$^{40}Ar/^{39}Ar$ Geochronology Results for the Salt Lake City North Quadrangle, Utah

by

Adam P. McKean and
Nevada Isotope Geochronology Laboratory

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INTRODUCTION

This open-file report makes available raw analytical data from laboratory procedures completed to determine the age of rock samples collected during geologic mapping funded or supported by the U.S. Geological Survey (USGS) National Cooperative Geologic Mapping Program and the Utah Geological Survey (UGS). The reference listed in table 1 reports the age of the sample and generally provides additional information such as location, geologic setting, and significance or interpretation of the sample in the context of the area where it was collected. The analyses were performed by the Nevada Isotope Geochronology Laboratory (NIGL) under contract to UGS. These data are highly technical in nature and proper interpretation requires considerable training in the applicable geochronologic techniques.

The analytical data can be accessed electronically as an attachment to the PDF file of this report and are available at http://ugspub.nr.utah.gov/publications/open_file_reports/ofr-658/ofr-658.xls.

Table 1. *Salt Lake City North 7.5' quadrangle sample number, rock type, and location.*

Sample	Map Unit	Unit Name	Rock Type	Rock Name	Reference	Latitude (N)	Longitude (W)
SLCN2014-283-1	Tv	Volcanic breccia	volcanic breccia - clast	dacite	McKean, in preparation	40.79602	111.87639

Notes:
Location data based on NAD83.
Rock name using total alkali-silica diagram of LeBas and others (1986), for values normalized to 100% on a volatile free basis (data not shown here).

DISCLAIMER

This open-file release is intended as a data repository for information gathered in support of various UGS projects. The data are presented as received from the NIGL and do not necessarily conform to UGS technical, editorial, or policy standards; this should be considered by an individual or group planning to take action based on the contents of this report. The Utah Department of Natural Resources, Utah Geological Survey, makes no warranty, expressed or implied, regarding the suitability of this product for a particular use. The Utah Department of Natural Resources, Utah Geological Survey, shall not be liable under any circumstances for any direct, indirect, special, incidental, or consequential damages with respect to claims by users of this product.

The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

ACKNOWLEDGMENTS

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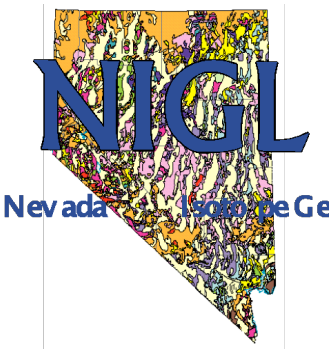
REFERENCES

LeBas, M.J., Le Maitre, R.W., Steckeisen, A.L., and Zanettin, B., 1986, A chemical classification of volcanic rocks based on the total alkali-silica diagram: Journal of Petrology, v. 27, part 3, p. 745-750.

McKean, A.P., in preparation, Interim geologic map of the Salt Lake City North quadrangle, Salt Lake and Davis Counties, Utah: Utah Geological Survey Open-File Report, scale 1:24,000.

The Nevada Isotope Geochronology Laboratory

University of Nevada, Las Vegas
Department of Geoscience



Report prepared by Terry Spell (Lab Director)
and Kathleen Zanetti (Lab Manager)
for the Utah Geological Survey
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Nevada Isotope Geochronology Laboratory - Description and Procedures

Samples analyzed by the $^{40}Ar/^{39}Ar$ method at the University of Nevada Las Vegas were wrapped in Al foil and stacked in 6 mm inside diameter sealed fused silica tubes. Individual packets averaged 3 mm thick and neutron fluence monitors (FC-2, Fish Canyon Tuff sanidine) were placed every 5-10 mm along the tube. Synthetic K-glass and optical grade CaF_2 were included in the irradiation packages to monitor neutron induced argon interferences from K and Ca. Loaded tubes were packed in an Al container for irradiation. Samples irradiated at the U. S. Geological Survey TRIGA Reactor, Denver, CO were in-core for 7 hours in the In-Core Irradiation Tube (ICIT) of the 1 MW TRIGA type reactor. Correction factors for interfering neutron reactions on K and Ca were determined by repeated analysis of K-glass and CaF_2 fragments. Measured $(^{40}Ar/^{39}Ar)_K$ values were 2.00 (± 150.00%) x 10^{-4}. Ca correction factors were $(^{36}Ar/^{37}Ar)_{Ca}$ = 2.34 (± 10.28%) x 10^{-4} and $(^{39}Ar/^{37}Ar)_{Ca}$ = 7.92 (± 11.04%) x 10^{-4}. J factors were determined by fusion of 4-8 individual crystals of neutron fluence monitors which gave reproducibility's of 0.52% to 0.69% at each standard position. Variation in neutron fluence along the 100 mm length of the irradiation tubes was <4%. Matlab curve fit was used to determine J and uncertainty in J at each standard position. No significant neutron fluence gradients were present within individual packets of crystals as indicated by the excellent reproducibility of the single crystal fluence monitor fusions.

