Radiometric Ages of Igneous Rocks From Pima, Santa Cruz, and Cochise Counties, Southeastern Arizona

GEOLOGICAL SURVEY BULLETIN 1379

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By RICHARD F. MARVIN, T. W. STERN,
S. C. CREASEY, *and* HARALD H. MEHNERT

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A tabulation of K-Ar, Pb-α, *and* Rb-Sr *ages for igneous rocks ranging in age from Pliocene to Precambrian*

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1973

UNITED STATES DEPARTMENT OF THE INTERIOR

ROGERS C. B. MORTON, *Secretary*

GEOLOGICAL SURVEY

V. E. McKelvey, *Director*

Library of Congress catalog-card No. 72-600374

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402-Price: Paper cover—35 cents domestic postpaid or 25 cents GPO Bookstore

Stock Number 2401-00283

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By RICHARD F. MARVIN, T. W. STERN, S. C. CREASEY, and HARALD H. MEHNERT

ABSTRACT

The U.S. Geological Survey has determined, by the K-Ar, Rb-Sr, and Pb-α methods, 126 radiometric ages of samples from the southeast corner of Arizona. All the data pertaining to these determinations, including both published and unpublished data, are assembled in tabular form. The radiometric ages of the samples indicate that during the Phanerozoic, from Triassic to Pliocene, the region experienced periods of plutonic and volcanic activity. Many of the exposed Precambrian rocks have a geologic history that extends back approximately 1,300–1,600 m.y. ago.

INTRODUCTION

During the last 10 years the U.S. Geological Survey has determined 126 radiometric ages on a total of 100 samples collected in Pima, Santa Cruz, and Cochise Counties in the southeast corner of Arizona. Many of these ages are unpublished; the others are published, but are scattered through various reports that describe regional or local stratigraphy or detailed economic investigations. In most reports the analytical data related to the radiometric ages are not presented, and in some reports that do contain the analytical data the descriptions of sample localities of the dated rocks are missing or they are only generalized. The purpose of the present report, therefore, is to assemble the data pertinent to all 126 ages.

Many geologists commonly evaluate age determinations only in the light of geologic evidence and do not adequately consider the importance of the analytical data. Admittedly, an analytically valid age may occasionally prove to be geologically spurious because it conflicts with incontrovertible geologic field relations.

Geologic events or natural physical processes can cause loss or gain of radiogenic isotopes after initial crystallization of a mineral, which in turn causes a spurious radiometric age. A geochronologist would require, however, that both the geologic setting and the analytical data be evaluated. Full presentation of the analytical data would reveal possible problems arising from the actual physical measurements during analysis, and would be useful in assessing the reliability of the particular radiometric age.

The ages and related data presented in this paper can be of aid to those familiar with the local geology of southeastern Arizona; however, these ages do not constitute a formal geochronological study. Examples of such studies made in this region are those of the Tucson Mountains by Bikerman and Damon (1966) and of the Roskruge Mountains by Bikerman (1967).

ACKNOWLEDGMENTS

We are indebted to many Survey personnel for information and courtesies but especially to Harald Drewes, John R. Cooper, Philip T. Hayes, Frank S. Simons, and Tom L. Finnell. We also acknowledge the exacting work done by Gerald T. Cebula, John H. Mangum, and George C. Cone in obtaining necessary mineral concentrations.

RADIOMETRIC AGES

Radiometric ages were determined for a total of 100 rock samples collected from the southeast corner of Arizona. The samples are listed in table 1 according to geographic area (for example, Sierrita Mountains, Santa Rita Mountains) and within each area, according to age, with the youngest first. The relative locations of the mountain ranges and hills are shown in figure 1.

In all, 84 K-Ar, 38 Pb-α, and four Rb-Sr ages were determined. The analytical data for these ages are shown in tables 2, 3, and 4, respectively. The analytical techniques used are described by Evernden and Curtis (1965) for the K-Ar method, Jaffe, Gottfried, Waring, and Worthing (1959) for Pb-α, and Peterman, Doe and Bartel (1967), for Rb-Sr. Most of the mass spectrometric analyses of argon were made with the argon gas under static conditions; all other argon analyses were made under dynamic conditions (Hamilton, 1965, p. 54). Those K-Ar ages of Late Cretaceous or Tertiary age that were determined in the early 1960's were reported with only two significant figures, whereas today the ages are generally reported with three significant figures.

Many samples were dated by both the K-Ar and Pb-α methods. For other samples, coexistent biotite and hornblende both were

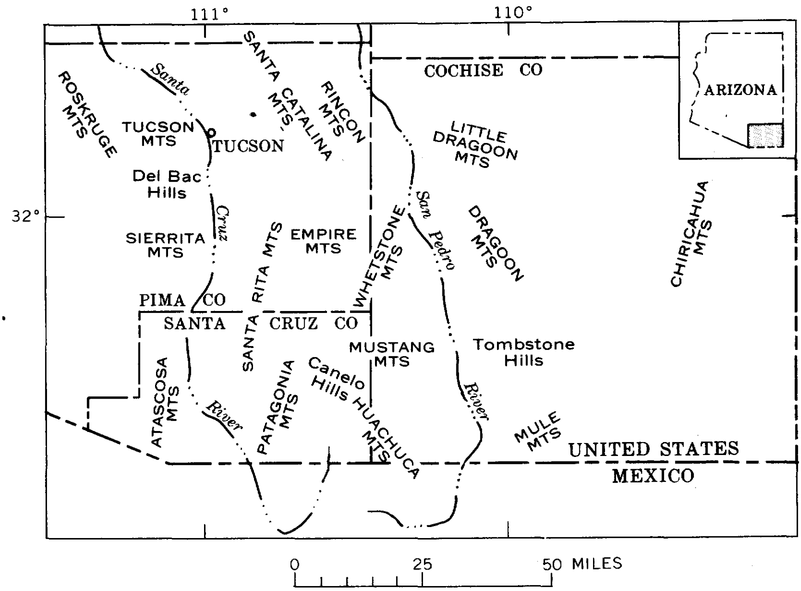

FIGURE 1.—Map of southeast corner of Arizona showing locations of geographic features mentioned in text.

analyzed by the K-Ar method. One of the purposes of this procedure, whether using two different age methods or a biotite-hornblende pair, was to check for reduced ages—those caused by a thermal event some time after the initial crystallization of the rock. Owing to the large degree of uncertainty that is inherent in the Pb-α age method, the practice of checking the K-Ar age by the Pb-α age is not now usually followed. When possible, a K-Ar mica age is now usually checked against an amphibole age from the same specimen or against a Rb-Sr whole-rock age. Unfortunately, many rocks can be dated by only one mineral.

No doubt some reservations will be held concerning these Pb-α ages until they are confirmed or disproved by U-Pb isotopic ages. However, most Pb-α ages are consistent, within analytical error, with the geologic sequence as determined by field evidence within a geographic area, such as the Santa Rita Mountains. The large number of Pb-α ages determined for different igneous units in this region indicates that suitable zircons are available for U-Pb age investigations.

