

DISCUSSION OF GEOLOGY OF THE FAIRVIEW RANGE AND GRASSY MOUNTAIN LINCOLN COUNTY, NEVADA

by

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STRUCTURE

Structure is complex in the Fairview Peak Quadrangle but simple in the Grassy Mtn. and western parts of the adjacent Pony Springs and Bristol Range NE Quadrangles. In the Fairview Peak Quadrangle, some major northwesterly trending horst-and-graben blocks consist of sequences of tuff and sedimentary rock units that have many faults whereas others consist of thick Lund tuff and tuff of Deadman Spring that seemingly are little faulted; this lack of faults, however, may only reflect the absence of marker layers in these thick deposits, locally as much as 1 km or so. Comparatively thick units that also lack markers in the adjacent mapped quadrangles may also belie complex faulting. Fault complexity is a result of local caldera-related deformation compounded by regional tectonism.

Indian Peak Caldera Complex

Geologic mapping in areas east and southeast of the Fairview Range and Grassy Mountain, combined with regional gravity data, have defined the large Indian Peak caldera complex, a nest of at least four inset calderas and two additional poorly defined sources of regional ash-flow sheets (Best and others, 1989a). The northern two-thirds of the Fairview Peak Quadrangle and southern two-thirds of the Grassy Mtn. Quadrangle occupy the northwestern lobe of the complex (fig. 1). Stratigraphic relations of volcanic units in these quadrangles constrain the nature of the caldera complex in this lobe, even though such relations are obscured by subsequent faulting, erosion, and concealment beneath younger deposits. Northern margins of three individual calderas—from oldest to youngest—are exposed southward in the Grassy Mtn. Quadrangle. The southern margin of only the youngest caldera is approximately located in the central Fairview Peak Quadrangle.

The Indian Peak caldera is the oldest well-documented depression in the caldera complex and developed as ash flows that formed tuffs of the Wah Wah Springs Formation were erupted at about 30 Ma. In the east central part of the Grassy Mtn. Quadrangle is a 250-m-thick section of andesitic tuff that crops out over an area of about 2 km² and overlies older

andesitic lava flows; this distinctive tuff closely resembles the intracaldera tuff member of the Wah Wah Springs Formation exposed on the north flank of Indian Peak in the Needle Range (fig. 1 and Best and others, 1987a) and in the northern Wilson Creek Range (Willis and others 1987). Although limited in volume, this remnant of the intracaldera tuff member indicates the Indian Peak caldera extends into the Grassy Mtn. Quadrangle. The caldera margin must lie just to the north of the intracaldera remnant because only Paleozoic rocks crop out for tens of kilometers northward (fig. 1). The remaining margin of the Indian Peak caldera in these two quadrangles has apparently been engulfed in younger calderas.

The southern boundary of exposures of the intracaldera tuff member of the Wah Wah Springs Formation and underlying andesitic lava flows in the Grassy Mtn. Quadrangle is an arcuate contact with a thick pile of uniform tuff of Deadman Spring emplaced at 29.63 Ma. Although obscure faults may repeat the section of Deadman Spring, its apparent thickness is about 2 km. Although the arcuate contact is everywhere concealed beneath Quaternary deposits, it appears to be a fault because bedrock closest to the contact commonly has slickensides and the Deadman is locally altered. Our preferred interpretation is that the arcuate fault is a caldera-ring fault and the thick pile of tuff of Deadman Spring south of it is an intracaldera deposit. A lens of outflow tuff of the Wah Wah Springs Formation embedded within the Deadman Spring is interpreted to be a landslipped slab emplaced into the intracaldera Deadman Spring tuff during its deposition. The caldera is here named the Kixmiller caldera for Kixmiller Summit which divides the Fairview Range on the south from Grassy Mountain on the north and which lies about 1 km north of the ring fault. In the Fairview Peak Quadrangle, apparently southward thinning tuff of Deadman Spring occurs in horst and graben blocks and there is no evidence for a southern margin of the Kixmiller caldera.

No evidence for a caldera related to eruption of the tuff of Silver King Well has been found.

