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Universidad Nacional Autónoma de México, Instituto de Geología, México, D.F.

EOCENE $^{40}Ar/^{39}Ar$ AGE DATA OF SUPPOSED CRETACEOUS VOLCANICS (RHYOLITE TUFF FORMATION) IN NORTHEASTERN SONORA, MEXICO

Spencer G. Lucas[1], William C. McIntosh[2] and Carlos Manuel González-León[3]

ABSTRACT

Single-crystal laser-fusion $^{40}Ar/^{39}Ar$ techniques were used to determine the eruptive age of a rhyolitic tuff that immediately overlies the Upper Cretaceous Cabullona Group in northeastern Sonora, Mexico. Analyses of eight individual sanidine phenocrysts agree closely and yield a mean age of 34.58 ± 0.04 Ma. The rhyolite tuff erupted in latest Eocene time, and is not a product of Late Cretaceous volcanism as previously interpreted.

Key words: Isotopic geochemistry, volcanism, $^{40}Ar/^{39}Ar$ dating, Sonora, Mexico.

RESUMEN

Se utilizó el método 40Ar/39Ar de fusión por láser en cristal sencillo para determinar la edad de erupción de una toba riolítica que yace inmediatamente sobre el Grupo Cabullona, del Cretácico Superior en Sonora nororiental, México. Los análisis de ocho cristales individuales de sanidino concuerdan cercanamente y proporcionan una edad media de 34.58 ± 0.04 Ma. La erupción de la toba riolítica tuvo lugar en el Eoceno más tardío y no es un producto del vulcanismo del Cretácico Tardío, como se había interpretado previamente.

Palabras clave: Geoquímica isotópica, vulcanismo, método $^{40}Ar/^{39}Ar$, Sonora, México.

INTRODUCTION

Taliaferro (1933) introduced the name Cabullona Group for sedimentary and volcanic rocks in northeastern Sonora of presumed Late Cretaceous age. He divided the Cabullona Group into five lithostratigraphic units (ascending order): Snake Ridge Formation, Camas Sandstone, Packard Shale, Upper Red Beds and Rhyolite Tuff (Figure 1). Recent fossil collecting in the lower four sedimentary units of Taliaferro's Cabullona Group has confirmed their age as Late Cretaceous, Santonian-early Maastrichtian (Lucas and González-León, 1990; González-León, 1994; Lucas *et al.,* 1995). These units also have been redefined lithostratigraphically (Figure 1) by González-León (1994).

For lithostratigraphic reasons, Taliaferro's uppermost Cabullona Group unit—Rhyolite Tuff—has been removed from the Cabullona Group, although it is still considered as a valid formation; this volcanic unit does not lithologically resemble underlying siliciclastic non-marine sediments, which it unconformably overlies (Lucas and González-León, 1990; González-León, 1994). However, the age of the Rhyolite Tuff formation has been uncertain. It has generally been regarded as Late Cretaceous, a correlative of the Salero and Hidalgo formations of southeastern Arizona-southwestern New Mexico, volcanic units with established Late Cretaceous isotopic ages that overlie correlatives of the Cabullona Group sedimentary units (Lucas and González-León, 1990). Here, an isotopic age obtained by the $^{40}Ar/^{39}Ar$ technique of a sample collected from the base of the Rhyolite Tuff is reported, in order to contribute to clarify the age of that unit.

SAMPLING LOCALITY

The contact between the Rhyolite Tuff unit and underlying Lomas Coloradas Formation is well exposed along tributaries of Arroyo El Peñascal, northwest of the abandoned Rancho Santa Bárbara (Figure 2). Here, the Lomas Coloradas Formation consists of siliciclastic red beds with dinosaur fossils of late Campanian-Maastrichtian age, 90 to 216 m below the base of the overlying Rhyolite Tuff (Figure 3). Beds of the Lomas Coloradas Formation (Figure 1) dip 17° to N63°W.