For those who have difficulty in remembering the numerical geologic time scale, table 5 has been included to help the reader translate the ages listed in table 1 to their corresponding major stratigraphic or time division. It should be noted that many radiometric ages are on or near a time division boundary. In these instances, the possible age range, as indicated by the analytical error, may straddle the boundary; for example, the age of a sample may be Late Cretaceous or early Paleocene. The geologist, interpreting this radiometric age, may think that geologic field relations indicate a Late Cretaceous age in preference to the early Paleocene age. As a result of such decisions, some of the published radiometric ages in this tabulation have been interpreted more strictly than their analytical error alone would allow.

DISCUSSION

The radiometric ages discussed in this report have been of great help to geologists in deciphering the geologic history of the many intrusions and volcanics in southeastern Arizona. Paleontologic control, in many areas, is either nonexistent or of very limited help. With the help afforded by these ages, a much clearer understanding of the geologic history has been obtained, both on a local basis (see Cooper, 1971; Drewes, 1968, 1970, 1971b, 1972; Hayes and others, 1965; and Simons, 1972) and on a regional basis (Hayes, 1970a). However, the complete story is not known; some ages—discordant ages—indicate tectonic, thermal, or perhaps hydrothermal events that complicate or confuse our understanding of the geologic history. Altered rock or unsuitable material prevents determination of ages in crucial areas. Many problems remain for geochronologists and geologists.

For the most part, the Tertiary and Late Cretaceous ages determined for the rocks in this region coincide with the age span of igneous episodes determined by detailed geochronologic studies in the Tucson, Roskruge, and Chiricahua Mountains of Arizona (Bikerman and Damon, 1966; Bikerman, 1967; Marjaniemi, 1968). These tabulated ages also indicate that igneous activity was most intense during the middle Tertiary and during the late Late Cretaceous and Paleocene. These two periods of intense activity agree with the peaks of a histogram of radiometric ages drawn by Damon and Mauger (1966) from ages representing the entire Basin and Range province.

The youngest igneous rock radiometrically dated by us is a basalt flow of late Miocene or early Pliocene age. This basalt flow and others that are intercalated with gravels of the Nogales Formation on the west side of the Atascosa Mountains may represent a local outbreak of the same igneous event that produced felsic ash flows and basic flows and dikes during the late Miocene and early Pliocene (14.4–9.7 m.y.) in the Roskruge Mountains (Bikerman, 1967).

No middle Miocene volcanic rocks have been disclosed by our ages, although rocks of that age are known elsewhere in southeastern Arizona—dacite near Superior dated by Creasey and Kistler (1962) and basaltic andesite in the Tucson Mountains dated by Bikerman and Damon (1966). Our radiometric ages do indicate widespread igneous activity during the late Oligocene and early Miocene (28–23 m.y.). Dikes of this age are known in the Sierrita and Santa Rita Mountains (samples 1, 2, 15, table 1), in the Roskruge Mountains (Bikerman, 1967), and in the Tucson Mountains (Bikerman and Damon, 1966). Tuffs and flows of mappable proportions also formed at this time in the Patagonia Mountains (samples 51, 52, table 1), Tucson Mountains (Bikerman and Damon, 1966), Chiricahua Mountains (Marjaniemi, 1968), Del Bac Hills (Percious, 1968), and Santa Rita Mountains—Grosvenor Hills Volcanics (Drewes, 1968). During this same period of igneous activity, plutons were emplaced in the Santa Rita, Rincon, and Dragoon Mountains (samples 18, 19, 80, 81, 82, 89, 90, table 1).

Early and middle Oligocene ages are not common but have been obtained for plutonic rock in the Roskruge Mountains (Bikerman, 1967), and for extrusive rock in the Dragoon Mountains (sample 91, table 1). Similar ages for volcanic rock have also been determined for the Helmet Fanglomerate near the Sierrita Mountains (Damon, 1968) and for tuff in the Pantano Formation near the Rincon Mountains (Damon and Bikerman, 1964). (The Pantano Formation may range in age from late Eocene to early Miocene—see sample 71, table 1 this report, and Finnell, 1970, p. A36, who assigned an Oligocene to Miocene age.)

Bikerman and Damon (1966) reported that extrusive activity in the Tucson Mountains during late Eocene or early Oligocene formed the Rillito Andesite of Brown (1939). One or more rhyolitic tuffs in the Pantano(?) Formation near the Mustang Mountains are of the same age as the Rillito Andesite.

A cessation of most igneous activity for about 10 m.y. occurred between the middle Tertiary igneous episode and an older igneous episode that extended from Late Cretaceous to middle Eocene, terminating with the emplacement of the Texas Canyon Quartz Monzonite in the Little Dragoon Mountains (sample 88, table 1) and (or) with the Eocene igneous activity in the Sierrita Mountains (samples 4, 5, 6, table 1; and Damon and Mauger, 1966). This older igneous episode culminated in the late Late Cretaceous and Paleocene.

Intrusive igneous activity during the Paleocene produced stocks and plugs in the Sierrita, Santa Rita, and Patagonia Mountains (samples 10, 21–25, 53, 54, table 1). Extrusive igneous activity also occurred as evidenced by a rhyolite tuff in the Sierrita Mountains (Creasey and Kistler, 1962) and by the Gringo Gulch Volcanics in the Santa Rita Mountains (Drewes, 1968). To the northwest, Paleocene flows and tuffs commonly occur in the Roskruge Mountains (Bikerman, 1967) and in the Tucson Mountains (Bikerman and Damon, 1966).

During the Late Cretaceous, large stocks were formed in the Empire and Whetstone Mountains (samples 74, 75, 76, 79, table 1), the Tombstone Hills—the Schieffelin Granodiorite (Creasey and Kistler, 1962), and the Santa Rita Mountains—Elephant Head Quartz Monzonite, Madera Canyon Granodiorite, and Josephine Canyon Diorite (Drewes, 1968). Upper Cretaceous volcanics are the Demetrie Volcanics and Red Boy Rhyolite in the Sierrita Mountains (Cooper, 1971), the Salero Formation and the volcanic sections of the Fort Crittenden Formation in the Santa Rita Mountains (Drewes, 1968, 1971b), the volcanics of Dove Canyon in the Canelo Hills (Simons, 1972), the trachyandesite of Meadow Valley in the Patagonia Mountains (Simons, 1972), Uncle Sam Porphyry in Tombstone Hills (Drewes, 1971b, p. C75), and the Sugarloaf Quartz Latite in the Dragoon Mountains (Hayes, 1970a, p. B28; Drewes, 1971b, p. C75). Similar igneous activity was occurring during this time in the Tucson Mountains (Bikerman and Damon, 1966) and in the Roskruge Mountains (Bikerman, 1967).

Volcanic activity during the Early Cretaceous is indicated by the volcanic sections of the Temporal and Bathtub Formations (Drewes, 1968, 1971b). However, radiometric ages have not confirmed the age designation of these formations (see samples 41, 46, table 1).

