 USGS-OFR-85-47

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

URANIUM-SERIES DATING OF SECONDARY CARBONATE AND SILICA PRECIPITATES RELATING TO FAULT MOVEMENTS IN THE NEVADA TEST SITE REGION AND OF CALICHE AND TRAVERTINE SAMPLES FROM THE AMARGOSA DESERT

Open-File Report 85-47

Prepared in cooperation with the
Nevada Operations Office
U.S. Department of Energy
(Interagency Agreement DE-AI08-78ET44802)

Denver, Colorado
1985

 USGS-OFR-85-47

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

URANIUM-SERIES DATING OF SECONDARY CARBONATE AND SILICA PRECIPITATES RELATING TO FAULT MOVEMENTS IN THE NEVADA TEST SITE REGION AND OF CALICHE AND TRAVERTINE SAMPLES FROM THE AMARGOSA DESERT

By

Barney J. Szabo and Peg A. O'Malley

CONTENTS

ILLUSTRATIONS

TABLES

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURGVEY

URANIUM-SERIES DATING OF SECONDARY CARBONATE AND SILICA PRECIPITATES RELATING TO FAULT MOVEMENTS IN THE NEVADA TEST SITE REGION AND OF CALICHE AND TRAVERTINE SAMPLES FROM THE AMARGOSA DESERT

BY

Barney J. Szabo and Peg A. O'Malley

ABSTRACT

Fault associated secondary carbonate and opal samples from the Nevada Test Site area together with travertine samples from the Amargosa Desert were dated by the uranium-series disequilibrium method. Analyses of secondary carbonate samples from Yucca Mountain and from Crater and Yucca Flats yielded minimum ages for the last significant displacements of associated faults between 27,000 and 219,000 years. Dating results of an opaline carbonate rock sample from a fault on the east side of Yucca Mountain indicate that the age of the deposit is greater than 360,000 years. Two dates of travertine vein samples show that spring discharge was occuring before about 360,000 years ago in the Kinney area of the Amargosa Desert. Ages obtained for travertine laminae from the Furnace Creek Wash area suggest that significant movement along this low-angle fault occurred more than 132,000 years ago.

INTRODUCTION

Secondary carbonates and silica are commonly associated with Quaternary faulting in the Nevada Test Site region, southern Great Basin. They fill fault-related fractures and cement alluvial and colluvial materials and they also occur in association with spring discharges. Dating of these secondary minerals by the uranium-series disequilibrium method can provide constraints for associated Quaternary tectonic movements.

The application of uranium-series dating to carbonate and opal is possible because these minerals coprecipitate dissolved uranium, but are usually free of initial ^{230}Th. The measurements of the growth toward equilibrium of ^{230}Th with respect to ^{238}U and ^{234}U allow the calculation of the time elapsed since deposition, provided that these secondary deposits remained a closed system with respect to uranium isotopes and ^{230}Th. Because secondary carbonate often contains varying amounts of detrital material, some of the dating is accomplished through use of a graphical correction procedure which includes analytical results of both the acid-soluble carbonate and the acid-insoluble residue fractions as described by Szabo and others (1981). Presentation of the results of the analyses of these various minerals sampled from Nevada Test Site area localities is the subject of this report.

ANALYTICAL PROCEDURE

Sample pretreatment, leaching and dissolution procedures used are described by Szabo and others (1981). After isolation and purification of uranium and thorium, the concentrations and the ^{234}U/^{238}U, ^{230}Th/^{232}Th and ^{230}Th/^{234}U activity ratios were determined by alpha spectrometry.

SECONDARY CARBONATES FROM CRATER FLAT, YUCCA MOUNTAIN AND YUCCA FLAT AREAS

Samples 368, 386, 387 and 395 are fault associated secondary carbonates which cement a sand and gravel matrix. The samples, collected by W. J. Carr from trenched faults along the eastern edge of Crater Flat and on Yucca Mountain (fig. 1), are not fault displaced. Deposition of the carbonates thus post-dates the latest important movements of the faults.

