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A SUMMARY OF RADIOMETRIC AGE DETERMINATIONS ON ROCKS FROM PERU

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Most of the radiometric ages tabulated in this summary are from two sources. Fifty ages, mainly on granitic and metamorphic rocks, determined by the Isotope Geology Laboratory of the Institute of Geological Sciences, London, and by J. F. Evernden of the University of California, Berkeley, have been published by Stewart, Evernden, and Snelling (1974). Fifty-two age determinations, mainly on Cenozoic volcanic rocks collected by the writer, have been made by E. H. McKee and M. L. Silberman of the U. S. Geological Survey, Menlo Park, California, and by Edward Farrar of Queen's University, Kingston, Ontario, Canada. Most of these ages have been published in papers which are cited below. The remaining ages are from seven additional papers by various authors.

METHODS OF DATING AND MATERIALS DATED

Nearly all of the age determinations were made by the potassium-argon method. A very few rubidium-strontium (5 rocks) and fission track (2 specimens) ages are available. Most of the age determinations have been made on biotite mineral separates; relatively few dates were obtained on hornblende, plagioclase, and sanidine mineral separates and on whole-rock material.

The potassium-argon method has proved ideal for dating middle and late Cenozoic volcanic rocks and for dating young mineral deposits. K-Ar dating utilizing biotite-hornblende mineral pairs should be adequate for detailed chronologic studies of the Coastal, Arequipa, and Cordillera Blanca batholiths. Whole-rock rubidium-strontium and uranium-lead methods, however, will be required to adequately date early Mesozoic, Paleozoic, and Precambrian igneous and metamorphic events. Zircon methods probably also will be required to date the late Mesozoic-early Tertiary volcanic envelope of the Coastal batholith.

GEOLOGIC HISTORY

Available Precambrian, Paleozoic, and Mesozoic ages are discussed by Stewart and others (1974). Gneiss of definite Precambrian age is present in Arequipa Department (13 and 14 of the present tabulation), and granitic rocks of lower Paleozoic age are found in various parts of southern Peru. There is good evidence for plutonism in Permian and in late Triassic-early Jurassic.

Ages presented by Stewart and others (1974) show that the emplacement of the Coastal batholith began approximately 100 m.y. ago, about 20 m.y. before the onset of Andean deformation. Most of the plutons of the Coastal batholith, however, were emplaced during late Cretaceous and Paleocene into coeval volcanic strata (Cobbing, 1973). Igneous activity within the Coastal batholith block continued into the Oligocene, producing a number of centered volcano-plutonic complexes (Cobbing and Pitcher, 1972).

During Eocene the Coastal batholith block in central Peru was uplifted, and a new depositional basin formed to the east (Noble and McKee, 1975; Noble, McKee, and others, 1978). Clastic rocks (Casapalca Formation) and subaqueous volcanics (together termed the Castrovirreyna Sequence by Noble and McKee, 1975), deposited in this basin, range from late Eocene (55-57) to early and probably middle Miocene. Tuffs of Oligocene to early Miocene age (60 and 101) unconformably overlie rocks of the Coastal batholith along the southwestern margin of the basin. Similar relations appear to hold for northern and southern Peru.

The Andes underwent strong compressive deformation during the late Tertiary. Folding and subsequent uplift and erosion is dated radiometrically as middle Miocene (Noble, McKee, and others, 1974; McKee and others, 1975; Noble and McKee, 1975; Farrar and Noble, 1976). Igneous activity continued until the latest Cenozoic, with volcanic rocks of late Pliocene age being found in central (44-46) and southern (34, 35) Peru.

AGE OF MINERAL DEPOSITS

The porphyry copper deposits of Toquepala and Cerro Verde in southern Peru have been dated by combined field and radiometric evidence (125, 27, 28) as Paleocene. The disseminated deposit at Michiquillay in northern Peru is early Miocene (49, 20.6 m.y.) (Laughlin and others, 1968; Hollister, 1974).