Irradiated FC-2 sanidine standards together with CaF_2 and K-glass fragments were placed in a Cu sample tray in a high vacuum extraction line and were fused using a 20 W CO_2 laser. Sample viewing during laser fusion was by a video camera system and positioning was via a motorized sample stage. Samples analyzed by the furnace step heating method utilized a double vacuum resistance furnace similar to the Staudacher et al. (1978) design. Reactive gases were removed by three GP-50 SAES getters prior to being admitted to a MAP 215-50 mass spectrometer by expansion. The relative volumes of the extraction line and mass spectrometer allow 80% of the gas to be admitted to the mass spectrometer for laser fusion analyses and 76% for furnace heating analyses. Peak intensities were measured using a Balzers electron multiplier by peak hopping through 7 cycles; initial peak heights were determined by linear regression to the time of gas admission. Mass spectrometer discrimination and sensitivity was monitored by repeated analysis of atmospheric argon aliquots from an on-line pipette system. Measured $^{40}Ar/^{36}Ar$ ratios were 288.21 ± 1.29 % during this work, thus a discrimination correction of 1.0255 (4 AMU) was applied to measured isotope ratios. The sensitivity of the mass spectrometer was ~6 x 10^{-17} mol mV^{-1} with the multiplier operated at a gain of 36 over the Faraday. Line blanks averaged 3.49 mV for mass 40 and 0.02 mV for mass 36 for laser fusion analyses and 8.55 mV for mass 40 and 0.03 mV for mass 36 for furnace heating analyses. Discrimination, sensitivity, and blanks were relatively constant over the period of data collection. Computer automated operation of the sample stage, laser, extraction line and mass spectrometer as well as final data reduction and age calculations were done using LabSPEC software written by B. Idleman (Lehigh University). An age of 28.02 Ma (Renne et al., 1998) was used for the Fish Canyon Tuff sanidine fluence monitor in calculating ages for samples.

For $^{40}Ar/^{39}Ar$ analyses a plateau segment consists of 3 or more contiguous gas fractions having analytically indistinguishable ages (i.e. all plateau steps overlap in age at ± 2σ analytical error) and comprising a significant portion of the total gas released (typically >50%). Total gas

(integrated) ages are calculated by weighting by the amount of ^{39}Ar released, whereas plateau ages are weighted by the inverse of the variance. For each sample inverse isochron diagrams are examined to check for the effects of excess argon. Reliable isochrons are based on the MSWD criteria of Wendt and Carl (1991) and, as for plateaus, must comprise contiguous steps and a significant fraction of the total gas released. All analytical data are reported at the confidence level of 1σ (standard deviation).

Renne, P.R., Swisher, C.C, Deino, A.L., Karner, D.B., Owens, T.L., DePaolo, D.J., 1998, Intercalibration of standards, absolute ages and uncertainties in $^{40}Ar/^{39}Ar$ dating, *Chemical Geology*, v. 145, p. 117-152.

Staudacher, T.H., Jessberger, E.K., Dorflinger, D., and Kiko, J., A refined ultrahigh-vacuum furnace for rare gas analysis, *J. Phys. E: Sci. Instrum*., *11*, 781-784, 1978.

Wendt, I., and Carl, C., 1991, The statistical distribution of the mean squared weighted deviation, *Chemical Geology*, v. 86, p. 275-285.

Note: Check your samples data sheets for the discrimination, and fluence monitor values used for each sample.

Nevada Isotope Geochronology Laboratory - Sample Descriptions – McKean UT DNR

General Comments: Your sample was run as conventional furnace step heating analyses on a bulk biotite mineral separate. All data are reported at the 1σ uncertainty level, unless noted otherwise.