Stocks of Jurassic age are the Sierrita Granite of Lacy (1959) in the Sierrita Mountains (sample 11, table 1), the Squaw Gulch Granite in the Santa Rita Mountains (Drewes, 1968), the granite of Comoro Canyon and quartz monzonite of Mount Benedict in the Patagonia Mountains (Simons, 1973), the Huachuca Quartz Monzonite in the Huachuca Mountains (Hayes, 1970b), the Gleeson Quartz Monzonite in the Dragoon Mountains (Anderson, 1968), and the Juniper Flat Granite in the Mule Mountains (Creasey and Kistler, 1962). Ages of these plutons range from 178 to 145 m.y. and suggest that most of the plutons were emplaced about Middle Jurassic. Tuffs and flows of Jurassic age are found in the Canelo Hills, Huachuca, Santa Rita, and Patagonia Mountains—Canelo Hills Volcanics (Hayes and Raup, 1968; Hayes, 1970a; Drewes, 1971b; Simons, 1972). The Canelo Hills Volcanics may range in age from Triassic through Jurassic.

A few stocks gave discordant ages—a Jurassic age by the Pb-α method and a Late Cretaceous or Paleocene age by the K-Ar method. After considering the geologic possibilities, the geologists mapping the stocks decided that the Jurassic age was correct.

Late Triassic plutons, as indicated by Pb-α ages, are the quartz monzonite of Harris Ranch in the Sierrita Mountains (Cooper, 1971, p. D13) and the Piper Gulch Monzonite in the Santa Rita Mountains (Drewes, 1968). Triassic flows and tuffs are the Ox Frame Volcanics (Cooper, 1971), the Gardner Canyon and Mount Wrightson Formations in the Santa Rita Mountains (Drewes, 1968, 1971b), and the Gardner Canyon Formation in the Empire Mountains (sample 77, table 1).

Those Pb-α ages that suggest a Mississippian, Pennsylvanian, or Permian age are probably spurious. The Paleozoic marine sedimentary sequence, ranging in age from Cambrian to Permian, indicates that the region was stable and that igneous activity at this time was unlikely.

The presence of Precambrian intrusive rocks in the Sierrita, Santa Rita, and Patagonia Mountains is confirmed by Pb-α and Rb-Sr ages (samples 14, 48, 49, 61, table 1). In the Santa Rita Mountains, it is likely that all K-Ar mica ages for the Precambrian Continental Granodiorite (Drewes, 1968) will be reduced ages, due to heating caused by Mesozoic and (or) Tertiary igneous activity.

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TABLES 1–5

TABLE 1.—*Rock type, locality, and calculated age of samples from southeastern Arizona*

[Samples are listed, under geographic region, according to age, with the youngest first. Radiometric-age method (K-Ar, Rb-Sr, or Pb-α) and analyzed mineral or material (B for biotite; F, K-feldspar; H, hornblende; M, muscovite; P, plagioclase; S, sanidine; WR, whole rock; and Z, zircon) are specified within the parentheses following the calculated age. Analytical data are shown on tables 2, 3, and 4]

Sample No.	Rock type, intrusive body, or stratigraphic formation	Location (latitude N., longitude W.)	Calculated age (m.y.)		Comment and (or) reference
			Sierrita Mountains		
1	Andesite	31°56′45″ 111°04′15″	24	(K-Ar,B)	Creasey and Kistler (1962, p. D1, No. 7 of table 120.1).
2	Kersantite	31°59′42″ 111°04′	26.4±1.0	(K-Ar,B)	Unpublished age of unmineralized dike cutting hypogene copper ore body, Mission mine, Pima district; dike is related to the same igneous event that produced the 24-m.y.-old andesite dikes (see sample 1).
3	Granodiorite, sheared and altered.	31°59′30″ 111°07′	36±2	(K-Ar,B)	Unpublished age for granodiorite; Damon and Mauger (1966) obtained 50.7±1.1 m.y. for muscovite from pegmatite cutting this intrusion (J. R. Cooper, written commun., 1971).
4	Granodiorite porphyry, Ruby Star(?) Granodiorite.	31°58′ 111°06′	46±2	(K-Ar,B)	Unpublished age; it may have been reduced by pegmatitic activity dated by Damon and Mauger (1966) (see comment for sample 3); Lovering and others (1970, p. B5) considered the Ruby Star Granodiorite to be Paleocene (see sample 10).
5	Gangue	31°59′35″ 111°04′	47±2	(K-Ar,F)	Unpublished age, Mission mine, Pima district; probably a reduced age.
6	Altered diorite	31°52′ 111°07′	47±3	(K-Ar,F)	Unpublished age of mineralized rock from west end of the Esperanza mine, Pima district; probably a reduced age. Damon and Mauger (1966) obtained 62.6±2.0 m.y. for altered diorite in the same area and 60.6±1.8 m.y. for muscovite from quartz veinlets, Esperanza pit, 31°52.0′N, 111°07.7′W.

7	Quartz monzonite porphyry	31°52′30″ 111°07′45″	56	(K-Ar,B)	Creasey and Kistler (1962, p. D1, No. 5 of table 120.1).
8	Rhyolite tuff	31°57′30″ 111°04′30″	57	(K-Ar,B)	Creasey and Kistler (1962, p. D1, No. 6 of table 120.1).
9	Coarse biotite veinlets in diorite.	31°53′ 111°09′	60±3 56±3	(K-Ar,B) (K-Ar,F)	Unpublished ages for diorite from copper prospect 1.6 mi. WNW. of Esperanza mine; Lovering and others (1970, p. B7) mentioned age relations of igneous intrusions.
10	Granodiorite, Ruby Star Granodiorite.	31°54′00″ 111°06′30″	60	(K-Ar,B)	Creasey and Kistler (1962, p. D1, No. 4 of table 120.1).
11	Alkali granite, Sierrita Granite of Lacy (1959).	31°54′ 111°11′30″	150±20 55±3	(Pb-α,Z) (K-Ar,B)	Ages given by sample T169 (Cooper, 1971, p. D13); biotite age appears to be a reduced age. Damon (1966, p. 23) cited a Rb-Sr age of 140±14 m.y. for the age of an alkali granite sample collected near sample 11.
12	Quartz monzonite, quartz monzonite of Harris Ranch.	31°52′ 111°10′	190±20	(Pb-α,Z)	Age given by sample T400 (Cooper, 1971, p. D13).
13	Quartz monzonite, quartz monzonite of Harris Ranch(?).	31°56′ 111°16′	210±30 40±2	(Pb-α,Z) (K-Ar,B)	Unpublished ages; biotite age appears to be a reduced age.
14	Gneissic quartz monzonite	31°54′ 111°05′	850±100	(Pb-α,Z)	Unpublished age for Precambrian granitic complex (J. R. Cooper, written commun., 1971).
			Santa Rita Mountains		
15	Rhyolite vitrophyre, Box Canyon dike swarm.	31°45′30″ 110°48′05″	25.9±1.3	(K-Ar,S)	Age given by sample 899 (Drewes, 1971c). Also see Drewes (1972.)
16	Rhyodacite vitrophyre, Grosvenor Hills Volcanics.	31°34′05″ 110°53′10″	26.2±1.9	(K-Ar,P)	Age given by sample 710 (Drewes, 1971a). Drewes (1968, p. C15; 1972) considered the Grosvenor Hills Volcanics to be late(?) Oligocene.
17	Latite vitrophyre, Grosvenor Hills Volcanics.	31°31′15″ 110°50′55″	26±2 27±3 40±10	(K-Ar,B) (K-Ar,H) (Pb-α,Z)	Ages given by sample 315 (Drewes, 1971a). See comment for sample 16.
18	Granodiorite, granodiorite of the San Cayetano Mountains.	31°32′15″ 110°59′00″	27.6±1.3	(K-Ar,B)	Age given by sample 687 (Drewes, 1971a). (Also see Drewes 1972.)