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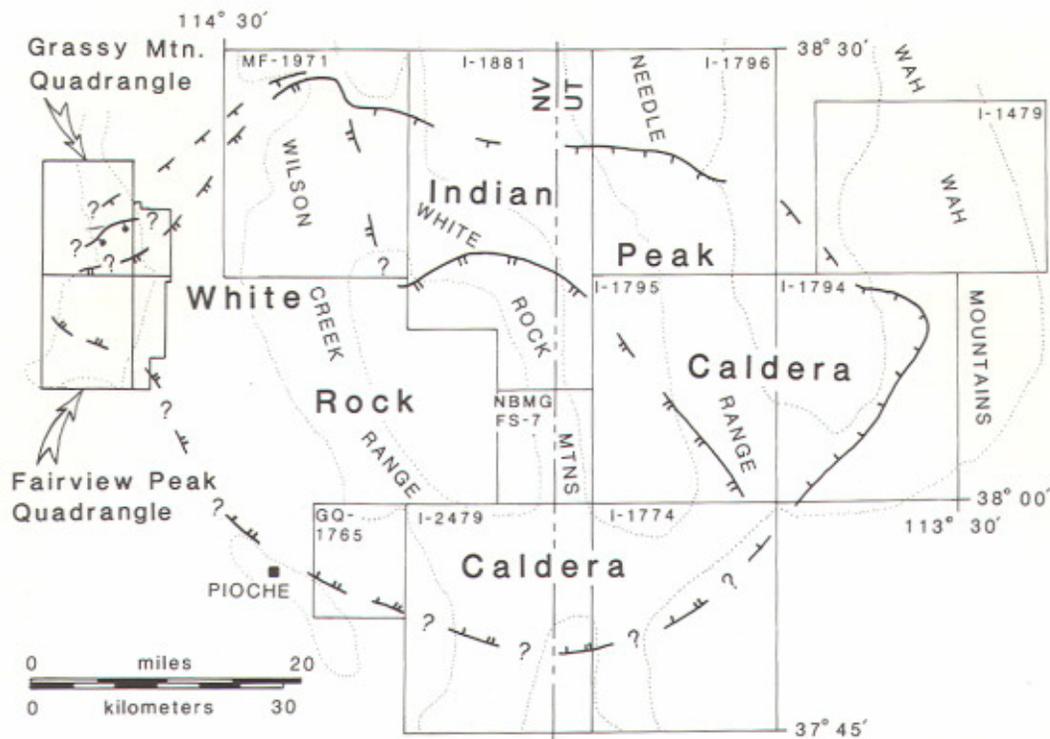


Figure 1. Index map showing mapped area comprising the Grassy Mtn. and Fairview Peak Quadrangles and the western parts of the Pony Springs (on the north) and Bristol Range NE Quadrangles in relation to two major calderas—Indian Peak and White Rock—in the Indian Peak caldera complex (Best and others, 1989a). Published maps in this area are MF-1479 (Abbott and others, 1983), I-1774 (Best, 1987), I-1795 (Best and others, 1987b), I-1796 (Best and others, 1987c), I-1794 (Best and others, 1987d), I-1881 (Best and others, 1989b), I-1971 (Willis and others, 1987), NBMG FS-7 (Keith and others, 1994), GQ-1765 (Best and Williams, 1997), and I-2479 (Williams and others, 1997).

The White Rock caldera created during eruption of ash flows that formed the tuff member of the Lund Formation at 28.83 Ma is only preserved in fault-bounded segments in the mapped area. A segment of its approximate topographic margin and of its structural fault margin can be located in the northern Fairview Peak Quadrangle (see plate 1) but these margins to the north in the southernmost Grassy Mtn. Quadrangle are obscure, if at all present; there is a possibility of trap-door collapse deepening southward. Lund tuff is possibly as much as 2 km thick in the northern part of the Fairview Peak Quadrangle (cross section A-A') and, in the central part, this tuff is underlain by, intercalated with, and locally overlain by breccias of older units, chiefly tuff of Deadman Spring (see cross section B-B'); this relation indicates collapse of the caldera wall, which was made of these older units, while Lund ash-flows were accumulating in the deepening White Rock depression. The terrane of the breccia member (Tlbd and local Tlbc and Tlbs) north of and extending more than 1 km southward from Fox Cabin Spring appears to lie on pre-Lund Formation rocks. This mass of breccia may have originated as a landslide which moved across a topographic shelf that was cut into older rocks and that was located outside the structural margin of the White Rock caldera. A similar but better exposed relationship of the sort envisaged here is located along the northern margin of

