Fission-track ages of air-fall tuffs in Pliocene basin-fill sediments near 111 Ranch, Graham County, Arizona

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FISSION-TRACK AGES OF AIR-FALL TUFFS IN PLIOCENE BASIN-FILL SEDIMENTS NEAR 111 RANCH, GRAHAM COUNTY, ARIZONA

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The purpose of this report is to present fission-track ages of samples of air-fall, water-reworked tuffs interlayered in upper Cenozoic sedimentary rocks in southeast Arizona. The samples we dated were collected by T. Galusha (deceased) and R. H. Tedford of the American Museum of Natural History from the 111 (One-eleven) Ranch beds of Seff (1960), which comprise a continuous sequence of fossiliferous Pliocene and Pleistocene lacustrine and fluviatile basin-fill sediments in the San Simon Valley, 24 km southeast of Safford, in Graham County, Arizona. Our age determinations will aid in the biostratigraphic and paleomagnetic studies currently being done in the area.

According to R. H. Tedford (written commun., 1978), the sedimentary rocks near 111 Ranch are the most fossiliferous and best exposed of the Safford basin fills and an important area to calibrate the earliest North American appearance of the fossil mammals capybara and glyptodont. In addition, the position of the Blancan and Irvingtonian land mammal age boundary (Savage, 1951) in relation to the Gauss and Matuyama paleomagnetic reversal boundary (Mankinen and Dalrymple, 1979) can be determined at the 111 Ranch locality. The paleomagnetic character of the rocks near 111 Ranch currently is being studied by N. M. Johnson of Dartmouth College, N. D. Opdyke of Columbia University, and E. H. Lindsay of the University of Arizona and is being compared with the paleomagnetic character of the upper Cenozoic sedimentary rocks of the nearby San Pedro Valley (Johnson and others, 1975). The vertebrate faunas of the 111 Ranch area are currently being studied by Lindsay to compare them with faunas at similar localities in the southwestern United States (Johnson and others, 1975; Lindsay and others, 1975).

It is beyond the scope of this paper for us to describe the local geology of the 111 Ranch area or to make detailed interpretations of the fission-track ages relative to the faunal and paleomagnetic succession in southeast Arizona, inasmuch as Tedford and others are currently studying the mammalian paleontology and paleomagnetic stratigraphy. Furthermore, we have no detailed knowledge of the stratigraphic relationships of the tuffs and the sedimentary rocks of the area.

Previous work

The geology of the San Simon Valley was first described by Schwennessen (1921) and later by Knechtel (1936); both loosely correlated the sediments in the valley with the Gila Conglomerate of Gilbert (1875). These sediments, particularly the fossiliferous ones near 111 Ranch, were studied by J. F. Lance and others from the University of Arizona (Lance, 1958 and 1960; Seff, 1960; Wood, 1960). Lance (1960) identified and named two local mammalian vertebrate faunas (based on the distribution of fossil horses within the rocks of the 111 Ranch area): the Flat Tire (older) and Tusker (younger). Wood (1962) described the faunas in detail, and concluded that the Tusker fauna is early Irvingtonian in age and the Flat Tire fauna is probably late Blancan in age. However, recent work by R. H. Tedford and T. Galusha (written commun., 1978), in collaboration with N. D. Opdyke, N. M. Johnson, and E. H. Lindsay, suggests that the two faunas are both late Blancan in age and approximately equivalent to the Wolf Ranch and California Wash faunas of the St. David Formation in the nearby San Pedro Valley (Johnson and others, 1975; Lindsay, 1978).

Sample preparation and methods

Tuff samples from the 111 Ranch beds were prepared for fission-track dating using standard heavy liquid and magnetic procedures. Heavy mineral concentrates of each tuff were examined under a stereomicroscope to determine if enough glass-mantled zircons were present for fission-track dating. Only one of the tuffs, no. 78W211, contained enough glass-mantled zircons to allow dating. Tracks in the zircon crystals and the muscovite detector were counted at 1000 magnification using a petrographic microscope. Tracks in 15 zircon crystals were counted.

