Age	Error (1s)
PALMP(RB/FC)-08 Plagioclase			
66094-21	Plateau	41.41	0.84
66094-04	TF	41.90	0.18
66094-16	Plateau	42.00	0.66
66094-20	Plateau	42.07	0.19
66094-17	Plateau	42.11	0.64
66094-07	TF	42.16	0.10
66094-23	Plateau	42.19	0.21
66094-09	TF	42.20	0.18
66094-18	Plateau	42.23	0.14
66094-11	TF	42.28	0.11
66094-15	Step-B	42.30	0.12
66094-22	Plateau	42.41	0.22
66094-01	Plateau	42.57	0.08
66094-14	Plateau	42.59	0.17
66094-10	TF	42.600	0.059
66094-02	TF	42.80	0.16
66094-08	TF	42.938	0.069
66094-19	Step-B	43.61	0.34
66094-12	TF	43.69	0.14
66094-03	TF	43.827	0.096
66094-13	TF	44.82	0.13
66094-06	TF	46.790	0.098
66094-05	TF	628.700	0.430
Weighted mean erupiton age (2s)		**42.30±0.11 Ma**	MSWD = 1.86

Notes:

Run id = lab sample identifier
Tf = total fusion analysis
Tga = total gas age from age spectrum analysis
Plateau = plateau age determined from age spectrum analysis
Step-b or step-c = single step from age spectrum analysis
Data shown within box are used to determine weghted mean eruption age
Mswd = mean squared weighted deviates
Weighed mean age based on inverser varience
Error multipled by squareroot mswd for mswd >1.

Run ID	Method	Age	Error (1s)
PALMP(RB/FC)-01 Plagioclase			
66090-13	Step-B	41.837	0.095
66090-20	Plateau	42.02	0.23
66090-07	TF	42.06	0.12
66090-21	Plateau	42.06	0.18
66090-11	TF	42.123	0.080
66090-06	TF	42.162	0.091
66090-19	Plateau	42.36	0.23
66090-01	Plateau	42.42	0.22
66090-12	Step-B	42.91	0.16
66090-09	TF	43.31	0.15
66090-17	Step-B	43.34	0.19
66090-16	Step-B	44.31	0.20
66090-04	TF	44.601	0.096
66090-02	TF	44.758	0.090
66090-03	TF	44.88	0.36
66090-08	TF	45.01	0.10
66090-15	Step-B	45.44	0.19
66090-14	Step-C	48.13	0.21
66090-10	TF	49.55	0.10
Weighted mean erupiton age (2s)		**42.08±0.11 Ma**	MSWD = 1.66

Run ID	Method	Age	Error (1s)
PALMP(RB-AC)-02 Plagioclase			
66091-14	TF	43.251	0.056
66091-07	TF	43.472	0.050
66091-06	TF	43.662	0.081
66091-03	TF	43.688	0.053
66091-02	TF	43.710	0.079
66091-15	TF	43.814	0.064
66091-08	TF	43.939	0.084
66091-12	TF	43.990	0.065
66091-05	TF	44.150	0.055
66091-11	TF	44.158	0.040
66091-09	TF	44.178	0.047
66091-16	TF	44.214	0.092
66091-17	TF	44.230	0.040
66091-10	TF	44.317	0.077
66091-13	TF	44.353	0.059
66091-01	Plateau	44.46	0.12
66091-04	TF	44.523	0.008
Weighted mean erupiton age (2s)		**43.52±0.18 Ma**	MSWD = 10.7