the Indian Peak caldera just southeast of Atlanta (Best and others, 1989b, fig. R38). Widespread shearing and cataclasis of the tuff of Deadman Spring and to a lesser extent in the tuff of Silver King Well in the mapped area are believed to be related to collapse of the White Rock caldera.

Many calderas experience post-collapse resurgence as differentially uplifted horst-and-graben blocks. Whether this has occurred in the White Rock caldera is uncertain because of a strong overprint of high-angle faulting that is at least partly post-volcanic because youngest volcanic units are affected. Although most are relatively thin, eight different volcanic units rest on the upper Lund tuff in the northern Fairview Peak Quadrangle. Differential vertical displacement of horst-and-graben fault blocks related to resurgence of the White Rock caldera could have controlled this depositional pattern.

Faults

The mapped area is complexly faulted. Some faults may have had initial displacement prior to volcanism, such as the one that strikes northerly through Peers Spring; pre-volcanic movement manifest in Mississippian units apparently dropped the east side down but post-volcanic movement dropped the west side down. Other faults may be related to resurgent uplift of the

White Rock caldera as just discussed. Still other faults have had significant post-volcanic movement, such as the west-northwest-striking fault that juxtaposes units Tf and PIPe 2 km west of the Silverhorn Mine. Three major faults shown in the northeastern half of cross section A-A' may have experienced a km or more of post-volcanic movement; the one three km east of Fairview Peak is a probable segment of the structural fault margin of the White Rock caldera that experienced renewed movement after deposition of unit Tbm.

Most mapped faults appear to strike in two more-or-less preferred directions: north to north-northwest and east-southeast to east-northeast; these will be referred to here as northerly and easterly faults, respectively. Both bound horsts and grabens. Northerly faults are generally the longer and several terminate against easterly faults, but the opposite is also evident. This relationship might suggest that northerly faults developed before and after easterly ones or, more likely, the faults constitute a single orthogonal set formed in a three-dimensional strain field (Davis and Reynolds, 1996, p. 314). Easterly strikes with northerly dips to as much as vertical in compaction foliation in tuff units in the southern half of the mapped area indicate a significant amount of north-south crustal extension. In fact, these dips are the steepest seen by the senior author in ash-flow tuff units in the southeastern Great Basin. North of a west-northwest-trending line that passes approximately through the Robison Mine on the east and Fence Spring on the west, dips are generally south to southwest in volcanic units. The easterly strikes are not typical of the Indian Peak caldera complex generally, nor of surrounding areas, where northwesterly strikes prevail. Bartley (1989) also observed the east-striking faults in the Fairview Peak Quadrangle and considered two possible models of origin for the east-striking faults: (1) vertical-axis rotation of more northerly striking faults or (2) a transient 90° rotation in the direction of the least principal horizontal stress during volcanism, compared to the approximately east-west direction before and after volcanism.

With regard to the vertical axis rotation, it should be noted that our mapping has revealed a major set of northerly faults, which, if a 90° rotation had occurred, would have been originally east-striking, so not solving the problem of atypical north-south extension. Also, paleomagnetic data show no significant vertical axis rotation (Overtoom and others, 1993). With regard to the second of Bartley's proposed interpretations, Best (1988b) found many east-striking, upper Oligocene to lower Miocene dikes in the southeastern Great Basin. These dikes were interpreted to reflect a regional perturbation of the stress field so that the least principal horizontal direction was north-south during this period of volcanism. In most parts of the Great Basin the north-south least horizontal principal stress may have only influenced the strike of intruding dikes.

But in the vicinity of the Fairview Peak Quadrangle, this state of stress may have been expressed in significant north-south crustal extension.