TABLE 1.—*Rock type, locality, and calculated age of samples from southeastern Arizona*—Continued

Sample No.	Rock type, intrusive body, or stratigraphic formation	Location (latitude N., longitude W.)	Calculated age (m.y.)		Comment and (or) reference
		Santa Rita Mountains--Continued			
19	Rhyodacite vitrophyre	31°35′35″ 110°55′35″	27.8±2.2	(K-Ar,H)	Age given for sample 581 (Drewes, 1971a). Laccolith intruding Grosvenor Hills Volcanics (H. Drewes, written commun., 1971).
20	Rhyolite porphyry, Gardner Canyon dike swarm.	31°43′13″ 110°46′03″	40±10	(Pb-α,Z)	Age given by sample 340 (Drewes, 1971a). Dikes are likely Oligocene (H. Drewes, written commun., 1971).
21	Granodiorite	31°50′15″ 110°48′25″	53.5±2.0 52.2±2.0	(K-Ar,B) (K-Ar,B)	Age given by sample 1051 (Drewes, 1971c). Paleocene stock (Lovering and others, 1970, p. B4).
22	Quartz latite porphyry	31°52′31″ 110°47′20″	53.9±2.0	(K-Ar,B)	Unpublished age of Paleocene plug mentioned by Lovering and others (1970, p. B4).
23	do	31°46′00″ 110°46′45″	55.7±2.2	(K-Ar,B)	Paleocene plug (Lovering and others, 1970, p. B4; Drewes, 1970, p. A8).
24	do	31°51′15″ 110°45′30″	55.8±2.1	(K-Ar,B)	Age given by sample 1185 (Drewes, 1971c). Paleocene plug (Lovering and others, 1970, p. B4; Drewes, 1970, p. A8).
25	do	31°51′45″ 110°47′00″	56.3±2.1	(K-Ar,B)	Age given by sample 1245 (Drewes, 1971c). Paleocene plug (Lovering and others, 1970, p. B4).
26	Latitic lava, Mount Wrightson Formation.	31°41′40″ 110°58′30″	60±10	(Pb-α,Z)	Age given by sample 917 (Drewes, 1971a). Age is spurious as Mount Wrightson Formation is Triassic according to Drewes (1968, p. C6–C7; 1971b, p. C14).
27	Hornblende dacite porphyry, Gringo Gulch Volcanics.	31°35′05″ 110°46′55″	60.4±4.2	(K-Ar,H)	Age given by sample 660 (Drewes, 1971a). (Also see Drewes, 1972.)
28	Microgranodiorite, Gringo Gulch Volcanics.	31°35′10″ 110°46′40″	60±3 50±10	(K-Ar,B) (Pb-α,Z)	Age given by sample 281 (Drewes, 1971a). (Also see Drewes, 1972.)

29	Diorite, Josephine Canyon Diorite.	31°33′55″ 110°50′40″	60±10	(Pb-α,Z)	Age given by sample 292 (Drewes, 1971a). Josephine Canyon Diorite is Late Cretaceous according to Drewes 1968, p. C12).
30	-----do -------------------	31°34′55″ 110°51′10″	67±3 60±10	(K-Ar,B) (Pb-α,Z)	Ages given by sample 316 (Drewes, 1971a). See comment for sample 29.
31	Quartz monzonite, Josephine Canyon Diorite.	31°32′50″ 110°49′40″	60±20	(Pb-α,Z)	Age of fine-grained quartz monzonite phase of the Josephine Canyon Diorite, sample 507 (Drewes, 1971a). See comment for sample 29.
32	Dacite porphyry -----------	31°37′25″ 110°47′30″	67±3 60±10	(K-Ar,H) (Pb-α,Z)	Ages given by sample 379 from Paleocene dike (Drewes, 1971a).
33	Quartz porphyry, Elephant Head Quartz Monzonite.	31°42′35″ 110°56′00″	68.2±3.0 170±20	(K-Ar,B) (Pb-α,Z)	Ages given by sample 754 (Drewes, 1971a). An age of Late Cretaceous for the Elephant Head Quartz Monzonite has been designated, but a Jurassic age is not geologically impossible (Drewes, 1968, p. C13–C14).
34	Quartz monzonite, Elephant Head Quartz Monzonite.	31°43′35″ 110°53′50″	69.0±2.9 190±30	(K-Ar,B) (Pb-α,Z)	Ages given by sample 876 (Drewes, 1971a). See comment for sample 33.
35	Rhyodacite welded tuff, Salero Formation.	31°35′45″ 110°55′35″	72.5±3.3	(K-Ar,B)	Age given by sample 580 (Drewes, 1971a). Drewes (1968, p. C11–C12; 1971b, p. C74–C75) stated that the Salero Formation is Late Cretaceous. Simons (1972, p. E21).
36	Quartz diorite -------------	31°55′20″ 110°42′30″	73.6±2.8	(K-Ar,B)	Unpublished age of quartz diorite stock mapped by Finnell (1971).
37	Quartz monzonite ----------	31°55′50″ 110°43′36″	73.8±2.6	(K-Ar,B)	Unpublished age of quartz monzonite stock mapped by Finnell (1971).
38	Granite, Squaw Gulch Granite.	31°36′30″ 110°56′20″	145±6 160±20	(K-Ar,B) (Pb-α,Z)	Ages given by sample 605 (Drewes, 1971a). Squaw Gulch Granite described by Drewes (1968, p. C8).
39	-----do -------------------	31°34′15″ 110°49′05″	160±20	(Pb-α,Z)	Age given by sample 282 (Drewes, 1971a). See comment for sample 38.
40	Porphyritic granodiorite, Continental Granodiorite.	31°37′03″ 110°55′45″	159±7	(K-Ar,B)	Unpublished age given by sample of recrystallized Precambrian granodiorite (H. Drewes, written commun., 1971).