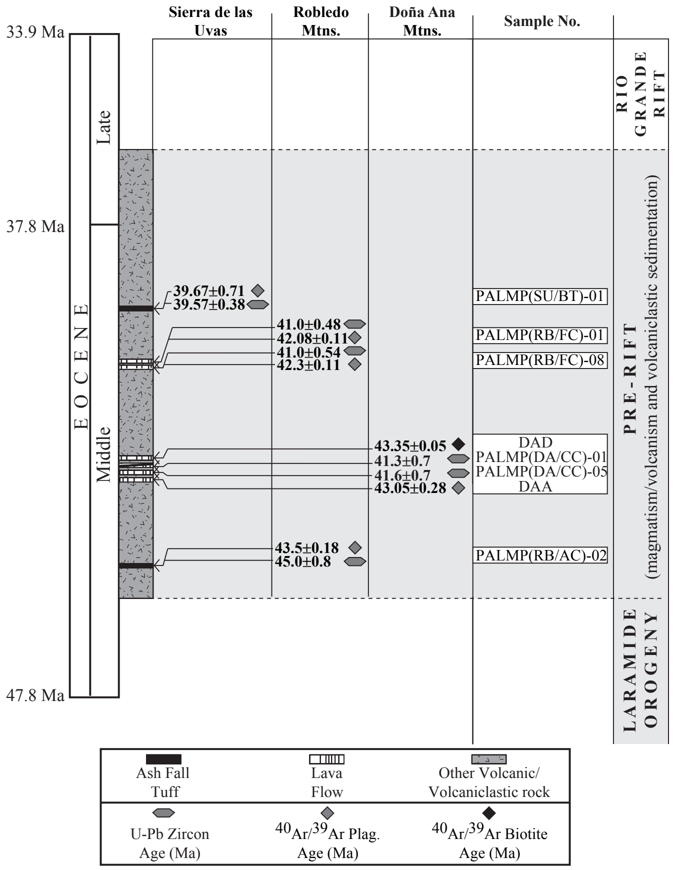

FIGURE 2. Composite stratigraphic column of the Palm Park Formation showing ^{40}Ar/^{39}Ar and zircon ages with sample identifiers and the mountain ranges from where the samples originate.