Bartley (1989) proposed that extension in the Fairview Quadrangle was synvolcanic, based upon angular discordances within the volcanic sequence. One such discordance can be seen 0.8 km northeast of Scotty Spring where the east-striking Cottonwood Wash Tuff (Tc) dips 55°-75°N and the overlying Petroglyph Cliff Ignimbrite (Tpc) dips only 18°. This discordance occurs between pre- and post-caldera units and could therefore be related to caldera processes and not to any regional extensional tectonic event in the eastern Great Basin. Many faults of both northerly and easterly orientation cut all volcanic units and are not, therefore, necessarily synvolcanic.

It is difficult to evaluate how much horst-and-graben formation might be related to possible resurgence of the White Rock caldera and how much to subsequent late Cenozoic extension that produced the Basin and Range structural province.

Ekren and Page (1995) postulated an east-trending volcanic trough located near the southern margin of the Fairview Peak Quadrangle. They allege that this trough subsided during ash-flow eruptions in the western part of the Indian Peak volcanic field. A trough is indicated by the substantial south to north thickening of the tuff member of the Lund Formation and the tuff of Deadman Spring near the northern margin of the adjacent Bristol Well and Coyote Spring Quadrangles which bound the mapped area on the south and southeast, respectively. Ekren and Page (1995) proposed that the trough may be structurally controlled by the east-striking Blue Ribbon lineament of Rowley and others (1978). The existence of east-trending troughs or valleys that controlled local variations in thickness of ash-flow deposits in the Indian Peak volcanic field has been known for many years (Campbell, 1978; Best and Keith, 1983; Best, 1986; Best and others, 1987a; Best, 1988a). The regional distribution of the outflow tuff sheet of the Lund Formation (Best and others, 1989a, fig. 5C) suggests the possibility of some sort of east-west trough into which the ash flows were erupted. Alternatively, post-emplacment development of an east-trending graben and subsequent erosion to the north and south could have been involved, but by the time of emplacement of the ash flows of the Isom Formation about 27 Ma, no topographic or structural control on their dispersal is apparent.

The area of steepest dips of tuff compaction foliation in the mapped area occurs in the southern part, along the boundary of townships 3 and 4 N., and chiefly near and within 3 km east of the Silverhorn Mine. This east-trending zone, here called the "Silverhorn zone," approximately parallels the nearby margin of the caldera complex and probable associated deep batholith. The Silverhorn zone is defined by (1) large outcroppings of jasperoid, chiefly silicified

Joana Limestone, (2) Oligocene granodiorite intrusive porphyry (Tgp), and (3) intrusions of rhyolite (Tr).

These features could be genetically related and constitute a manifestation of the Blue Ribbon lineament which extends into the Marysvale area of southern central Utah and possibly connects with the Warm Springs Lineament of Ekren and others (1976) in central Nevada. The role of these transverse zones in the Great Basin seems little appreciated.

ECONOMIC GEOLOGY

Both nonmetallic and metallic mineral resources occur in the Fairview Peak Quadrangle. Widespread areas of exposure of rhyolite (Tr) consist of perlite. From one of these occurrences, 1.3 km north-northwest of Scotty Spring, 5,000 tons of perlite was extracted prior to 1951; reserves of about 6 million tons are estimated (Tschanz and Pampeyan, 1970, table 8). Other perlite bodies to the east could conceivably be exploited.

The Silverhorn Mine, located near the west end of the east-trending Silverhorn zone described above, lies within massive bodies of jasperoid created by silicification of the Joana Limestone. Mineralization and alteration were probably related to the Oligocene magma intruded as unit Tgp. Mineralization in the jasperoid consists of seams of cerargyrite and argentite. No recorded production was noted by Tschanz and Pampeyan (1970, table 36) but during 1978 and 1979 Standard Slag mined 9,000 tons in an open-pit for Silverhorn Operating Company, Salt Lake City, Utah, according to written communication from John R. Harmon of The Standard Magnesia Company, Reno, Nevada. The ore was milled at Atlanta 40 km to the northeast and 86,956 ounces of silver and 61 ounces of gold were recovered.