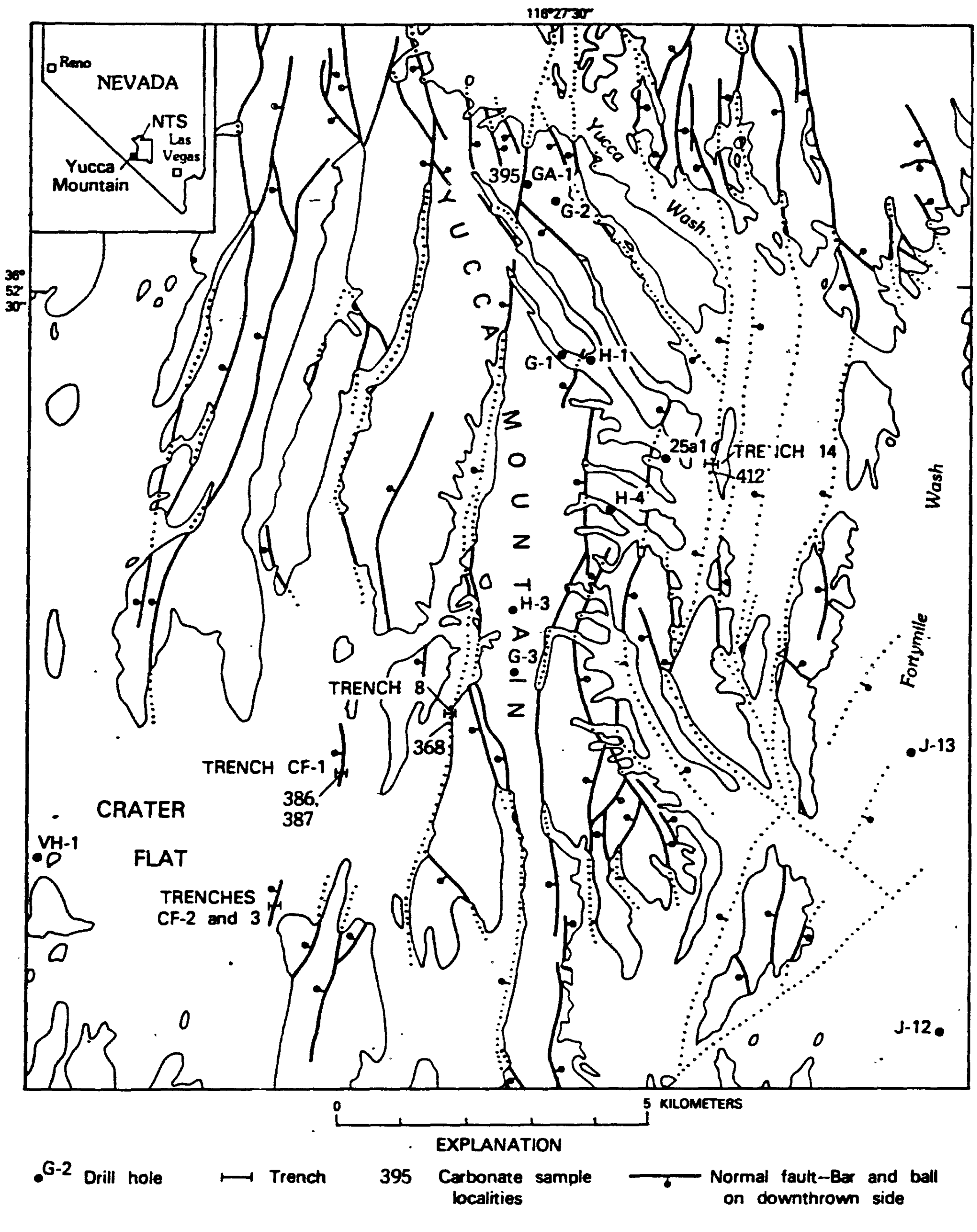

Figure 1. Map of Yucca Mountain area showing sample localities discussed in the text.

Sample 386 is a soft, layered caliche in fault next to the basalt ash and sample 387 a subhorizontal hard caliche above the fault in trench CF-1 (fig. 1). See Swadley and Hoover, (1983) for geology of the stratigraphic units in the trench. Sample 368 is calcrete in fault at the west foot of Yucca Mountain, about half km south of trench 8 (fig. 1). Sample 395 is a caliche collected above antithetic branch of fault exposed in trench adjacent to drill hole GA-1 on Yucca Mountain (fig. 1).

Analytical data of both the acid-soluble carbonate and the acid-insoluble residue fractions are shown in table 1. The calculated isochron-plot dates for the deposition of the secondary carbonates in the fault zones range between 27,000 and 70,000 years B.P.