Other data deposits are late Cenozoic. Dikes and a protrusive dome of porphyritic quartz latite ("Cerro Quartz Monzonite Porphyry") at the Cerro de Pasco mining district yield concordant K-Ar mineral ages (110-113) with a mean value of 14.7±0.2 m.y. (Silberman and Noble, 1977). At Morococha two specimens of monzonite closely related to disseminated and vein mineralization have been dated at 8.2 m.y. (83, 84) and an age of 7.2±0.3 m.y. (85) has been obtained on a whole-rock specimen of potassic altered quartz monzonite from the Toro Mocho disseminated deposit (Eyzaguirre and others, 1975). Quartz monzonite stocks closely related to mineralization at Yauricocha have a mean age of about 7 m.y. (Giletti and Day, 1968; 104, 105).

Base and precious metal mineralization at Julcani (Goodell and Petersen, 1974; Petersen and others, 1977) is closely bracketed between volcanic units that have yielded mean ages of 10.3±0.3 m.y. and 10.4±0.3 m.y. (65, 66). Mineralization at the Huachocolpa district postdates

FIGURE 1. Map of Peru showing the location of the dated rocks. (Sample numbers are keyed to sample descriptions; numbers are listed by Department.)

intermediate volcanic rocks ranging in age from about 10 m.y. to 8 m.y. and predates dikes about 4 m.y. old (McKee and others, 1975; 67-75); recent unpublished information suggests that mineralization is related to the 10 to 8 m.y. pulse of igneous activity. At Atunsulla two periods of hydrothermal activity and mineralization are recognized (Noble and others, 1974; Noble and McKee, in preparation). The first is bracketed between intermediate lavas, dated at 3.6 m.y. and 4.0 m.y. (42, 43), and the Atunsulla Tuff, dated at approximately 2.5 m.y. (44, 45). The second period postdates the Atunsulla Tuff and probably also a volcanic dome dated at 2.0 ± 0.1 m.y. (46).

Tungsten and base metal mineralization at the Pasto Buena deposit in northern Peru are genetically related to the stock dated at 9.5 ± 0.2 m.y. (Landis and Rye, 1974; 89). In southern Peru silver mineralization of the Orcopampa district is younger than tuffs dated at 19 m.y. (29, 30).

SAMPLE DESCRIPTIONS

Ancash Department

1. Giletti and Day (1968) — K-Ar
No. 1, table 1
Stewart and others (1974)
No. 14, table 1
Granodiorite, Coastal batholith (9°29′S; 78°17.5′W; Adan Mine, Casma area). Collected by: J. Fernandez C., A. Ballon, and/or R. Sprague; dated by: B. J. Giletti and H. W. Day, Brown Univ.
(biotite) 65±4 m.y.

2. Stewart and others (1974) — K-Ar
No. 9, table 1
Granodiorite (8°40′S; 78°20′W). Dated by: J. F. Evernden, Univ. Calif., Berkeley. (biotite) 28.9 m.y.

3. Farrar and Noble (1976) — K-Ar
No. 4, table 1
Dacite lava (9°33.4′S; 77°35.9′W). Collected by: D. C. Noble; dated by: E. H. McKee and L. B. Schlocker, U. S. Geological Survey. (biotite) 18.1±0.6 m.y.

4. Stewart and others (1974) — K-Ar
No. 8, table 1
Granodiorite, batholith of the Cordillera Blanca (8° 26′S; 78°02′W). Dated by: J. F. Evernden, Univ. Calif., Berkeley. (biotite) 12.0 m.y.

5. Stewart and others (1974) — K-Ar
No. 15, table 1
"Granite", batholith of the Cordillera Blanca (9°19′S; 77°24′W). Dated by: J. F. Evernden, Univ. Calif., Berkeley. (biotite) 9.7 m.y.