The Robison Mine lies at the east end of the Silverhorn zone of jasperoid and intrusions. No information was obtainable regarding mineralization and production.

Table 2. Ages of samples in the Fairview Peak Quadrangle. See figure 2 for details of step heating of samples FAIRV-3-201-2 (mafic lava flow flow member of Blawn Formation) and FAIRV-3-203-2 (Granitic porphyry). For sample FAIRV-1-207-1 (Tuff of Deadman Spring), five sanidine grains yielded >98% radiogenic argon by the $^{40}\text{Ar}/^{39}\text{Ar}$ laser fusion method (Best and others, 1995). Fission-track age of zircon from the rhyolite unit (Tr) was determined by B.J. Kowallis at Brigham Young University.

Sample no.	Latitude	Longitude	Lab no.	J	±J	Age (Ma)	± Age (Ma)#
<i>Blawn Formation, Mafic lava flow member</i>							
FAIRV-3-201-2	38°10'27"N	114°40'12"W	20622	0.003393	0.00001	20.99	0.09
<i>Rhyolite</i>							
FAIRV-3-201-3	38°10'11"N	114°39'00"W				25.7	1.7*
<i>Granitic porphyry</i>							
FAIRV-3-203-2	38°08'38"N	114°39'44"W	20651	0.01044	0.00002	29.65	0.07
<i>Tuff of Deadman Spring</i>							
FAIRV-1-207-1	38°13'34"N	114°37'35"W	7728	0.01682	0.00001	29.63	0.05

Standard error of the mean, incorporating error in J

* One sigma standard deviation

Table 1. Chemical analyses of stratigraphic units in the Fairview Peak Quadrangle determined by x-ray fluorescence spectrometry at Brigham Young University by David G. Tingey. Total iron as Fe_2O_3 . Oxide weights normalized to 100% total oxides. LOI, loss on ignition. For data on typical accuracy and precision of analyses see Nelson and Tingey (1997).

	1	2	3	4	5
SiO_2	53.08	77.15	65.19	72.24	74.56
TiO_2	1.91	0.05	0.55	0.44	0.60
Al_2O_3	15.73	13.29	15.66	14.67	16.53
Fe_2O_3	10.44	0.67	4.13	2.80	1.24
MnO	0.14	0.06	0.10	0.05	0.01
MgO	5.23	0.08	1.47	0.65	1.09
CaO	8.01	0.50	6.70	2.56	0.84
Na_2O	2.68	3.82	2.48	3.13	0.92
K_2O	2.12	4.39	3.56	3.39	4.03
P_2O_5	0.65	0.00	0.17	0.08	0.19
LOI	0.08	0.53	3.67	1.87	4.88
Total	98.23	98.68	98.62	99.09	100.25

1. FAIRV-3-188-1, unit Tbm, Fairview Peak, 38°12'15"N, 114°41'10"W
2. FAIRV-1-207-3B, unit Tr, dike, 38°15'52"N, 114°37'51"W
3. FAIRV-3-197-1, unit Tch, 38°14' 32" N, 114° 40' 21" W
4. FAIRV-3-160-1, unit Tb, 38°10' 40"N, 114°43' 50" W
5. FAIRV-3-203-2, unit Tgp, 38°8' 38" N, 114°39'42"W