TABLE 1.—*Rock type, locality, and calculated age of samples from southeastern Arizona*—Continued

Sample No.	Rock type, intrusive body, or stratigraphic formation	Location (latitude N., longitude W.)	Calculated age (m.y.)		Comment and (or) reference
Santa Rita Mountains--Continued					
41	Rhyolitic welded tuff, Temporal Formation.	31°34′40″ 110°47′50″	180±20	(Pb-α,Z)	Age given by sample 905 (Drewes, 1971a). Drewes (1968, p. C8–C9; 1971b, p. C33–C34) wrote that the Temporal Formation is probably Early Cretaceous and that the dated zircons may be xenocrystic, coming from the underlying Squaw Gulch Granite regolith.
42	Monzonite, Piper Gulch Monzonite.	31°37′40″ 110°49′35″	180±20	(Pb-α,Z)	Age given by sample 280 (Drewes, 1971a). Drewes (1968, p. C8–C9) described the Piper Gulch Monzonite as Triassic.
43	Quartz monzonite, Piper Gulch Monzonite.	31°45′30″ 110°46′	180±30	(Pb-α,Z)	Unpublished age. See comment for sample 42.
44	Dacite flow, upper member of Gardner Canyon Formation.	31°43′15″ 110°46′05″	190±20	(Pb-α,Z)	Age given by sample 339 (Drewes, 1971a). Gardner Canyon Formation is Triassic according to Drewes (1968, p. C7; 1971b, p. C24). Simons (1972, p. E2).
45	Latitic lava, middle member of Mount Wrightson Formation.	31°42′00″ 110°51′00″	220±30	(Pb-α,Z)	Age given by sample 918 (Drewes, 1971a). Mount Wrightson Formation described by Drewes (1968, p. C6–C7).
46	Dacite volcanic breccia, middle member of Bathtub Formation.	31°37′25″ 110°47′30″	250±45	(Pb-α,Z)	Age given by sample 1113 (Drewes, 1971a). The Bathtub Formation is Early Cretaceous according to Drewes (1968, p. C9–C10; 1971b, p. C43). Zircon age is too old.
47	Rhyolite tuff, tuff member of Fort Crittenden Formation.	31°40′25″ 110°57′00″	260±30	(Pb-α,Z)	Age given by sanmple 1046 (Drewes, 1971a). The Fort Crittenden Formation is Late Cretaceous according to Drewes (1968, p. C10–C11; 1971b, p. C63). Zircon age is too old.

48	Porphyroblastic granodiorite, Continental Granodiorite.	31°47′55″ 110°48′30″	1360±200 55.5±2.4	(Pb-α,Z) (K-Ar,B)	Ages given by sample 1046 (Drewes, 1971c). Drewes (1968, p. C5) described the Continental Granodiorite as Precambrian. K-Ar age is a reduced age. Biotite shows recrystallization fabric (H. Drewes, written commun., 1971).
49	-----do -------------------	31°47′55″ 110°46′50″	1450±160 800±80	(Pb-α,Z) (Rb-Sr,WR)	Ages given by sample 914 (Drewes, 1971c). Rb-Sr age is a reduced age. See comment for sample 48.
		Atascosa Mountains			
50	Olivine basalt, Nogales Formation.	31°27′ 111°03′30″	12.6±0.8	(K-Ar,WR)	Unpublished age of basalt flow intercalated in gravels of the Nogales Formation (H. Drewes, written commun., 1971).
		Patagonia Mountains			
51	Rhyolite tuff ---------------	31°27′40″ 110°40′	23±2 27±3	(K-Ar,B) (K-Ar,H)	Unpublished ages.
52	-----do -------------------	31°29′15″ 110°48′15″	26±2	(K-Ar,B)	Unpublished age. Damon and Bikerman (1964) obtained 25.3±5.1 m.y. for biotite from same locality (F. S. Simons, written commun., 1971).
53	Granodiorite ---------------	31°23′15″ 110°43′	58±3 58±5	(K-Ar,B) (K-Ar,H)	Unpublished ages for probable Paleocene pluton. Damon and Mauger (1966) determined a K-Ar age of 63.9±2.0 m.y. for sample of quartz diorite collected at 31°23.2′N, 110°43.1′W.
54	Quartz monzonite ----------	31°20′30″ 110°44′45″	58±3	(K-Ar,B)	Unpublished age for quartz monzonite facies of granodiorite pluton dated by sample 53 (F. S. Simons, written commun., 1971). See comment for sample 53.
55	Alkali syenite, granite of Comoro Canyon.	31°28′ 110°46′30″	150±20	(Pb-α,Z)	Unpublished age. Granite of Comoro Canyon is Jurassic according to Simons (1972, p. E10). Pluton mapped by Simons (1973).

TABLE 1.—*Rock type, locality, and calculated age of samples from southeastern Arizona*—Continued

Sample No.	Rock type, intrusive body, or stratigraphic formation	Location (latitude N., longitude W.)	Calculated age (m.y.)		Comment and (or) reference
			Patagonia Mountains--Continued		
56	Tuff, Nogales Formation ----	31°23′30″ 110°56′	153±10	(K-Ar,H)	This age is spurious as tuff is part of upper Tertiary Nogales Formation (F. S. Simons, written commun., 1971).
57	Quartz monzonite, quartz monzonite of Mount Benedict.	31°24′30″ 110°55′30″	160±7 164±19	(K-Ar,B) (K-Ar,H)	Unpublished ages. Pluton mapped by Simons (1973).
58	Granite, granite of Comoro Canyon.	31°26′30″ 110°47′	160±20	(Pb-*a*,Z)	Age given by sample 14 (Simons, 1972, p. E11, table 1). See comment for sample 55.
59	Quartz monzonite ----------	31°27′ 110°49′	240±30	(Pb-*a*,Z)	Age is anomalous; pluton is Precambrian(?) (F. S. Simons, written commun., 1971).
60	Granite, granite of Comoro Canyon.	31°29′45″ 110°46′00″	520±60	(Pb-*a*,Z)	Age is spurious (F. S. Simons, written commun., 1971). See comment for sample 55.
61	Quartz monzonite ----------	31°25′35″ 110°42′10″	1280±150	(Pb-*a*,Z)	Unpublished age. Pluton mapped by Simons (1973).
			Huachuca Mountains		
62	Quartz monzonite, Huachuca Quartz Monzonite.	31°22′ 110°17′	90±30	(Pb-*a*,Z)	Unpublished age which appears to be too young for this Jurassic pluton. See comment for sample 63.
63	-----do ------------------	31°21′15″ 110°15′15″	164±6	(K-Ar,B)	Hayes (1970b, p. A10) considered this pluton to be Jurassic; mapped by Hayes and Raup (1968).
64	Granodiorite, Huachuca Quartz Monzonite.	31°21′ 110°15′	210±30	(Pb-*a*,Z)	Unpublished age which appears to be too old for this Jurassic pluton. See comment for sample 63.
65	Welded tuff, Canelo Hills Volcanics.	31°23′20″ 110°23′	144±6 144±11	(K-Ar,B) (Rb-Sr,WR)	Hayes (1970b, p. A8); Simons (1972, p. E2). Rb-Sr age has not been published previously.