Sample 379 was collected in trench number 5 across the Boundary Fault at the north end of Yucca Flat by W. J. Carr. The relatively pure (94% $CaCO_3$) calcrete, apparently undisturbed by faulting, yielded a minimum date for the last displacement on the fault of 219,000 ± 30,000 years (table 1). See Knauss (1981) for location and geology of the trench and for additional uranium-series dates on carbonates.

OPALINE CARBONATE (SAMPLE 412) FROM YUCCA MOUNTAIN

Sample 412, collected by W. J. Carr from a fault on the east side of Yucca Mountain and exposed by trench 14 (fig. 1), is a thinly laminated white to cream-colored opal and opaline carbonate rock. The location of the sample relative to the fault and the stratigraphy of the units exposed in trench 14 are shown by Swadley and others, 1984. The sample is apparently not offset by the fault.

The whole-rock was divided into three representative samples for the uranium-series age analyses. One sample was selected from the upper

Table 1. Analytical data and calculated ages of carbonate samples from Crater Flat, Yucca Mountain and Yucca Flat areas

Sample No.	Percent[1] Carbonate	Fraction	Uranium (ppm)	Activity Ratios $^{234}U/^{238}U$	Activity Ratios $^{230}Th/^{232}Th$	Activity Ratios $^{230}Th/^{234}U$	U-Series[2] Age (k.a.)
CRATER FLAT AREA							
368[3]	90	Acid leach	3.62 ±0.07	1.28 ±0.02	34.3 ±1.7	1.06 ±0.04	70 ± 5
		Residue	1.96 ±0.04	1.19 ±0.02	23.6 ±1.4	2.30 ±0.09	n.a.
386	45	Acid leach	7.08 ±0.14	1.23 ±0.02	6.81 ±0.17	0.451 ±0.018	27 ± 3
		Residue	8.48 ±0.17	1.20 ±0.02	4.34 ±0.17	1.10 ±0.04	n.a.
387	58	Acid leach	7.26 ±0.15	1.13 ±0.02	4.23 ±0.17	0.479 ±0.019	33 ± 4
		Residue	8.68 ±0.17	1.07 ±0.02	2.54 ±0.10	1.03 ±0.04	n.a.
YUCCA MOUNTAIN							
395	48	Acid leach	5.56 ±0.11	1.34 ±0.02	3.09 ±0.15	0.529 ±0.021	>32
		Residue	14.5 ±0.3	1.28 ±0.02	5.55 ±0.22	0.722 ±0.036	n.a.
YUCCA FLAT AREA - BOUNDARY FAULT							
379	94	Acid leach	1.07 ±0.02	1.60 ±0.02	4.10 ±0.20	0.956 ±0.038	219±30
		Residue	1.48 ±0.03	0.982 ±0.015	0.737 ±0.022	0.892 ±0.036	n.a.

[1]Percent carbonate in whole sample.
[2]Isochron-plot ages after Szabo and others (1981).
[3]Represents a resample of TSV-115 which gave an age of >20,000 years (Szabo and others, 1981).
n.a. - not applicable.

carbonate-rich layer (412-1) and two were chosen from the opaline fraction of the rock (412-3 and 412-7). Opals have been reported by Knauss (1981) to be suitable for uranium-series dating.

412-1: This sample consists of a white to cream-colored, fine-grained, porous rock with a calcium carbonate percentage of 38%. Fine, semi-continuous laminations are present and the sample contains visible opaline fragments and detrital contaminants as well as subordinate thin primary opal laminae. The rock is friable and gritty with the exception of the opal laminae which are dense and resist scratching by fingernail. The sample was divided by acid leaching into two fractions. The residue represents the primary opal present in the carbonate-rich layer and some detrital components. The leachate is the calcium carbonate.

412-3: Below the carbonate-rich layer is a thick (as much as 1 cm), white to cream-colored, dense opaline layer. Porosity of the opal is variable, with dense layers and lenses alternating irregularly with discontinuous, vuggy intervals. Care was taken in sampling to segregate only the dense, pure opal for analysis. Carbonate content of this layer is negligible, less than 1% in the calculated sample. No leachate was produced for analysis.

412-7: This sample was taken from the lowest part of the whole rock. The sample superficially resembles 412-1, but contains only 12% calcium carbonate by analysis. The sample is thinly laminated and fine-grained with opal. Only the residual fraction of this sample, representing the opaline constituent, was analyzed.