6. Stewart and others (1974) — K-Ar, Rb-Sr
No. 16, tables 1 and 2
Granodiorite, batholith of the Cordillera Blanca (9° 45′S; 77°21′W). Dated by: Isotope Geology Laboratory, Institute of Geological Sciences, London. *Comments: Rb-Sr age is 5 m.y. assuming an initial $^{87}Sr/^{86}Sr$ ratio of 0.7050, and 13 m.y. assuming an initial ratio of 0.7030. Preferred age is 9.7 ± 0.6 m.y.
(biotite) 9.7±0.6 m.y.
(biotite) 5 m.y.*

7. Giletti and Day (1968) — K-Ar
No. 3, table 1
Stewart and others (1974)
No. 17, table 1
Granodiorite, batholith of the Cordillera Blanca (9° 45′S; 77°21′W). Collected by: J. Fernandez C., A. Ballon, and/or R. Sprague; dated by: B. J. Giletti and H. W. Day, Brown Univ. (biotite) 9.1±0.4 m.y.

8. Farrar and Noble (1976) — K-Ar
No. 6, table 1
Rhyolitic ash-flow tuff (9°08.0′S; 77°42.4′W). Collected by: D. C. Noble; dated by: E. Farrar, Queen's Univ. (biotite) 6.88±0.26 m.y.

9. Farrar and Noble (1976) — K-Ar
No. 5, table 1
Rhyolitic ash-flow tuff (10°08.4′S; 77°29.5′W). Collected by: D. C. Noble; dated by: E. Farrar, Queen's Univ. (biotite) 4.94±0.20 m.y.

10. Stewart and others (1974) — K-Ar
No. 11, table 1
Specimen of unknown character, batholith of the Cordillera Blanca (9°04′S; 77°50′W). Dated by: J. F. Evernden, Univ. Calif., Berkeley.
(muscovite) 4.1 m.y.

11. Stewart and others (1974) — K-Ar, Rb-Sr
No. 10, tables 1 and 2
Aplite, batholith of the Cordillera Blanca (8°50′S; 77° 50′W). Dated by: Isotope Geology Laboratory, Institute of Geological Sciences, London. *Comments: Rb-Sr age is 19 m.y. assuming an initial $^{87}Sr/^{86}Sr$ ratio of 0.7050, and 30 m.y. assuming an initial ratio of 0.7030. Preferred age is 3.6 ± 0.3 m.y.
(muscovite) 3.6±0.3 m.y.
(muscovite) 19 m.y.*

12. Stewart and others (1974) — K-Ar, Rb-Sr
No. 12, tables 1 and 2
Granodiorite, batholith of the Cordillera Blanca (9° 04′S; 77°50′W). Dated by: Isotope Geology Laboratory, Institute of Geological Sciences, London. *Comments: Rb-Sr age is 10 m.y. assuming an initial $^{87}Sr/^{86}Sr$ ratio of 0.7050, and 11 m.y. assuming an initial ratio of 0.7030. Preferred age is 2.7 ± 0.4 m.y.
(biotite) 2.7±0.4 m.y.
(biotite) 10 m.y.*

Arequipa Department

13. Stewart and others (1974) K-Ar
No. 50, table 1
Granitic gneiss (16°31′19″S; 71°35′43″W). Dated by: Isotope Geology Laboratory, Institute of Geological Sciences, London. (biotite) 679±12 m.y.

14. Stewart and others (1974) K-Ar
No. 43, table 1
Basic gneiss (16°07′30″S; 71°57′00″W). Dated by: Isotope Geology Laboratory, Institute of Geological Sciences, London. (biotite) 642±16 m.y.

15. Stewart and others (1974) K-Ar
No. 57, table 1
Coarse potassic granite ("granito rosado") (16°34′S; 72°38′W). Dated by: J. F. Evernden, Univ. Calif., Berkeley. Comment: Intrudes basement complex of Coastal Cordillera. (biotite) 447 m.y.

16. Stewart and others (1974) K-Ar
No. 45, table 1
Coarse potassic granite ("granito rosado") (16°13′30″S; 73°37′00″W). Dated by: J. F. Evernden, Univ. Calif., Berkeley. Comment: Intrudes basement complex of Coastal Cordillera. 395 m.y.