66	Andesite, andesite unit in Glance Conglomerate.	31°27′45″ 110°23′10″	220±35	(Pb-*a*,Z)	Unpublished age which is too old for this unit or field assignment by Hayes and Raup (1968) is in error (P. T. Hayes, written commun., 1971).
			Canelo Hills		
67	Latitic welded tuff, trachyandesite of Meadow Valley.	31°28′45″ 110°36′	72.1±3.0	(K-Ar,B)	Simons (1972, p. E21). Formation mapped by Simons (1973).
68	Partly welded latitic tuff, volcanics of Dove Canyon.	31°24′45″ 110°30′45″	72±4	(K-Ar,B)	Simons (1972, p. E18). Formation mapped by Simons (1973).
69	Welded tuff, Canelo Hills Volcanics.	31°24′ 110°23′	165±6	(K-Ar,B)	Hayes (1970a, p. B20). Tuff placed in Canelo Hills Volcanics by P. T. Hayes (written commun., 1971).
70	Rhyolitic tuff, Canelo Hills Volcanics.	31°29′30″ 110°32′	173± 8	(K-Ar,B)	Hayes and others (1965, p. M7); Drewes (1971b, p. C25); Simons (1972, p. E2, and p. E11, sample 12 of table 1).
			Mustang Mountains		
71	Rhyolitic tuff, Pantano(?) Formation.	31°37′ 110°25′	38.9±1.5	(K-Ar,B)	Unpublished age of Pantano(?) Formation (H. Drewes, written commun., 1971) which was mapped as "Tertiary gravels, deformed" by Hayes and Raup (1968). Finnell (1970, p. A36) has described the Pantano Formation as Oligocene to Miocene near the Empire Mountains.
72	Latitic welded tuff ---------	31°39′ 110°28′	310±40	(Pb-*a*,Z)	Unpublished age that is spurious; tuff is Triassic-Jurassic according to mapping by Hayes and Raup (1968).
			Empire Mountains		
73	Dacite, Pantano Formation --	31°52′48″ 110°39′51″	28.0±1.1	(K-Ar,B)	Finnell (1970, p. A36).
74	Quartz monzonite ----------	31°54′ 110°38′	70.3±2.5	(K-Ar,B)	Unpublished age for pluton mapped by Finnell (1971).
75	-----do -------------------	31°54′30″ 110°39′20″	80±15	(Pb-*a*,Z)	Do.
76	-----do -------------------	31°53′15″ 110°37′40″	110±20	(Pb-*a*,Z)	Do.

TABLE 1.—*Rock type, locality, and calculated age of samples from southeastern Arizona*—Continued

Sample No.	Rock type, intrusive body, or stratigraphic formation	Location (latitude N., longitude W.)	Calculated age (m.y.)		Comment and (or) reference
		Empire Mountains--Continued			
77	Rhyolite(?) tuff, Gardner Canyon Formation.	31°55′50″ 110°36′40″	170±35	(Pb-*a*,Z)	Unpublished age for formation mapped by Finnell (1971). Drewes (1971b, p. C24) provisionally stated that this formation is Triassic.
78	Rhyolitic welded tuff, Gardner Canyon(?) Formation.	31°51′07″ 110°44′58″	210±30	(Pb-*a*,Z)	Do.
		Whetstone Mountains			
79	Granodiorite	31°46′18″ 110°25′21″	74±4 74±4	(K-Ar,B) (K-Ar,H)	Ages determined for pluton mapped by Creasey (1967).
		Rincon Mountains			
80	Quartz monzonite	32°07′ 110°28′	23.5±0.9 24.8±0.9	(K-Ar,B) (K-Ar,M)	Unpublished ages for pluton.
81	Granodiorite	32°07′ 110°25′	26.3±0.9	(K-Ar,B)	Unpublished ages for pluton.
82	-----do	32°12′ 110°27′	27.3±1.1	(K-Ar,B)	Unpublished age for granodiorite stock.
83	Pegmatite	32°12′ 110°27′	36.8±1.6	(K-Ar,M)	Unpublished age for pegmatite within the granodiorite stock listed for sample 82 (H. Drewes, written commun., 1970).
84	Mica schist, Pinal Schist	32°12′ 110°27′	28.4±1.1	(K-Ar,B)	Unpublished age given by recrystallized Precambrian Pinal Schist (H. Drewes, written commun., 1970).
85	-----do	32°13′30″ 110°25′30″	33.8±1.2 29.0±0.9 28.9±1.0	(K-Ar,B) (K-Ar,M) (K-Ar,M)	Do.
86	Quartz monzonite, Rincon	32°06′	1540±60	(K-Ar,B)	Unpublished age for Rincon Valley

	Valley Granite of Acker (1958).	110°26′			Granite which was thought by Acker (1958) to be Laramide but it is Precambrian on the basis of radiometric dating.
87	-----do ------------------	32°05′ 110°37′	1450±50 1560±100	(K-Ar,B) (K-Ar,H)	Do.
			Little Dragoon Mountains		
88	Quartz monzonite, Texas Canyon Quartz Monzonite.	32°06′ 110°05′	50±3 52±3	(K-Ar,B) (K-Ar,B)	Unpublished ages for stock described by Cooper and Silver (1964) as probably early Tertiary. These ages are in good agreement with K-Ar ages determined by Livingston and others (1967) for this intrusion.
			Dragoon Mountains		
89	Quartz monzonite, Stronghold Granite.	31°56′ 109°59′30″	25.9±2	(K-Ar,B)	Unpublished age for pluton mapped by Gilluly (1956) and designated as Tertiary. Damon and Bikerman (1964) obtained an age of 22±3 m.y. for a sample of Stronghold Granite collected at 31°55′24″N, 109°58′00″W.
90	-----do ------------------	31°56′ 110°00′	26±2	(K-Ar,B)	Do.
91	Andesite, andesite member of Sugarloaf Quartz Latite.	31°48′ 109°47′	33.3±2.6	(K-Ar,H)	Unpublished age for formation mapped by Gilluly (1956) and designated by him as Cretaceous or Tertiary.
92	Quartz latite tuff, S O Volcanics.	31°44′ 109°53′	47±2	(K-Ar,B)	Unpublished age for formation mapped by Gilluly (1956) and designated as Tertiary. Sample collected from lower tuff member (H. Drewes, written commun., 1970).
93	Welded tuff, Sugarloaf Quartz Latite.	31°43′ 109°47′	72.8±2.8	(K-Ar,B)	Hayes (1970a, p. B28); Drewes (1971b, p. C75.
94	Quartz monzonite, Gleeson Quartz Monzonite.	31°44′ 109°52′30″	178±5	(K-Ar,M)	Anderson (1968, p. 1167).

TABLE 1.—*Rock type, locality, and calculated age of samples from southeastern Arizona*—Continued

Sample No.	Rock type, intrusive body, or stratigraphic formation	Location (latitude N., longitude W.)	Calculated age (m.y.)		Comment and (or) reference
			Tombstone Hills		
95	Rhyolite	31°39′12″ 110°02′42″	63	(K-Ar,B)	Creasey and Kistler (1962, p. D1, No. 2 of table 120.1).
96	Rhyodacite, Uncle Sam Porphyry.	31°41′15″ 110°14′45″	71.9±2.7	(K-Ar,B)	Late Cretaceous age according to Drewes (1971b, p. C75). This intrusive breccia was accorded a Tertiary age by Gilluly (1956).
97	Granodiorite, Schieffelin Granodiorite.	31°43′48″ 110°06′09″	72	(K-Ar,B)	Creasey and Kistler (1962, p. D1, No. 3 of table 120.1).
			Mule Mountains		
98	Granite, Juniper Flat Granite.	31°30′10″ 110°00′09″	163 186 188	(K-Ar,B) (Rb-Sr,B) (Rb-Sr,B)	Creasey and Kistler (1962, p. D1, No. 1 of table 120.1). Rb-Sr ages have been recalculated with $\lambda = 1.39 \times 10^{-11}$/yr for Rb^{87}.
			Chiricahua Mountains		
99	Granodiorite	32°06′ 109°24′	30.7±1.1	(K-Ar,B)	Small stock cutting thrust-faulted Paleozoic rocks (H. Drewes, written commun., 1971).
100	Quartz monzonite, quartz monzonite of Jhus Canyon.	31°59′ 109°14′	30.9±1.2	(K-Ar,B)	H. Drewes and F. E. Williams (unpub. data).