Samples 412-1 and -7 were separated into insoluble and acid-leachate fractions by dissolving the soluble portion in 0.5 F (formal) HNO_3, then washing and centrifuging the residue. Sample 412-3 was washed with 8 F HCl to remove any carbonate present, dried, and processed as residue only. Solid residues were subsequently dissolved in a mixture of concentrated HF and $HClO_4$, dried, redissolved in 8 F HCl, and processed identically to leachate fractions thereafter.

Results of analyses and calculated uranium-series ages are shown in table 2. The $^{230}Th/^{232}Th$ ratios from samples of silica-rich layers, 412-3 and -7, show very high values (279 and 130, respectively). Detrital contamination of these samples is interpreted to be very low, therefore the ^{230}Th present is dominantly the product of in place uranium decay. Sample 412-1 has yielded lower $^{230}Th/^{232}Th$ ratios in both the leachate and residual fractions (11 and 22) suggesting the presence of some but not significant amounts of detrital thorium. The uranium-series dating results indicate that the deposit represented by sample 412 is greater than 350,000 years in age.

CALICHE AND TRAVERTINE FROM AMARGOSA DESERT AREA

Samples 79-3-7P and 80-10-20F were collected from a large caliche deposit in the Main Hectorite Whiting Pit, Ash Meadows. The concordant dates of the two samples of 232,000 (+45,000, -20,000) and 259,000 (+45,000, -33,000) years (table 3) probably represent the time of recrystallization associated with silica replacement occurring in the caliche breccia (R. L. Hay, written communication, 1983). The clay that locally sedimented between the calciche nodules has reversed polarity. The reason for the possible long delay in recrystallization is not clear and it requires further study.

Travertine vein samples 81-3-19F and AM-9 are from the same carbonate deposit that fills a nearly horizontal fissure between the top of the lake beds and the overlying algal tufa. The calculated uranium-series dates of 435,000 (+172,000, -73,000) and 573,000 (+ infinity, -151,000) years (table 3)

Table 2. Results of analyses of opaline carbonate samples from trench-14, Yucca Mountain area.

Sample No.	Percent[1] Carbonate	Fraction	Uranium (ppm)	Activity Ratios $^{234}U/^{238}U$	$^{230}Th/^{232}Th$	$^{230}Th/^{234}U$	U-Series Age (k.a.)
412-1	38	Acid leach	5.7 ±0.1	0.975±0.013	10.9±0.7	1.11±0.03	>400
		Opal	15.3 ±0.3	1.029±0.013	21.9±0.3	1.01±0.03	>350
412-3	1	Opal	15.7 ±0.3	1.232±0.017	279±20	1.10±0.03	>400
412-7	12	Opal	16.8 ±0.3	1.133±0.014	130±6	1.11±0.03	>400

[1]Percent carbonate in whole sample.

Table 3. Analytical data and calculated uranium-series ages of carbonates from Amargosa Desert

Sample No.	Uranium (ppm)	Activity Ratios $^{234}U/^{238}U$	$^{230}Th/^{232}Th$	$^{230}Th/^{234}U$	U-Series[2] Age (k.a.)
Caliche Nodules - Main Hectorite Whiting Pit					
79-3-7P[1]	1.51 ±0.03	1.196 ±0.012	213 ±64	0.921 ±0.027	232^{+45}_{-20}
80-10-20F[1]	0.431 ±0.015	1.206 ±0.009	55 ±11	0.952 ±0.038	259^{+45}_{-33}
Travertine Vein[2]					
81-3-19F[3]	1.25 ±0.02	1.522 ±0.022	176 ±53	1.11 ±0.03	435^{+172}_{-73}
AM-9[4]	1.24 ±0.02	1.486 ±0.022	242 ±50	1.13 ±0.03	$573^{+\infty}_{-151}$

1 Collected by R. L. Hay, 3.2 km south of IMV Plant, near center; east of edge SE 1/4 Sec. 6, T. 26N., R.5 E., (Calif. part of Ash Meadows 15 min. Quad.).
2 Vein location is SW 1/4, NW 1/4, sec.23, T.17S, R50E.
3 Collected by K. Kyser.
4 Collected by I. J. Winograd.

are at the upper limits of the resolution of the method. The dates indicate that spring discharge was occurring before about 360,000 years ago in the Kinney area of the Amargosa Desert.