Glass shards of the tuffs were prepared for fission-track dating using the population procedure but omitting annealing prior to irradiation (Naeser, 1976, p. 8). Each glass sample was split into two groups. The first group was mounted in epoxy, and the second, to be used to count induced tracks, was sent to a nuclear reactor for irradiation and then mounted in epoxy. After grinding the glass shard and epoxy mixture to expose maximum surface area of the shards, the two groups were etched back-to-back in a 24 percent hydrofluoric acid solution at room temperature for 45 seconds. However, owing to the extremely low spontaneous track density in most of the shards, more surface area was needed to count a reasonable number of spontaneous tracks. Another, coarser (>60 mesh) group of shards from each sample was mounted in epoxy, ground, and etched under the same conditions, and used for counting spontaneous tracks. Tracks in the glass samples were counted at 630 magnification using a petrographic microscope.

The decay constant for spontaneous fission of ^{238}U used in calculating the ages of the tuffs is $\lambda_f = 7.03 \times 10^{-17}$ yr^{-1} (Roberts and others, 1968). The neutron flux the dated samples received was determined by counting the induced tracks in a low-uranium muscovite detector which covered NBS glass no. SRM-962 during irradiation. Neutron doses were calibrated against the copper value determined at the National Bureau of Standards.

DISCUSSION

Samples from six of the tuff layers in the rocks of the 111 Ranch area were sent to us by Tedford and Galusha, but three of these (nos. 78W210, 78W212 and 78W213) contained too few fossil tracks in glass shards to give a meaningful fission-track age. Fission-track glass ages for three of the tuff layers (samples nos. 78W208, 78W209, and 78W211) are given below. However, fission-track ages of glass shards generally yield minimum ages owing to track annealing (Naeser and others, 1980).

Only one sample (no. 78W211) contained enough glass-

TABLE 1. Partial chemical analyses of the glass phases of six air-fall tuffs from the 111 Ranch area, Graham County, Arizona.

[Analyses by colorimetric and atomic absorption photospectrometric methods, by P. Briggs, U.S. Geological Survey; amounts of oxides in weight percent, and others parts per million]

Sample No.	Laboratory No.	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	Mn	Rb	Zn
78W208	D-217003	69.2	13.1	1.5	0.25	1.1	4.2	3.4	0.27	0.02	0.02	0.007
78W209	D-217004	69.3	13.0	1.5	.25	1.1	4.2	3.4	.27	.02	.02	.007
78W210	D-217005	69.2	13.1	1.6	.40	1.2	4.1	3.3	.28	.02	.02	.007
78W211	D-217006	69.7	11.8	2.1	.14	1.0	4.0	3.1	.21	.031	<.02	.010
78W212	D-217007	67.5	12.6	2.7	1.02	2.1	3.6	2.5	.48	.06	<.02	.008
78W213	D-217008	71.0	11.4	3.0	.67	1.8	3.5	2.5	.62	.38	<.02	.009

mantled zircons for a zircon fission-track age determination to be made. The zircon fission-track age obtained from this tuff, 2.33 ± 0.24 m.y., agrees well with the established age of the Gauss and Matuyama paleomagnetic reversal of about 2.48 m.y. (Mankinen and Dalrymple, 1979, p. 624), considering the tuff's stratigraphic position relative to the Gauss and Matuyama paleomagnetic boundary in the 111 Ranch area (R. H. Tedford, written commun., 1978).

In addition to fission-track dating, we also prepared pure glass fractions from each tuff sample for analysis to compare their chemical composition with that of other analyzed tuffs of late Cenozoic age in our collection. The results of the chemical analyses for certain major and minor elements are listed in table 1. The amounts of the elements (weight percent) total only about 94 percent, which suggests that the glass shards contain several percent of water. The tuffs are fairly silicic (well over 70 percent SiO_2 recast water free) and contain appreciable amounts of iron and calcium, similar to analyzed tuffs derived from the Cascade Range in the Pacific Northwest; perhaps the tuffs were derived from that area. Three of the tuff samples from the lower part of the succession in the 111 Ranch area (nos. 78W208, 78W209, and 78W210), collected from outcrops only about 200 m apart (R. H. Tedford, written commun., 1978), are very similar in composition and were probably formed during one volcanic ash fall. Each other tuff sample in the sequence has a significantly different chemical composition.