TABLE 2.—*Analytical data for K-Ar ages of mineral samples from southeastern Arizona*

Decay constant: K^{40} $\lambda_\epsilon = 0.585 \times 10^{-10}$/yr. $\lambda_\beta = 4.72 \times 10^{-10}$/yr.

Atomic abundance: $K^{40}/K = 1.19 \times 10^{-4}$

[Analysts: Argon analyzed by H. H. Mehnert, S. C. Creasey, H. H. Thomas, and R. F. Marvin, except as noted. Potassium values determined (by flame photometry using a lithium internal standard) by Violet Merritt, except as noted. Sample description and locality shown on table 1]

Sample No.	Analyzed mineral	K_2O (percent)	$*Ar^{40} \times 10^{-10}$ (moles/gram)	$*Ar^{40}$ (percent)	Calculated age (m.y.)
		Sierrita Mountains			
1[1]	Biotite	4.66	1.69	71	24±1
2	do	8.25	3.240	86	26.4±1.0
		8.29			
3	do	[2] 7.26	3.87	73	36±2
4	do	[2] 6.58	4.49	42	46±2
5	K-feldspar	[3] 16.04	11.38	74	47±2
6	do	[3] 14.92	10.63	58	47±3
7[1]	Biotite	5.98	6.15	89	56±2
8[1]	do	7.16	7.47	92	57±2
9	Biotite	[3] 8.62	7.782	91	60±3
	K-feldspar	3.45	2.902	51	56±3
10[1]	Biotite	7.28	8.10	88	60±2
11	do	[2] 6.37	5.22	79	55±3
13	do	[2] 8.24	4.94	81	40±2
		Santa Rita Mountains			
15	Sanidine	5.92	2.345	60	25.9±1.3
		6.13			
		6.18			
		6.17			
16	Plagioclase	[4] .82	0.3185	56	26.2±1.9
17	Biotite	[2] 6.45	2.49	71	26±2
	Hornblende	.751	0.305	44	27±3
18	Biotite	[5] 8.19	3.400	84	27.6±1.3
		8.37			
19	Hornblende	[5] .69	.28	59	27.8±2.2
		.69			
21	Biotite	7.09	5.682	90	53.5±2.0
		7.12	5.545	88	52.2±2.0
22	do	8.67	7.119	95	53.9±2.0
		8.97			
23	Biotite	7.17	6.071	89	55.7±2.2
		7.39			
24	do	7.87	6.603	94	55.8±2.1
		7.93			
25	do	8.43	7.080	87	56.3±2.1
		8.38			
27	Hornblende	[5] .69	.62	71	60.4±4.2
		.69			
28	Biotite	[2] 6.13	5.54	80	60±3
30	do	[2] 7.46	7.52	78	67±3
32	Hornblende	[2] .693	.702	57	67±3
33	Biotite	[5] 8.41	8.598	94	68.2±3.0
		8.40			
34	do	8.14	8.548	88	69.0±2.9
		8.35			
35	do	[5] 4.94	5.36	86	72.5±3.3
		4.88			
36	do	6.88	7.608	95	73.6±2.8
		6.86			
37	do	8.89	9.862	94	73.8±2.6
		8.88			
38	do	[5] 5.52	12.11	94	145±6
		5.31			

See footnotes at end of table.

TABLE 2.—*Analytical data for K-Ar ages of mineral samples from southeastern Arizona*—Continued

Sample No.	Analyzed mineral	K_2O (percent)	$^*Ar^{40} \times 10^{-10}$ (moles/gram)	$^*Ar^{40}$ (percent)	Calculated age (m.y.)
Santa Rita Mountains--Continued					
40	do	[5] 7.40	18.15	96	159±7
		7.43			
48	do	8.83	7.323	92	55.5±2.4
		8.79			
Atascosa Mountains					
50	Whole rock	1.18	.2218	69	12.6±0.8
		1.19			
Patagonia Mountains					
51	Biotite	[2] 8.58	2.02	20	23±2
	Hornblende	.514	.212	42	27±3
52	Biotite	[2] 6.73	2.59	20	26±2
53	Biotite	[2] 6.32	5.52	80	58±3
	Hornblende	.355	.311	39	58±5
54	Biotite	8.49	7.40	85	58±3
56	Hornblende	.78	1.829	90	153±10
		.77			
57	Biotite	6.50	15.89	96	160±7
		6.41			
	Hornblende	.55	1.395	59	164±19
		.55			
Huachuca Mountains					
63	Biotite	7.47	18.76	96	164±6
		7.41			
65	do	[5] 7.73	17.06	93	144±6
Canelo Hills					
67	Biotite	8.20	8.824	96	72.1±3.0
		8.06			
68	do	[2] 6.61	7.13	73	72±4
69	do	8.48	21.53	98	165±6
		8.45			
70	do	[2] 6.69	17.88	81	173±8
Mustang Mountains					
71	Biotite	8.45	4.870	87	38.9±1.5
		8.37			
Empire Mountains					
73	Biotite	8.17	3.403	84	28.0±1.1
		8.17			
74	do	8.92	9.421	96	70.3±2.5
		8.93			
Whetstone Mountains					
79	Biotite	[2] 7.03	7.811	86	74±4
	Hornblende	.609	.6824	63	74±4
Rincon Mountains					
80	Biotite	8.94	3.124	79	23.5±0.9
		8.97			
	Muscovite	9.79	3.611	79	24.8±0.9
		9.84			

TABLE 2.—*Analytical data for K-Ar ages of mineral samples from southeastern Arizona*—Continued