The lowest beds of the Rhyolite Tuff unit are thin, white, laminated layers of biotite, sanidine and quartz-rich tuff that dip 25° to N10°W. The tuff thus overlies the Lomas Coloradas Formation with an angular unconformity. The sample for dating was taken from the stratigraphically lowest tuff bed, at UTM coordinates 3'445,860N and 606,670E, and zone 12 given by a GPS positioner (Figures 2 and 3).

$^{40}Ar/^{39}Ar$ AGE

A sanidine separate was prepared from a 2-kg sample of rhyolite tuff by crushing, sieving to 400-800 μm, ultrasonically cleaning with dilute (7%) hydrofluoric acid, then applying magnetic and density-liquid techniques, followed by hand picking. A 30-mg aliquot of sanidine phenocrysts was pack-

[1] *New Mexico Museum of Natural History and Science, 1801 Mountain Road N.W., Albuquerque, New Mexico 87104, U.S.A.*
[2] *New Mexico Bureau of Mines and Mineral Resources, Socorro, New Mexico 87801, U.S.A.*
[3] *Estación Regional del Noroeste, Instituto de Geología, Universidad Nacional Autónoma de México, Apartado Postal 1039, Hermosillo, Sonora 83000, México.*

Taliaferro (1933)			González-León (1994)	
Upper Cretaceous	Cabullona Group	Rhyolite tuff		
		Upper red beds	Lomas Coloradas Formation	Cabullona Group
		Packard shale	Packard shale	
		Camas sandstone	Camas sandstone	
		Snake ridge	Corral de Enmedio Formation	

El Cemento Conglomerate

Figure 1. Comparison between original nomenclature proposed for the Cabullona Group by Taliaferro (1933) and the modified nomenclature proposed by González-León (1994).

aged with alternating flux monitors of Fish Canyon Tuff sanidine (27.84 Ma, relative to Mmhb-1 hornblende at 520.4 Ma; Samson and Alexander, 1987) and irradiated in the L67 position of the Ford reactor at the University of Michigan.

$^{40}Ar/^{39}Ar$ analyses were performed at the New Mexico Geochronology Research Laboratory in the New Mexico Institute of Mining and Technology. This facility includes a MAP 215-50 mass spectrometer attached to a fully-automated, all-metal argon extraction system equipped with a 10-watt CO_2 laser. Sample and monitor grains were fused using the CO_2 laser at power levels of 1.6 watts for 15 seconds, then reactive gases were removed using a SAES GP-50 getter prior to expansion into the mass spectrometer.

Extraction line blanks during these analyses ranged from 5×10^{-17} to 2×10^{-16} moles ^{40}Ar and 5×10^{-19} to 2×10^{-18} moles ^{36}Ar. The neutron flux values (J-values) within irradiation packages were determined to a precision of ±0.25% by averaging results of four subsamples (each 14 crystals, approximately 1 mg) of each sanidine monitor.

Single-crystal laser fusion results from the eight individual sanidine phenocrysts from the rhyolite tuff range in age from 34.53 to 35.65 Ma, with 1σ analytical precision from ± 0.17 to 0.25%. Radiogenic yields were high (98.5 to 99.5%) for each grain, and K/Ca values ranged from 28 to 61.8 (Table 1, Figure 4). The mean age and 1σ error calculated for the population of eight grains is 34.58 ± 0.04 Ma; this value is considered to be a precise determination of the eruption age of the ignimbrite.