TRAVERTINE FROM FURNACE CREEK WASH AREA

Travertine sample 13N was collected by I. J. Winograd in a nearly horizontal fault zone in the Furnace Creek Wash area, southwest of Amargosa Desert. Fault movement displaced vertical calcitic veins in the fanglomerate of the Funeral Formation (Winograd and Doty, 1980). The locality is about 1.6 km southwest of the Furnace Creek fault zone.

The travertine was split into four laminae, each about 5 mm in thickness, which were analyzed separately. Analytical results and calculated uranium-series dates are shown in table 4. The first samples were dissolved in concentrated HCl and $HClO_4$ acids, then analyzed. The average uranium-series date of the four travertine laminae is 187,000 ± 20,000 years B.P. The samples contained about 1 to 3 percent finely disseminated clay, that is presumedly significantly older than the travertine, therefore the calculated average date is considered a maximum date for the travertine deposition.

Aliquots of two of the laminae (13N-3 and -4) were leached by 0.5 F HNO_3 acid solution, followed by removal of the acid-insoluble residue fractions by centrifuging. The average age of the clay-free carbonate leach fractions of laminate 13N-3 and -4 is 132,000 ± 12,000 years B.P. (table 4). This average date represents a minimum age for significant movement along this low-angle fault in the Furnace Creek Wash area.

Table 4. Analytical data and calculated uranium-series ages of laminae of travertine sample 13N from Furnace Creek Wash area.

Sample No.	Uranium (ppm)	Thorium (ppm)	Activity Ratios $^{234}U/^{238}U$	$^{230}Th/^{232}Th$	$^{230}Th/^{234}U$	U-Series Age (k.a.)
			Total Dissolution			
1	0.564 ±0.011	0.75 ±0.04	1.07 ±0.02	2.05 ±0.06	0.868 ±0.035	209±25
2	0.668 ±0.013	0.86 ±0.04	1.08 ±0.02	2.00 ±0.06	0.793 ±0.032	165±16
3	0.609 ±0.012	0.88 ±0.04	1.09 ±0.02	1.84 ±0.06	0.819 ±0.033	177±18
4	0.693 ±0.014	1.05 ±0.05	1.11 ±0.02	1.82 ±0.06	0.859 ±0.034	198±22
			Carbonate Leach			
3	0.39 ±0.02	0.57 ±0.06	1.11 ±0.02	1.79 ±0.05	0.733 ±0.037	138±14
4	0.68 ±0.03	0.71 ±0.07	1.07 ±0.02	1.97 ±0.06	0.691 ±0.035	125±12
			Acid-Insoluble Residue			
3	0.74 ±0.04	0.95 ±0.10	1.03 ±0.02	1.90 ±0.05	0.769 ±0.038	n.a.
4	1.06 ±0.05	3.7 ±0.4	0.811 ±0.024	1.63 ±0.05	2.41 ±0.12	n.a.

n.a. - not applicable

Acknowledgements

W. J. Carr, I. J. Winograd, R. L. Hay and K. Kyser provided the samples. We thank W. J. Carr and D. L. Hoover for their helpful review of the manuscript.

REFERENCES

Knauss, K. G., 1981. Dating fault associated Quaternary material from the Nevada Test Site using uranium-series methods: Lawrence Livermore Laboratory, Livermore, CA., UCRL-53231, 51 p.

Szabo, B. J., Carr, W. J., and Gottschall, W. C., 1981. Uranium-thorium dating of Quaternary carbonate accumulations in the Nevada Test Site region, southern Nevada: U.S. Geological Survey Open-File Report 81-119, 33 p.

Winograd, I. J., and Doty, G. C., 1980. Paleohydrology of the southern Great Basin, with special reference to water table fluctuations beneath the Nevada Test Site during the late(?) Pleistocene: U.S. Geological Survey Open-File Report 80-569, 91 p.

Swadley, W. C., and Hoover, D. L., 1983. Geology of faults exposed in trenches in Crater Flat, Nye County, Nevada: U.S. Geological Survey Open-File Report 83-698, 15 p.

Swadley, W. C., Hoover, D. L., and Rosholt, J. N., 1984. Preliminary report on late Cenozoic faulting and stratigraphy in the vicinity of Yucca Mountain, Nye County, Nevada: U.S. Geological Survey Open-File Report 84-788, 42 p.