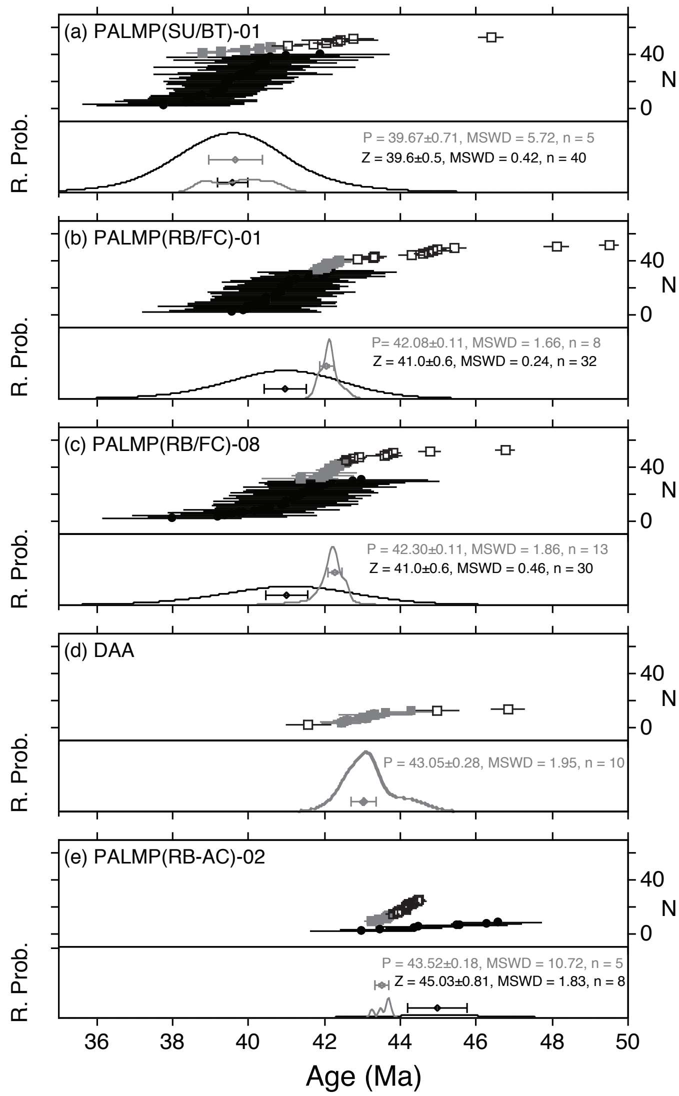

FIGURE 3. Comparison of plagioclase (P) and zircon (Z) results from the Palm Park Formation from: **A**) an ash-fall tuff from the Sierra de las Uvas Mountains, **B-C**) two lavas from Faulkner Canyon in the Robledo Mountains, **D**) a lava from the base of the section in Cleofas Canyon, and **E**) an ash-fall tuff at the base of the Palm Park Formation in Apache Canyon in the Robledo Mountains. There is general agreement between plagioclase and zircon weighted-mean ages, however individual dates of plagioclase are slightly older than zircon dates. Weighted-mean plagioclase ages represent best estimates for time of eruption with the error reported at 2σ. Data shown with unfilled symbols are not used for weighted-mean calculations and are interpreted to be xenocrystic in nature.

The spectra are generally flat and yield plateau ages ranging between ~41.4 and 42.6 Ma and have variable precisions between 0.08 and 0.8 Ma (Table 2). Total fusion ages are similar to plateau ages with one grain yielding a date of >600 Ma. Eight total-fusion analyses yield ages that range from ~42.5 to 47 Ma. Combining some plateau and total fusion ages, thirteen analyses yield a normal distribution and weighted-mean age of 42.30±0.11 Ma (Fig. 3c). This date is older, at 2σ analytical precision, than the weighed-mean zircon age of 41.0±0.6 Ma.

Nineteen single plagioclase crystals from a second Palm Park Formation lava flow in the upper portion of Faulkner Canyon were either fused in one step (n=9) or step-heated (n=10) using 2 or 3 steps (PALMP(RB/FC)-01). The spectra are quite variable in shape and age with 3 grains yielding flat spectra and ages between ~42.0 and 42.4 Ma while others have either increasing or decreasing ages across their spectra (Table 2). Some steps are >50 Ma while others are as young as ~40 Ma. Total fusion dates have two main modes at ~42.1 and ~44.8 Ma with one grain at ~43.5 and another at ~49.5 Ma. The 8 youngest dates, which are a combination of plateau and fusion ages, yield a weighted-mean age of 42.08±0.11 Ma (Fig. 3b). This age overlaps (at 2σ) the zircon weighed-mean age of 41.0±0.6 Ma. However, individual plagioclase dates are consistently older than individual zircon dates, which is common for most samples in this study (Fig. 3).

Bell Top Mountain, Sierra de las Uvas Mountains

Fourteen single plagioclase crystals from an ash-fall deposit in the Sierra de las Uvas Mountains were analyzed. Four were step-heated and 10 were fused in a single step (PALMP(SU/BT)-01). Spectra are flat with plateau ages between 39.3±0.4 and 42.8±0.4 Ma. Fusion ages range from ~39 to 180 Ma with the majority of dates between ~40 and 42 Ma. The five youngest plateau and fusion dates yield a slightly scattered distribution and weighted-mean age of 39.67±0.71 Ma (Fig. 3a), which is indistinguishable from a zircon age of 39.6±0.5 Ma. Concordance of these ages suggest that the top of the Palm Park Formation is ~39.6 Ma.

DISCUSSION

$^{40}Ar/^{39}Ar$ Plagioclase Ages

The $^{40}Ar/^{39}Ar$ data are somewhat complex and do not by themselves yield unambiguous ages. In general, where analyses were conducted on single crystals, spectra are commonly flat and indicate that argon loss is not a major factor contributing to the scatter of ages for individual samples. Also, many single plagioclase crystals yield dates much older than individual zircons from the same samples, which appears to indicate that these older plagioclases are inherited grains either incorporated at the volcanic source or during post-eruption reworking. Thus, we take the youngest distribution of plagioclase grains as yielding the most accurate eruption ages.