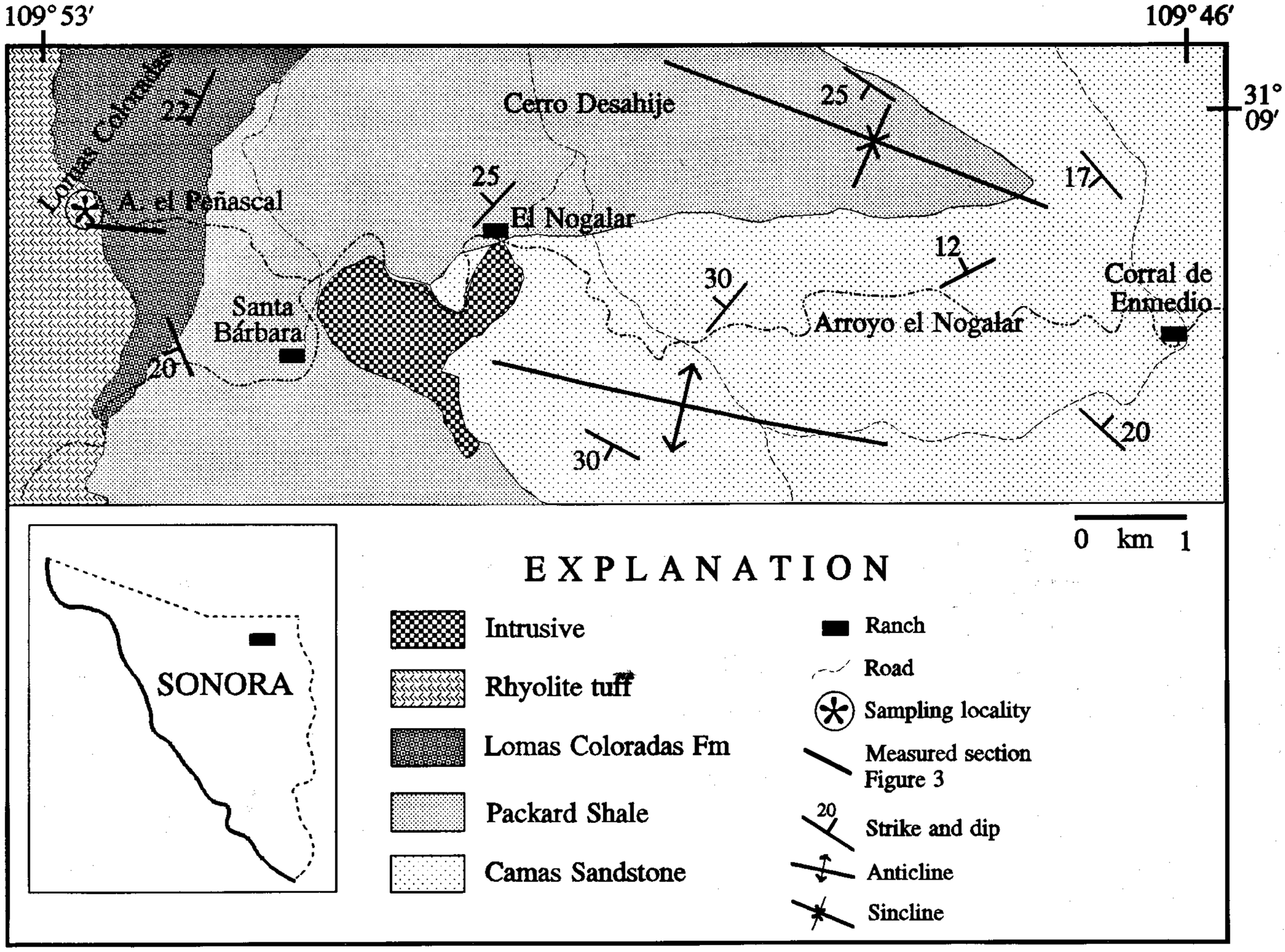

Figure 2. Geologic map of the central part of the Cabullona basin in northeastern Sonora, showing main features of the area, and location of measured stratigraphic section reported in Figure 3 (map modified from González-León, 1994).