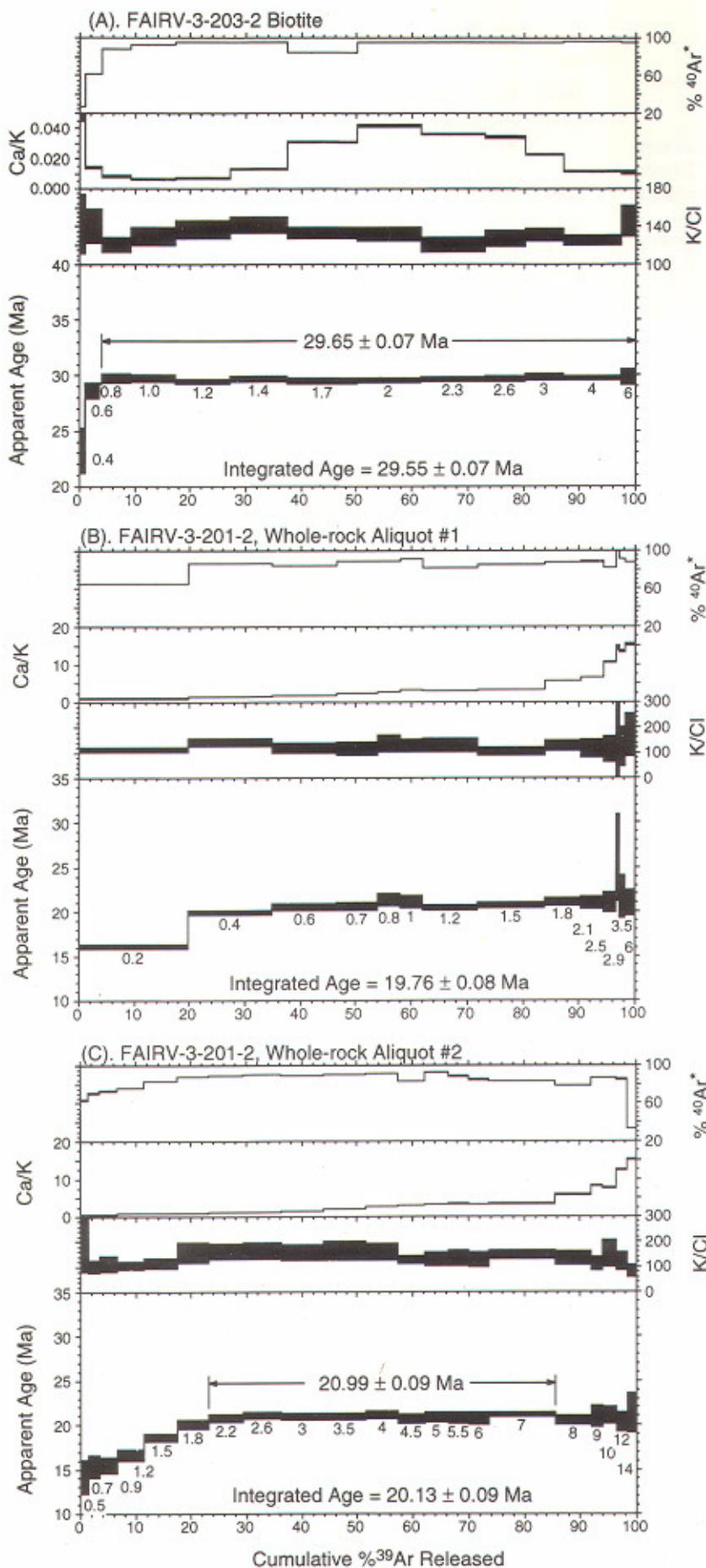


Figure 2. Incremental-heating $^{40}\text{Ar}/^{39}\text{Ar}$ age spectra for biotite and whole rock from the Fairview Peak Quadrangle. (A) results on biotite from Granite Porphyry (Tgp), sample FAIRV-3-203-2. An apparent age plateau (29.65 ± 0.07 Ma) extends across 96% of the total ^{39}Ar release, suggesting only minor alteration of the biotite. (B) and (C) are results for two aliquots of whole rock of the mafic lava flow member of the Blawn Formation, sample FAIRV-3-201-2. The two experiments yield nearly identical results, although (C) captures the release pattern in more detail. The early part of the experiment yields an apparent age pattern that is likely the result of minor alteration, possible weathering of the sample. Nevertheless, the release pattern settles into a plateau in aliquot #2 with an apparent age of 20.99 ± 0.09 Ma, probably closely approximating the eruptive age of the lava flow. All errors are inclusive of error in the neutron fluence parameter, J . A defocused Ar-laser was used as the heating device for experiments (A) and (B), whereas a CO_2 laser with a 6x6 mm integrating lens was employed in experiment (C) (Sharp and Deino, 1996).

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