As shown in Figure 3, both the zircon data and the plagioclase data yield interpreted ages that follow stratigraphic order. Individual plagioclase dates are substantially more precise than zircon dates, and thus, have the potential to provide a more discriminatory choice of which dates to combine into a weighted-mean eruption age. However, zircon is likely less susceptible to open-system effects (i.e., Pb-loss) than plagioclase is to argon loss. As a result and despite the poor precision of the zircon ages, their weighted-mean ages could be more accurate. A concern for low precision zircon data, however, is that such low-precision ages could conceal systematic errors that can potentially shift the mean age in either direction depending on the accuracy of various corrections (i.e., initial Pb), which in turn can yield discordance between zircon and plagioclase ages. Additionally, zircon ages can be marginally older than plagioclase ages because U/Pb systematics record the age of zircon crystallization whereas the argon system in plagioclase records eruption due to rapid cooling from magmatic conditions to surface temperatures. Thus, if there is significant zircon crystal residence in the magma prior to eruption, the two systems can yield slightly disparate ages.

Apache Canyon, Robledo Mountains

The two separate exposures of Palm Park Formation rocks in Apache and Faulkner Canyons of the Robledo Mountains (Fig. 2) have disparate $^{40}Ar/^{39}Ar$ and zircon ages (Figs. 3b, 3c, and 3e). The ash-fall tuff (PALMP(RM/AC)-02) located at the base of the Palm Park Formation in Apache Canyon, which Ramos et al. (this volume) suggest originated from a distal volcanic source, has a $^{40}Ar/^{39}Ar$ plagioclase age of 43.52±0.18 Ma (Fig. 3e). This age is more precise and just slightly more than 2σ younger than associated zircons that have an age of 45.0±0.8 Ma. This relationship likely results from zircon crystallization occurring slightly earlier than eruption. Both ages, however, confirm the age of the basal portion of the Palm Park Formation in exposures from across south-central New Mexico (Seager et al., 2008).

Cleofas Canyon, Doña Ana Mountains

Plagioclase (43.05±0.28 Ma) and zircon ages (41.3±0.7 and 41.6±0.7 Ma; Creitz et al., this volume) of Cleofas Canyon lavas at the base and middle of the Palm Park Formation in the Doña Ana Mountains (Fig. 2) suggest that Palm Park rocks in Cleofas Canyon likely belong to the middle to lower part of the formation. Although present in various localities throughout south-central New Mexico, the Palm Park Formation in the Doña Ana Mountains is commonly highly altered and composed of both dacitic and andesitic lava flows. Plagioclase crystals were obtained from fresh andesite associated with a lava flow in the upper reaches of Cleofas Canyon but attempts to obtain fresh feldspars from additional outcrops of andesite in which zircons were obtained were unsuccessful, which reflects the highly and variably altered nature of Palm Park lavas in the Doña Ana Mountains.

In regards to rocks up-section in Cleofas Canyon, the dacite that hosts the biotite has a plateau age (43.35±0.05 Ma, Fig. 4) that appears robust, but is too old based on the underlying DAA plagioclase and zircon ages. Thus, we find its accuracy questionable. We suspect that this altered biotite is contaminated by excess argon (cf. Hora et al., 2010) and/or has experienced ^{39}Ar recoil ejection during irradiation causing the sample to yield an inaccurately old age. As such, we give little credence to this age and exclude it from further discussions.

Faulkner Canyon, Robledo Mountains

Plagioclase analyses from andesitic lavas from the Palm Park Formation in Faulkner Canyon in the Robledo Mountains yield a range of ages from 46 to 41.3 Ma (Figs. 3b