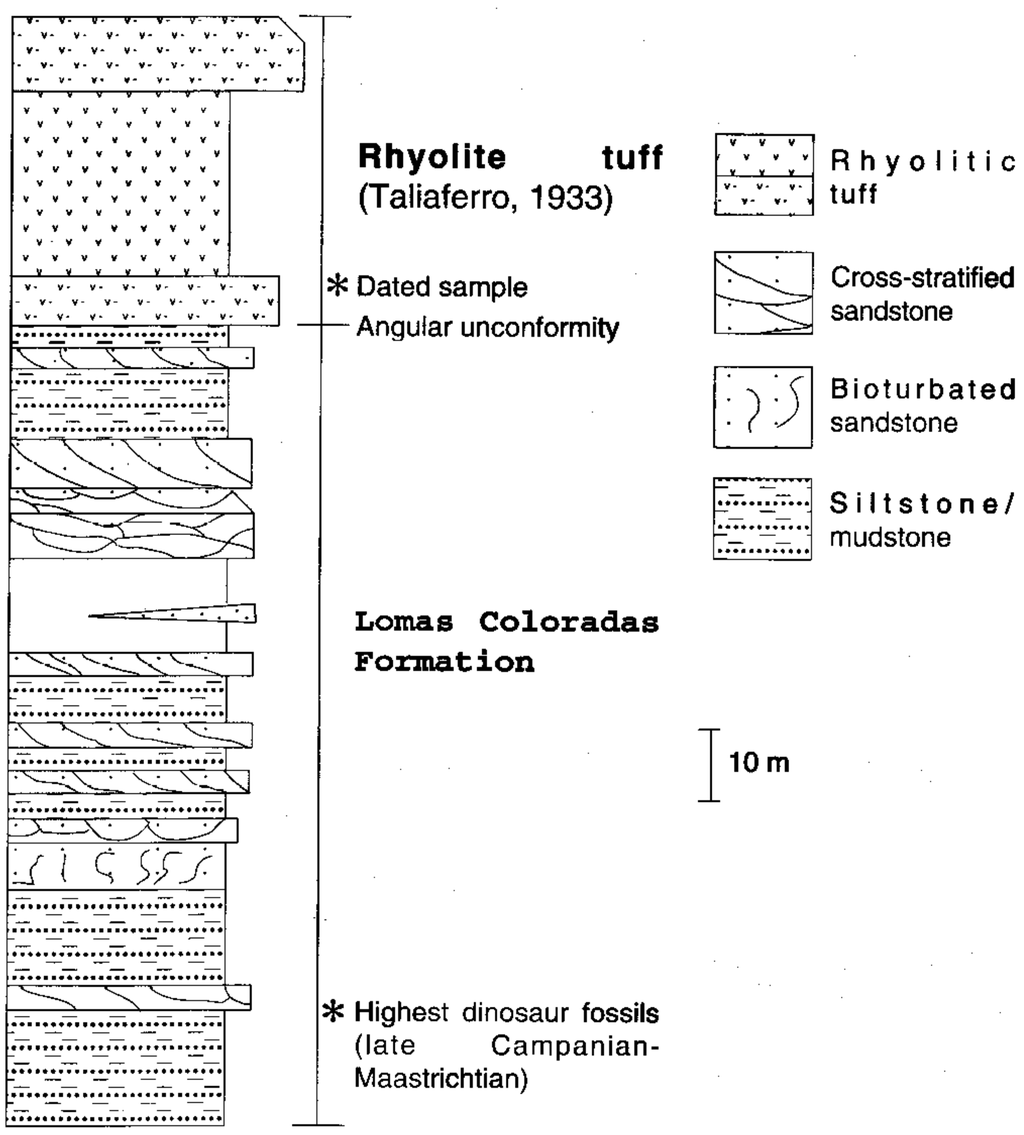

Figure 3. Measured stratigraphic section of upper part of the Lomas Coloradas Formation and lower part of the Rhyolite Tuff unit of Taliaferro (1933). Also indicated are the highest positions of latest Cretaceous dinosaur remains found and location of dated rhyolitic sample.

DISCUSSION

The mean age reported here of 34.58± 0.04 Ma indicates the base of the Rhyolite Tuff unit is latest Eocene in age, very close to the Eocene-Oligocene boundary (Berggren *et al.*, 1995). Previously, the Rhyolite Tuff unit above the Cabullona Group was considered to be of Late Cretaceous age. Taliaferro (1933) first suggested this age. In southeastern Arizona, the Salero Formation is andesite to dacite breccias, rhyodacite tuff and welded tuff as much as 1,400-m thick. The Salero Formation has yielded K-Ar ages in the range of 70-75 Ma (Bikerman and Damon, 1966; Hayes and Drewes, 1978; Marvin *et al.*, 1978) and overlies the Fort Crittenden Formation, strata that contain invertebrate and vertebrate fossils that support correlation with the Cabullona Group.