17. Stewart and others (1974) K-Ar
No. 49, table 1
Staurolite schist (16°29′51″S; 73°11′18″W). Dated by: Isotope Geology Laboratory, Institute of Geological Sciences, London. Comment: Preferred age of 210 ± 5 m.y. probably represents partial outgassing by some nearby granitic intrusion.
(muscovite) 210±5 m.y.
(biotite) 209±5 m.y.

18. Evernden and Kistler (1970) K-Ar
No. 1158, table 5
Stewart and others (1974)
No. 48, table 1
Quartz diorite (16°16′S; 73°11′W, at Ocona). Dated by: J. F. Evernden, Univ. Calif., Berkeley. Comments: Small stock, intrudes Mitu Group of middle to late Permian age. Location given by Evernden and Kistler (1970) does not agree with value from Stewart and others (1974) given above. (biotite) 204 m.y.

19. Stewart and others (1974) K-Ar
No. 42, table 1
Granite (16°06′30″S; 71°56′00″W). Dated by: Isotope Geology Laboratory, Institute of Geological Sciences, London. Comment: Minimum age.
(muscovite) 188±6 m.y.

20. Stewart and others (1974) K-Ar
No. 44, table 1
Granite (16°09′30″S; 73°48′00″W). Dated by: J. F. Evernden, Univ. Calif., Berkeley. Comment: Geological knowledge insufficient for significance of date to be assessed. (potash feldspar) 177 m.y.

21. Stewart and others (1974) K-Ar
No. 46, table 1
Pegmatite from granite-amphibolite intrusion breccia (16°13′30″S; 73°37′00″W). Dated by: J. F. Evernden, Univ. Calif., Berkeley. Comment: Geological knowledge insufficient for significance of date to be assessed. (muscovite) 162 m.y.

22. Stewart and others (1974) K-Ar
No. 47, table 1
Foliated diorite (16°15′S; 73°08′W). Dated by: J. F. Evernden, Univ. Calif., Berkeley. Comment: Intruded by quartz diorite dated at 204 m.y. (specimen No. 18); the age thus is anomalously low. (biotite) 157 m.y.

23. Estrada (1969) K-Ar
Stewart and others (1974)
No. 51, table 1
Volcanic breccia possibly belonging to the Chocolate Formation (Jurassic) (16°30′10″S; 71°35′27″W). Dated by: Geochron Laboratories. Comment: Date appears to reflect a thermal event about 77 m.y. ago.
(biotite) 78.0±2.4 m.y.

24. Estrada (1969) K-Ar
Stewart and others (1974)
No. 52, table 1
Banded gneiss (16°30′23″S; 71°36′07″W). Dated by: Geochron Laboratories. Comments: Belongs to regionally metamorphosed complex which has yielded Precambrian ages; date appears to reflect a thermal event about 77 m.y. ago. (biotite) 77.8±2.5 m.y.

25. Estrada (1969) K-Ar
Stewart and others (1974)
No. 53, table 1
Brecciated gneiss (16°30′29″S; 71°35′51″W). Dated by: Geochron Laboratories. Comments: Belongs to regionally metamorphosed complex which has yielded Precambrian ages; date appears to reflect a thermal event about 77 m.y. ago. (biotite) 77.3±2.5 m.y.

26. Estrada (1969) K-Ar
Stewart and others (1974)
No. 54, table 1
Lamprophyre dike intruding Precambrian gneiss (16°30′39″S; 71°35′44″W). Dated by: Geochron Laboratories. (biotite) 76.2±3.3 m.y.

27. Estrada (1969) K-Ar
Stewart and others (1974)
No. 55, table 1
Yarabamba granodiorite, Arequipa batholith (16°31′57″S; 71°34′23″W). Dated by: Geochron Laboratories. (biotite) 58.9±2.0 m.y.

28. Estrada (1969) K-Ar
Stewart and others (1974)
No. 56, table 1
Tiabaya granodiorite, Arequipa batholith (16°31′02″S; 71°35′17″W). Dated by: Geochron Laboratories. (biotite) 56.8±2.0 m.y.

29. Noble and others (1974) K-Ar
No. 5, table 1
Pisaca Tuff. Rhyolitic tuff (15°14′06″S; 72°16′43″W). Collected by: D. C. Noble; dated by: E. Farrar, Queen's Univ. (biotite) 19.1±0.3 m.y.