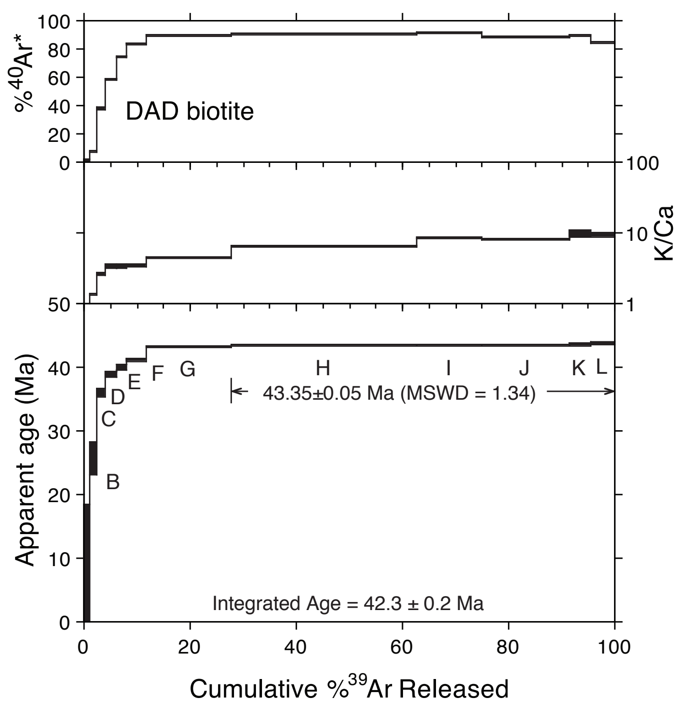

FIGURE 4. Age, K/Ca and radiogenic yield diagrams for DAD biotite. The generally low K/Ca values and climbing age spectrum pattern indicate that the sample is altered as confirmed by the presence of chlorite in the sample. The plateau age is older than the stratigraphically underlying zircon ages and thus the biotite age is interpreted to be inaccurate and likely affected by excess argon or ^{39}Ar recoil.

and 3c). Eight crystals from the stratigraphically higher unit (PALMP(RB/FC)-01) yield a normal distribution and weighted-mean age of 42.08±0.11 Ma with the youngest single age being 41.3±0.4 Ma. The weighted-mean plagioclase age is older than the younger zircon age of 41.0±0.6 Ma from the same rock. The stratigraphically lower sample (PALMP(RB/FC)-08) has a youngest population of plagioclase crystals with a weighted-mean age of 42.3±0.11 Ma that at 2σ, is analytically indistinguishable to PALMP(RB/FC)-01. Like above, this age is slightly discordant compared to the zircon age of 41.0±0.6 Ma.

Bell Top Mountain, Sierra de las Uvas Mountains

Plagioclase crystals from an ash-fall deposit in the Sierra de las Uvas Mountains, which Ramos et al. (this volume) suggest originates from a distal magmatic source, yields a zircon weighted-mean age of 39.6±0.5 Ma and a plagioclase age of 39.7±0.7 Ma (Fig. 3a). These ages confirm that these rocks represent some of the youngest parts of the Palm Park Formation in south-central New Mexico.

Palm Park Formation Regional Characteristics

Overall, $^{40}Ar/^{39}Ar$ ages are similar to the ages of zircons in most Palm Park volcanic rocks in south-central New Mexico and confirm the ages of the top and bottom of the Palm Park Formation stratigraphic sequence (Fig. 2). These ages confirm independent assessments of earlier and later formed Palm Park Formation lithologies (e.g., Seager et al., 2008). Minor discrepancies between feldspar and zircon ages, however, may indicate the likely additional presence of plagioclase xenocrysts, although most ages overlap at the 2σ level, where some crystals may not have fully degased when entrained into Palm Park Formation lavas.

CONCLUSIONS

Volcanic rocks of the Palm Park Formation, exposed in the Doña Ana Mountains, Robledo Mountains, and Sierra de las Uvas Mountains, result from volcanic activity occurring between ~44 to 39 Ma. These rocks are mainly composed of locally-derived andesitic and dacitic rocks erupted at the time when magmatism associated with Laramide orogenesis transitioned to magmatism associated with the ignimbrite flare-up in south-central New Mexico. $^{40}Ar/^{39}Ar$ ages mostly overlap zircon ages at 2σ, and confirm that plagioclase can yield accurate ages despite Palm Park Formation rocks being generally altered. This is important because $^{40}Ar/^{39}Ar$ geochronology can play a pivotal role when trying to correlate Palm Park Formation lavas and ash-fall tuffs that occur in regionally discrete units in multiple mountain ranges. In general, dates determined here are the first to constrain the ages of Palm Park Formation lithologies at moderately high precision and mark a critical step forward to understanding the origins, stratigraphic relationships, and potential correlative units of Palm Park Formation rocks found across south-central New Mexico that originate in a period of time that remains geologically poorly understood.

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Supplemental data can be found at http://nmgs.nmt.edu/repository/index.cfml?rid=2018005

Sunrise over the Organ Mountains. Photograph by Peter A. Scholle.