In southwestern New Mexico, the Hidalgo Formation consists of basaltic and andesitic flows, flow breccia and tuff of intermediate composition approximately 1,700-m thick (Zeller, 1970; Lawton *et al.*, 1993). Fission-track and K/Ar ages from the Hidalgo Formation (summarized by Lucas *et al.*, 1990) indicate an age range of 61–70 Ma, whereas Lawton and others (1993) reported an Ar/Ar age of 71.44 ± 0.19 Ma for the base of the Hidalgo Formation. The fission-track and K/Ar ages suggested much of the Hidalgo Formation is of Paleocene age, but the Ar/Ar age more closely correlates it to the Salero Formation.

The Salero and Hidalgo formations indicate regional Late Cretaceous volcanism, so correlation of the Rhyolite Tuff above the Cabullona Group with this volcanism was reasonable, although the rhyolitic composition would be unusual for Laramide volcanism. However, the new $^{40}Ar/^{39}Ar$ age indicates the rhyolite tuff actually is an extension of the mid-Tertiary ignimbrite sheets of felsic ash-flow tuffs characteristic of the Basin and Range of southwestern New Mexico and southeastern Arizona (*e. g.*, Deal *et al.*, 1978). Indeed, this high-precision $^{40}Ar/^{39}Ar$ age determination of 34.58 ± 0.04 Ma is similar to the age of early erupted ignimbrites in the Mogollon-Datil (McIntosh *et al.*, 1992) and Boot Heel (McIntosh *et al.*, 1991) volcanic fields of southwestern New Mexico.

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Table 1. Analytical results and Ar-isotopic data for eight sanidines from the Rhyolite Tuff formation, Cabullona basin, northeastern Sonora.

Run ID#	$^{40}Ar/^{39}Ar$	$^{37}Ar/^{39}Ar$	$^{36}Ar/^{39}Ar$	$^{39}Ar_k$ [moles]	K /Ca	^{40}Ar [%]	Age [Ma]	± Err[1]	SEM[2]
339-10	4.67	1.48E-02	1.80E-04	1.1E-16	34.4	98.5	34.533	0.081	
339-07	4.62	1.14E-02	2.47E-05	3.9E-16	44.7	99.4	34.545	0.068	
339-03	4.62	1.32E-.2	3.14E-05	1.4E-16	38.7	99.4	34.557	0.077	
339-06	4.64	1.09E-02	7.67E-05	9.3E-16	47.0	99.1	34.571	0.086	
339-05	4.62	1.82E-02	2.11E-05	2.1E-16	28.0	99.5	34.575	0.061	
339-04	4.63	8.26E-03	2.16E-05	1.5E-16	61.8	99.5	34.586	0.070	
339-02	4.63	9.81E-03	2.89E-05	2.2E-16	52.0	99.4	34.611	0.073	
339-01	4.63	9.12E-03	1.91E-05	1.4E-16	55.9	99.5	34.645	0.076	
Mean n = 8							34.578	0.036	0.013

Notes: [1] Error is 1 sigma deviation. [2] SEM is standard error of the mean analytical parameters: Neutron flux value: J = 0.0042074 ± 0.00001, discrimination = 1.0081 ± 0.0015, $^{39}Ar_{Ca}/^{37}Ar_{Ca}$ = 0.00067 ± 0.00005, $^{36}Ar_{Ca}/^{37}Ar_{Ca}$ = 0.00026 ± 0.0002, $^{38}Ar_k/^{39}Ar_k$ = 0.0119, $^{40}Ar_k/^{39}Ar_k$ = 0.019 ± 0.002.