30. Noble and others (1974) K-Ar
No. 6, table 1
Chilcaimarca Tuff. Rhyolitic ash-flow tuff (15°16′33″S; 72°23′59″W). Collected by: D. C. Noble; dated by: E. Farrar, Queen's Univ. (biotite) 18.9±0.4 m.y.

31. Noble and others (1974) K-Ar
No. 7, table 1
Rhyodacitic ash-flow tuff (15°50′S; 72°45′W; above town of Chuquibamba). Collected by: D. C. Noble; dated by: E. Farrar, Queen's Univ. (biotite) 13.8±0.3 m.y.

32. Farrar and Noble (1976) K-Ar
No. 7, table 1
Rhyolitic ash-flow tuff (15°11.9′S; 72°20.0′W). Collected by: D. C. Noble; dated by: E. Farrar, Queen's Univ. (nonhydrated glass) 10.77±0.15 m.y.

33. Farrar and Noble (1976) K-Ar
No. 8, table 1
Dacitic ash-flow tuff (15°11.0′S; 72°22.8′W). Collected by: D. C. Noble; dated by: E. Farrar, Queen's Univ. (biotite) 6.16±0.09 m.y.

34. Laharie (1973) K-Ar
Formación Sencca (sillar of Arequipa) (near Arequipa). 3.05 m.y.

35. Laharie (1973) K-Ar
Volcanico Chila (near Arequipa). 2.35 m.y.

Ayacucho Department

36. Noble, Silberman, and others (1978) K-Ar
No. AYA-PAN, table 1
Comendite lava (13°00.4′S; 74°06.9′W). Collected by: D. C. Noble; dated by: M. L. Silberman, U. S. Geological Survey. Comment: Rock is Permian or Triassic; date reflects resetting by low-grade metamorphism. (whole rock) 128±4 m.y.

37. D. C. Noble and E. H. McKee K-Ar
(unpub. data)
Ayacucho Formation. Rhyolite tuff, specimen AYA-PUM (13°03.7′S; 74°13.0′W). Analytical data: K_2O = 9.16%, $^*Ar^{40}$ = 0.8853 x 10^{-10} moles/gm, $^*Ar^{40}/\Sigma Ar^{40}$ = 32.8%; collected by: D. C. Noble; dated by: E. H. McKee, U.S. Geological Survey. (sanidine) 6.5±0.3 m.y.

38. D. C. Noble and M. L. Silberman K-Ar
(unpub. data)
Dacite lava, specimen AYA-24, (13°20.3′S; 74°12.2′W). Analytical data: K_2O = 8.05 (average of six analyses), $^*Ar^{40}$ = 8.980 x 10^{-11} moles/gm, $^*Ar^{40}/\Sigma Ar^{40}$ = 60.2%; collected by: D. C. Noble; dated by: M. L. Silberman, U. S. Geological Survey. (biotite) 7.5±0.2 m.y.

39. Noble and others (1975) K-Ar
No. AYA-10, table 1
Low-silica andesite lava (13°23.6′S; 74°21.6′W). Collected by: D. C. Noble; dated by: M. L. Silberman, U. S. Geological Survey. (whole rock) 5.1±0.3 m.y.

40. Noble and others (1975) K-Ar
No. AYA-1A, table 1
Low-silica latite lava (13°04.8′S; 74°10.6′W). Collected by: D. C. Noble; dated by: M. L. Silberman, U. S. Geological Survey. (whole rock) 3.7±0.4 m.y.

41. Noble and McKee (in preparation) K-Ar
No. 6, table 1
Dacite lava (13°21.4′S; 74°38.0′W). Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey. Comment: Age obtained on somewhat altered biotite concentrate, does not agree with geological evidence that unit postdates 2.5 m.y. old Atunsulla Tuff. (biotite) 6.1±0.2 m.y.

42. Noble and McKee (in preparation) K-Ar
No. 5, table 1
Dacite lava (13°23.1′S; 74°37.5′W). Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey. (biotite) 4.0±0.2 m.y.