Sample No.	Analyzed mineral	K_2O (percent)	$^*Ar^{40} \times 10^{-10}$ (moles/gram)	$^*Ar^{40}$ (percent)	Calculated age (m.y.)
		Rincon Mountains--Continued			
81	Biotite	9.26	3.617	68	26.3±0.9
		9.26			
82	do	8.93	3.627	85	27.3±1.1
		8.93			
83	Muscovite	8.69	4.776	58	36.8±1.6
		8.74			
84	Biotite	9.59	4.039	95	28.4±1.1
		9.54			
85	do	9.47	4.766	97	33.8±1.2
		9.50			
	Muscovite	10.54	4.513	69	29.0±0.9
		10.44			
		10.52	4.507	69	28.9±1.0
		10.46			
86	Biotite	5.90	207.6	99	1540±60
		5.89			
87	do	7.09	227.7	99	1450±50
		7.08			
	Hornblende	.61	22.12	99	1560±100
		.63			
		Little Dragoon Mountains			
88	Biotite	[2] 9.19	6.859	90	50±3
	do	8.68	6.758	86	52±3
		Dragoon Mountains			
89	Biotite	[2] 7.92	2.767	65	25.9±2
90	do	[2] 9.00	3.473	74	26±2
91	Hornblende	.80	.3938	66	33.3±2.6
		.80			
92	Biotite	[2] 9.77	5.705	75	47±2
93	do	8.73	9.550	90	72.8±2.8
		8.71			
94	Muscovite	11.94	27.42	99	178±5
		Tombstone Hills			
95[1]	Biotite	8.96	8.70	--	63±3
96	do	5.65	6.102	90	71.9±2.7
		5.64			
97[1]	do	4.01	4.46	--	72±3
		Mule Mountains			
98[1]	Biotite	6.61	17.1	--	163±7
		Chiricahua Mountains			
99	Biotite	9.00	4.122	79	30.7±1.1
		9.05			
100	do	8.32	3.821	91	30.9±1.2
		8.29			

*Radiogenic argon.
[1] Analytical data adapted from Creasey and Kistler (1962, p. D1, table 120.1). Data not exactly as shown by them.
[2] Analysts: H. Collins Whitehead and Lois Schlocker.
[3] Analysts: P. L. D. Elmore and H. Smith.
[4] Average of 10 determinations.
[5] Analyst: Wayne Mountjoy.

TABLE 3.—*Analytical data for Pb-α ages of zircon from southeastern Arizona*

[Radioactivity of the zircons was measured by an alpha counter by T. W. Stern. All lead determinations were made by Harold Westley, except Nos. 38, 45, 58, and 76 which were made by Norma Rait. All lead concentrations were determined by spectrographic methods. Superscript "s" in the lead column indicates a single determination. All other values are average of duplicate determinations. Samples with less than 10 ppm lead are difficult to analyze and therefore less confidence is placed in their age. Ages were calculated by the following equations:

$$t \text{ (age)} = \frac{C\,Pb}{\alpha} \text{ (for age range of 0–200 m.y.)}.$$

where "C" is the constant, 2485, which is based on an assumed Th/U ratio of 1.0. α is the alpha counts per milligram per hour.

$$T \text{ (age)} = t - \tfrac{1}{2}\, kt^2 \text{ (for age range 200–1,700 m.y.)},$$

where "k" is the decay constant, 1.56×10^{-4}, which is based on the above assumed Th/U ratio. Sample descriptions and locality shown on table 1]

Sample No.	α/mg/hr	Pb (ppm)	Calculated age (m.y.)
Sierrita Mountains			
11	796	46.5	150±20
12	246	18.5	190±20
13	590	49.5	210±30
14	270	99	850±100
Santa Rita Mountains			
17	268	3.9	40±10
20	1338	23	40±10
26	154	3.6	60±10
28	250	4.8	50±10
29	356	9.1	60±10
30	247	6.2	60±10
31	402	9.9[s]	60±20
32	285	7.0[s]	60±20
33	775	54.2	170±20
34	633	48	190±30
38	113	7.3	160±20
39	435	28.1	160±20
41	134	9.9	180±20
42	568	42	180±20
43	229	16.3	180±30
44	149	11.5	190±20
45	375	33.7	220±30
Santa Rita Mountains--Continued			
46	107	11.1	250±45
47	220	23.2	260±30
48	127	79	1360±200
49	125	83.5	1450±160
Patagonia Mountains			
55	79	4.7	150±20
58	168	11.0	160±20
59	251	24.5[s]	240±30
60	273	60.0	520±60
61	207	120	1280±150
Huachuca Mountains			
62	333	12[s]	90±30
64	365	31	210±30
65	108	9.8	220±35
Mustang Mountains			
72	134	17.2	310±40
Empire Mountains			
75	326	10.9	80±15
76	215	9.5	110±20
77	154	10.3	170±35
78	179	15.5	210±30

TABLE 4.—*Analytical data for Rb-Sr ages of samples from southeastern Arizona*

Decay constants for Rb^{87} : $\lambda\beta = 1.39 \times 10^{-11}$/yr.
Isotope abundance: $Rb^{87}/Rb = 0.283$ g/g.

[Analysts: for samples 49 and 65, Z. E. Peterman, R. A. Hildreth, and W. T. Henderson; for sample 96, analytical data from Creasey and Kistler (1962, p. D1, table 120.1). Sample descriptions and locality shown on table 1]

Sample No.	Analyzed material	Rb^{87} (ppm)	Total Sr (ppm)	Sr^{87*} (ppm)	Sr^{87*} (percent)	Calculated age m.y.)
Santa Rita Mountains						
49	Whole rock ----------	81.9	230	0.964	5.8	[1]800±80
Huachuca Mountains						
65	Whole rock ----------	115.7	64.7	0.245	5.2	[2]144±11
Mule Mountains						
96	Biotite --------------	384	22.2	0.994	--	[3]186±7
	-----do --------------	388	21.3	1.017	--	188±8

* Radiogenic strontium.
[1] Assumed initial Sr^{87}/Sr^{86} of 0.703.
[2] Assumed initial Sr^{87}/Sr^{86} of 0.7065.
[3] Recalculated using Rb^{87} : $\lambda = 1.39 \times 10^{-11}$ y^{-1}.

TABLE 5.—*Major stratigraphic and time divisions*

Subdivisions in use by the U.S. Geological Survey				Age estimates commonly used for boundaries (in million years)[1]
Era or Erathem	System or Period		Series or Epoch	
Cenozoic	Quaternary		Holocene	
			Pleistocene	1.5–2
	Tertiary		Pliocene	ca. 7
			Miocene	26
			Oligocene	37–38
			Eocene	53–54
			Paleocene	65
Mesozoic	Cretaceous		Upper (Late) Lower (Early)	136
	Jurassic		Upper (Late) Middle (Middle) Lower (Early)	190–195
	Triassic		Upper (Late) Middle (Middle) Lower (Early)	225
Paleozoic	Permian		Upper (Late) Lower (Early)	280
	Carboniferous Systems	Pennsylvanian	Upper (Late) Middle (Middle) Lower (Early)	321
		Mississippian	Upper (Late) Lower (Early)	345
	Devonian		Upper (Late) Middle (Middle) Lower (Early)	395
	Silurian		Upper (Late) Middle (Middle) Lower (Early)	430–440
	Ordovician		Upper (Late) Middle (Middle) Lower (Early)	ca. 500
	Cambrian		Upper (Late) Middle (Middle) Lower (Early)	570
Precambrian				

[1] From Geological Society of London (1964, p. 260–262).

NOTE.—Estimates for ages of time boundaries are under continuous study and subject to refinement and controversy. Examples of other estimates for the Cenozoic part of the scale are given by Berggren (1969) and Evernden, Savage, Curtis, and James (1964).

U.S. GOVERNMENT PRINTING OFFICE : 1973 O—493-695

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