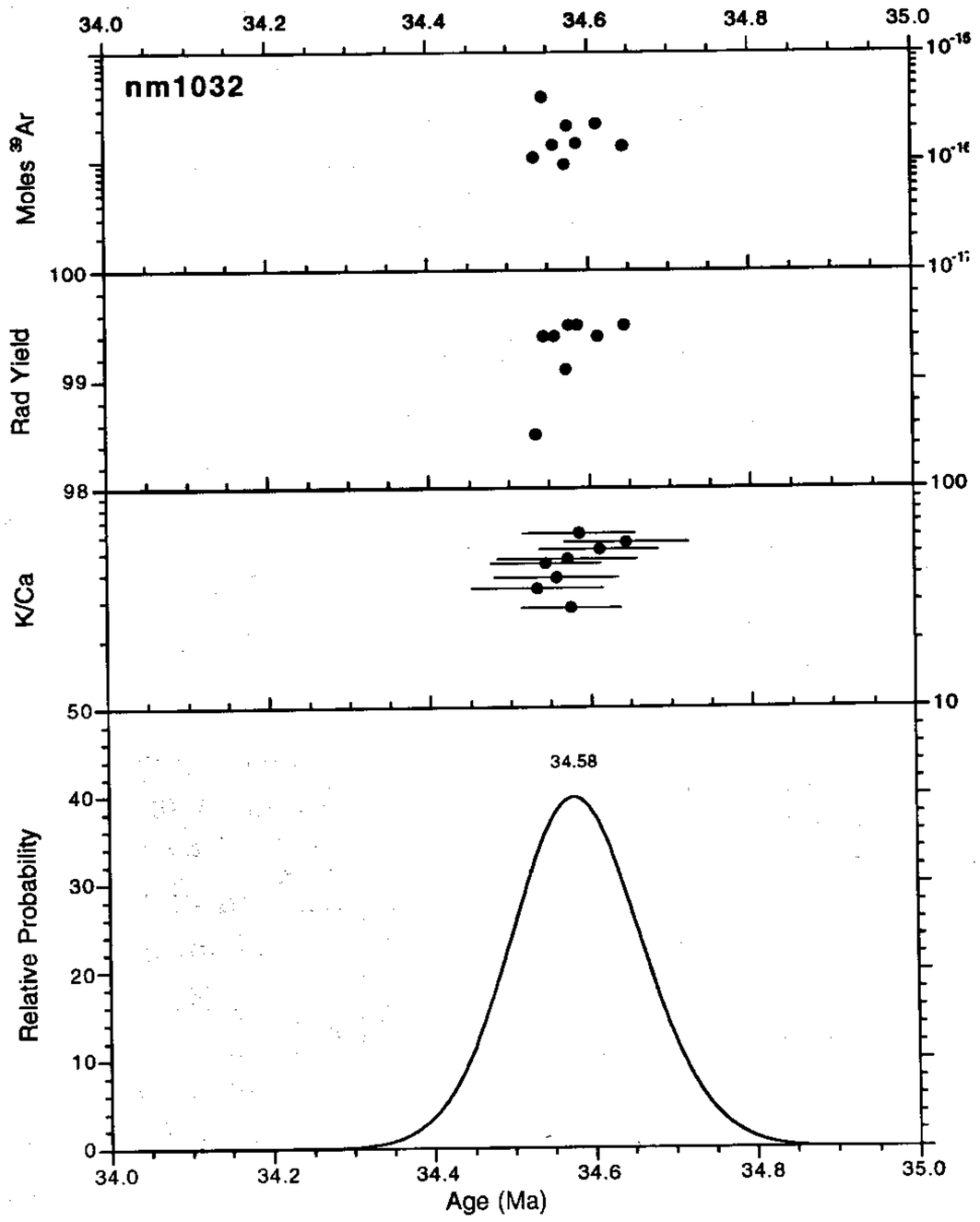

Figure 4. Single-crystal laser fusion $^{40}Ar/^{39}Ar$ analytical data for Rhyolite Tuff sanidine phenocrysts. Plot shows age vs. moles of ^{39}Ar, radiogenic yield, K/Ca, and relative probability (ideogram). Error bars in age vs. K/Ca plot show 1σ uncertainty in age of each single-crystal analysis.

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