43. Noble and McKee (in preparation) K-Ar
No. 4, table 1
Andesite lava (13°21.8′S; 74°32.8′W). Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey. (biotite) 3.6±0.2 m.y.

44\. Noble and McKee (in preparation) K-Ar
No. 3, table 1
Atunsulla Tuff. Rhyodacite ash-flow tuff (13°20.1′S; 74°26.3′W). Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey. Comment: Preferred age of Atunsulla Tuff is 2.5 ± 0.2 m.y.
(biotite) 2.7±0.2 m.y.

45\. Noble and McKee (in preparation) K-Ar
No. 2, table 1
Atunsulla Tuff. Rhyodacite ash-flow tuff (13°21.4′S; 74°20.4′W). Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey. Comment: Biotite was separated from a large pumice fragment from poorly welded lower part of unit. Preferred age for the Atunsulla Tuff is 2.5 ± 0.2 m.y.
(biotite) 2.3±0.3 m.y.

46\. Noble and McKee (in preparation) K-Ar
No. 1, table 1
Rhyodacite dome intruding ring fracture zone of Nevado Portugueza caldera (13°22.3′S; 74°38.1′W). Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey. (biotite) 2.0±0.1 m.y.

Cajamarca Department

47\. Laughlin and others (1968) K-Ar
No. PED-2a-66, table 1
Stewart and others (1974)
No. 3, table 1
Granodiorite stock (7°02′S; 78°20′W; about three miles northwest of Michiquillay ore body, Michiquillay mining district). Dated by: Geochronology Laboratories, Univ. Ariz., Tucson. (hornblende) 46.4±1.8 m.y.

48\. Stewart and others (1974) K-Ar
No. 2, table 1
Tonalite (7°14′S; 79°14′W). Dated by: Isotope Geology Laboratory, Institute of Geological Sciences, London. Comment: Preferred age is 43.5 ± 1.5 m.y.
(biotite) 43.5±1.5 m.y.
(hornblende) 39±6 m.y.

49\. Laughlin and others (1968) K-Ar
No. PED-2b-66, table 1
Stewart and others (1974)
No. 4, table 1
Hydrothermal biotite from sulfide-bearing rock from Michiquillay porphyry copper deposit (7°02′S; 78° 20′W; Michiquillay). Dated by: Geochronology Laboratories, Univ. Ariz., Tucson.
(biotite) 20.6±0.6 m.y.

Cuzco Department

50\. Stewart and others (1974) K-Ar
No. 61, table 1
Granite (13°33′S; 70°49′W). Dated by: J. F. Evernden, Univ. Calif., Berkeley. Comment: Intrudes slates containing Ordovician graptolites. 421 m.y.

51\. Evernden and Kistler (1970) K-Ar
No. 1155, table 5
Stewart and others (1974)
No. 62, table 1
Diorite (13°29′S; 70°42′W, in Cañon de Marcapata). Dated by: J. F. Evernden, Univ. Calif., Berkeley.
(biotite) 213 m.y.

Huancavelica Department

52\. Stewart and others (1974) K-Ar
No. 60, table 1
Granite-granodiorite (12°23′S; 74°41′W). Dated by: J. F. Evernden, Univ. Calif., Berkeley. Intrudes rocks of the Mitu Group. 251 m.y.

53\. Stewart and others (1974) K-Ar
No. 38, tables 1 and 2 Rb-Sr
Granodiorite of the Coastal batholith (13°37′S; 75° 23′W). Dated by: Isotope Geology Laboratory, Institute of Geological Sciences, London. Comments: Rb-Sr age is from a two-point biotite-potash feldspar isochron. Preferred age is 66 ± 1 m.y.
(biotite) 66±1 m.y.
(isochron) 69±3 m.y.

54\. Stewart and others (1974) K-Ar
No. 37, table 1
Quartz diorite from Coastal batholith (13°37′S; 75° 26′W). Dated by: Isotope Geology Laboratory, Institute of Geological Sciences, London. Comment: Preferred age is 65±2 m.y. (biotite) 65±2 m.y.
(hornblende) 63±3 m.y.