Trace element data given in table 2 suggest that tuff no. 78W211 dated at about 2.3 m.y., possibly correlates with a tuff in the Blanco Formation of Pliocene age (see Izett and others, 1972, p. 559, fig. 4) at the type locality of the Blancan land mammal assemblage, southeast of Lubbock, Texas. The correlation coefficient (Borchardt and others, 1972) for the two samples is 0.97, which, coupled with their similar faunal age, suggests that the two ash beds may be remnants of the same ash fall. More tephrochronologic information for these tuffs is required before this tentative correlation can be confirmed.

SAMPLE DESCRIPTIONS

1. *78W208* Fission track
(MWM 58 of R. H. Tedford)
Pale-gray lenticular vitric tuff (32°40'37"N, 109°29'16"W; center N line SW¼ NE¼ SW¼ S4,T9S,R28E, elevation 3400 ft, W side of Dry Mountain, 4.7 km SSW of 111 Ranch, Graham Co., AZ). *Collected by:* R. H. Tedford and T. Galusha. *Analytical data:* (glass) $P_S = 2.62 \times 10^3$ tracks per square centimeter (36 tracks counted), $P_i = 1.22 \times 10^5$ tracks per square centimeter (256 tracks counted), neutron flux = 1.65×10^{15} n/cm². **(glass) 2.17 ± 0.39 m.y.**

2. *78W209* Fission track
(MWM 59 of R. H. Tedford)

TABLE 2. Chemical analyses of the glass phases of sample 78W211 from Pliocene rocks of the 111 Ranch area, Arizona and a tuff in the Blanco Formation southeast of Lubbock, Texas.

[Analyses by instrumental neutron activation methods by D. M. McKown and R. J. Knight of the U.S. Geological Survey. Amounts of elements in parts per million except iron, which is in weight percent]

Sample No.	Laboratory No.	Locality	Cs	Rb	Th	U	La	Ce	Nd	Sm	Eu	Gd	Tb
77G100	D198677	Mount Blanco, Tex.	2.1	88	12.5	3.3	37.2	82.7	48	10.5	1.15	12.1	1.7
78W211	D226472	Sigmodon Ravine, 111 Ranch area, Ariz.	2.2	87	11.3	4.0	33.9	76.0	40	9.4	1.04	9.7	1.7

Sample No.	Dy	Tm	Yb	Lu	Ta	Zr	Hf	Sb	Sc	Mn	Fe
77G100	11.5	0.8	6.7	1.06	1.15	346	10.5	0.16	4.7	363	1.85
78W211	9.9	0.9	6.6	1.01	1.06	368	9.4	0.18	4.8	396	1.86

Pale-gray vitric tuff (32°40'44''N, 109°29'16''W; NE¼ NW¼ NE¼ SW¼ S4,T9S,R28E, 2.1 m stratigraphically above 78W208, W side of Dry Mountain, 4.5 km SSW of 111 Ranch, Graham Co., AZ). *Collected by:* R. H. Tedford and T. Galusha. *Analytical data:* (glass) P_S = 3.16 x 10^3 tracks per square centimeter (8 tracks counted), P_i = 1.20 x 10^5 (373 tracks counted), neutron flux = 1.65 x 10^{15} n/cm². **(glass) 2.67 ± 0.96 m.y.**

3. *78W211* Fission track
(Dry Mountain 222 of R. H. Tedford)
Light-gray vitric tuff (32°42'18''N, 109°27'45''W; SE¼ SW¼ NE¼ SE¼ S27,T8S,R28E, elevation about 3460 ft, N side of Dry Mountain, 2 km SE of 111 Ranch, Graham Co., AZ). *Collected by:* R. H. Tedford and T. Galusha. *Analytical data:* (glass) P_S = 2.61 x 10^3 tracks per square centimeter (46 tracks counted), P_i = 1.07 x 10^5 tracks per square centimeter (378 tracks counted), neutron flux = 1.65 x 10^{15} n/cm²; (zircon) P_S = 2.95 x 10^5 tracks per square centimeter (66 tracks counted), P_i = 7.39 x 10^6 tracks per square centimeter (828 tracks counted), neutron flux = 0.976 x 10^{15} n/cm².
(glass) 2.43 ± 0.38 m.y.
(zircon) 2.33 ± 0.24 m.y.

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