Furnace step heating analyses produce what is referred to as an apparent age spectrum. The "apparent" derives from the fact that ages on an age spectrum plot are calculated assuming that the non-radiogenic argon (often referred to as trapped, or initial argon) is atmospheric in isotopic composition ($^{40}Ar/^{36}Ar = 295.5$). If there is excess argon in the sample ($^{40}Ar/^{36}Ar > 295.5$) then these apparent ages will be older than the actual age of the sample. U-shaped age spectra are commonly associated with excess argon (the first few and final few steps often have lower radiogenic yields, thus apparent ages calculated for these steps are effected more by any excess argon present). Excess argon can also produce generally discordant age spectra. This is often verified by isochron analysis, which utilizes the analytical data generated during the step heating run, but makes no assumption regarding the composition of the non-radiogenic argon. Thus, isochrons can verify (or rule out) excess argon, and isochron ages are usually preferred if a statistically valid regression is obtained (as evidenced by the MSWD, mean square of weighted deviates, a measure of the coherence of the population). If such a sample yields no reliable isochron, the best estimate of the age is that the minimum on the age spectrum is a maximum age for the sample (it could be affected by excess argon, the extent depending on the radiogenic yield). $^{40}Ar/^{39}Ar$ total gas ages are equivalent to K/Ar ages. Plateau ages are sometimes found, these are simply a segment of the age spectrum which consists of 3 or more steps, comprising >50% of the total gas released, which overlap in age at the ±2σ analytical uncertainty level (not including the J-factor error, which is common to all steps). However, in general an isochron age is the best estimate of the age of a sample, even if a plateau age is obtained.

SLCN2014-283-1 Biotite

This sample produced a nearly ideal data set, with concordance between all 3 methods of age calculation. The age spectrum is flat throughout the gas release, with a total gas age (which is equivalent to a conventional K/Ar age) of 39.65 ± 0.44 Ma. Steps 1-12 (99% of the ^{39}Ar released) define an indistinguishable plateau age of 39.57 ± 0.46 Ma. The same steps define a statistically valid isochron with an initial $^{40}Ar/^{36}Ar$ ratio of 297.3 ± 2.3 (indistinguishable from atmospheric argon), and an age of 39.52 ± 0.19 Ma. Ca/K ratios are generally consistent with outgassing of a homogeneous biotite mineral separate. Radiogenic yields ($\%^{40}Ar^*$) are high, and thus do not suggest any recent alteration has occurred. The isochron age should be considered the most reliable for this sample. This is a data set indicative of a very reliable sample.

The interpretations given above are based simply on inspection of the laboratory data. Geologic relationships, which are unknown to us, are not considered. Please feel free to call or email (best way to contact me terry.spell@unlv.edu) if you have questions.

Nevada Isotope Geochronology Laboratory - Sample Descriptions

General Comments:

Isochrons are the most desirable treatment of $^{40}Ar/^{39}Ar$ data. This is because the isochron actually defines the isotopic composition of the initial argon in the sample (non-radiogenic argon). Ages calculated for an age spectrum are referred to as "apparent ages" because they are calculated assuming the initial argon is atmospheric in composition - thus, if there is excess argon ($^{40}Ar/^{36}Ar > 295.5$) the age will be overestimated. Isochrons have their measure of reliability, known as the mean square of weighted deviates (MSWD) which is a statistical goodness of fit parameter. If it is greater than a certain value (which changes depending on the number of points, see Wendt and Carl, 1991, the statistical distribution of the mean squared weighted deviation, Chem. Geol., v. 86, p. 275-285) then there is more scatter than can be explained by analytical errors and it is not a statistically valid isochron. If we provide an isochron it means that the statistical test is valid, if not then no valid isochron was obtained. Also, there are issues of number of data points defining the isochron - the more the better. Four points should be considered a bare minimum for statistical reasons, three points is getting to be a real concern. This can be understood simply by considering two points - a perfectly fit straight line can be put through any two points, so completely accidental data can have a perfect line fit. It follows that with three points there is less of a chance of an accidental line fit, but it is still a very real possibility (especially if analytical errors are fairly large), this possibility gets exponentially smaller as the number of points defining the line (isochron) goes up, thus more points = a more reliable isochron.

If there is no isochron, then a plateau age is next in preference. This is because a sample that gives ages which are analytically indistinguishable from step to step is exhibiting what is known as "ideal" behavior, which suggests it has a simple geologic history, e.g., rapid cooling as a basalt lava, followed by no reheating or alteration, both of which may produce disturbed (discordant) age spectra. A reliable plateau is 3 or more consecutive steps which are indistinguishable in age at the 2 sigma level and comprise >50% of the total ^{39}Ar released. The lack of an isochron or a plateau does not mean the sample provides no useful information, but their presence gives greater confidence in the ages obtained and requires less subjective interpretation.

Of course, you must consider that we run samples such as this "blind" in that we do not know the geologic relations of the samples, either when we analyze them, or when we provide these general interpretations. The geologic constraints must always be considered when interpreting isotopic ages; if any discrepancies arise feel free to discuss them with us, as it can in some cases make a difference in how age data are interpreted. All analytical errors are 1σ.