55\. Noble and others (in preparation) K-Ar
Rhyolite tuff, specimen B58-B (13°05.2′S; 75°03.3′W). Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey. Comment: Specimen is from the same unit as specimen B58 (#56).
(biotite) 41.2±1.2 m.y.

56\. Noble and others (1974) K-Ar
Noble and others (in preparation)
Rhyolite tuff, specimen B58 (13°05.4′S; 75°03.2′W). Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey. (biotite) 40.9±1.2 m.y.

57\. Noble and others (in preparation) K-Ar
Andesite or dacite lava, specimen LAVA S, (13°24.9′S; 74°54.8′W). Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey.
(plagioclase) 40.3±2 m.y.

58\. McKee and Noble (in preparation) K-Ar
Rhyolite or rhyodacite tuff, specimen PILPICACHA,

58. (continued)
($13°19.7'S; 74°59.3'W$; near Pilpicacha). Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey. (biotite) 30.4±1.0 m.y.

59. McKee and Noble (in preparation) K-Ar
Rhyodacite or rhyolite tuff, specimen CASA-S, (12° 48.3'S; 74°55.6'W). Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey.
(biotite) 26.4±0.8 m.y.

60. McKee and Noble (in preparation) K-Ar
Rhyolite or rhyodacite tuff, specimen CASTRO, (13° 19.1'S; 75°19.0'W). Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey. Comment: Age is probably a minimum value.
(biotite) 22.6±0.9 m.y.

61. Noble and others (1974) K-Ar
No. 4, table 1
McKee and Noble (in preparation)
Rhyolite tuff, specimen TUFO LIRCAY, (12°59.1'S; 74°44.0'W; near town of Lircay). Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey. Comment: Preferred age is 22.4 ± 1.0.
(biotite) 21.6±0.8 m.y.
(plagioclase) 22.9±1.3 m.y.

62. Noble and others (1974) K-Ar
No. 2, table 1
McKee and Noble (in preparation)
Rhyolite or rhyodacite tuff, specimen T2-2, (13°06.6' S; 75°03.9'W). Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey. Comment: Specimen is from unit directly above unit from which specimen 63 was obtained. (biotite) 21.4±0.6 m.y.

63. McKee and Noble (in preparation) K-Ar
Rhyolite or rhyodacite tuff, specimen T2-1, (13°06.6' S; 75°03.9'W). Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey. Comment: Specimen is from unit directly below unit from which specimen 62 was obtained. (biotite) 20.9±0.7 m.y.

64. Noble and others (1974) K-Ar
No. 3, table 1
McKee and Noble (in preparation)
Rhyolite or rhyodacite tuff (13°09.2'S; 75°04.2'W). Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey. (biotite) 13.9±0.4 m.y.

65. E. H. McKee and D. C. Noble K-Ar
(unpub. data)
Rhyodacite, Bulolo dike, Julcani volcanic center, specimen J-1, (12°56.8'S; 74°46.2'W; Julcani mining district). Analytical data: $K_2O = 8.88\%$, $^*Ar^{40} = 1.361 \times 10^{-10}$ mole/gm, $^*Ar^{40}/\Sigma Ar^{40} = 41.3\%$. Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey. (biotite) 10.3±0.3 m.y.

66. E. H. McKee and D. C. Noble K-Ar
(unpub. data)
Rhyodacite clast early pyroclastic sequence, Julcani volcanic center, specimen J-2, (12°57.3'S; 74°43.9'W; Julcani mining district). Analytical data: $K_2O = 9.02\%$, $^*Ar^{40} = 1.385 \times 10^{-10}$ mole/gm, $^*Ar^{40}/\Sigma Ar^{40} = 70.0\%$. Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey.
(biotite) 10.4±0.3 m.y.

67. McKee and others (1974) K-Ar
No. 1, table 1
Rhyodacite block from tuff breccia of Tinqui composite volcano (12°59'S; 75°02'W; Huachocolpa mining district). Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey.
(biotite) 10.4±0.3 m.y.

68. McKee and others (1975) K-Ar
No. 2, table 1
Rhyodacite block from tuff breccia of Tinqui composite volcano (13°04'S; 75°01'W; Huachocolpa mining district). Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey.
(biotite) 10.1±0.3 m.y.

69. McKee and others (1974) K-Ar
No. 3, table 1
Biotite-hornblende dacite from Chosecc dome complex (13°06.3'S; 74°55.2'W; Huachocolpa mining district). Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey. (biotite) 9.7±0.3 m.y.

70. McKee and others (1974) K-Ar
No. 4, table 1
Biotite-hornblende dacite from Manchaylla volcanic complex (12°58'S; 75°01'W; Huachocolpa mining district). Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey.
(biotite) 9.1±0.3 m.y.

71. McKee and others (1974) K-Ar
No. 5, table 1
Biotite-hornblende dacite from Huascar dome (13° 03.3'S; 74°54.6'W; Huachocolpa mining district). Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey. (biotite) 8.2±0.3 m.y.

72. Farrar and Noble (1976) K-Ar
No. 1, table 1

72. (continued)
Silicic ash-flow tuff (12°44.5'S; 74°54.2'W). Collected by: D. C. Noble; dated by: E. Farrar, Queen's Univ.
(biotite) 7.12±0.34 m.y.

73. McKee and others (1975) K-Ar
No. 6, table 1
Biotite-hornblende rhyodacite dike (13°06.6'S; 74° 57.5'W; Huachocolpa mining district). Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey. Comment: Cuts main veins at Blenda Rubia Mine.
(biotite) 4.6±0.2 m.y.

74. McKee and others (1975) K-Ar
No. 7, table 1
Biotite-hornblende rhyodacite dike (13°08.4'S; 74° 58.7'W; Huachocolpa mining district). Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey.
(biotite) 3.8±0.2 m.y.

75. McKee and others (1975) K-Ar
No. 8, table 1
Biotite-hornblende rhyodacite volcanic dome (13° 02.8'S; 74°57.4'W; Huachocolpa mining district). Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey.
(biotite) 3.7±0.2 m.y.

Ica Department

76. Stewart and others (1974) K-Ar
No. 35, table 1
Adamellite of Coastal batholith (13°25'S; 76°03'W). Dated by: Isotope Geology Laboratory, Institute of Geological Sciences, London.
(biotite) 92±2 m.y.

77. Stewart and others (1974) K-Ar
No. 36, table 1
"Granite," Coastal batholith (13°30'S; 75°29'W). Dated by: J. F. Evernden, Univ. Calif., Berkeley.
(biotite) 55.0 m.y.

Junin Department

78. Stewart and others (1974) K-Ar
No. 41, table 1
Granite-granodiorite (11°00'S; 75°18'W). Dated by: J. F. Evernden, Univ. Calif., Berkeley. Comment: Reported to intrude strata of the Mitu Group (upper Paleozoic), but plutonic body may be composite.
346 m.y.

79. Noble and others (in preparation) K-Ar
Volcanic sandstone, specimen CASA-7, (12°00.7'S; 75°28.6'W). Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey. Comment: Age is probably a minimum value.
(biotite) 38.8±1.0 m.y.

80. Noble and others (in preparation) K-Ar
Rhyolite tuff, specimen CASA-10, (12°01.2'S; 75° 29.7'W). Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey. Comment: Preferred age is 35.8 ± 1.0 m.y.; biotite has lost large amounts of radiogenic argon and potassium.
(biotite) 15.8±0.7 m.y.
(sanidine) 35.8±1.0 m.y.

81. Noble and others (in preparation) K-Ar
"Casapalca Formation." Dacite clast from coarse volcanic breccia, specimen CASA-W, (12°24.0'S; 75°18.4' W). Collected by: D. C. Noble; dated by: E. H. McKee, U. S. Geological Survey. Comment: Age is valid, although analytically imprecise.
(plagioclase) 30.3±6 m.y.

82. Farrar and Noble (1976) K-Ar
No. 2A, 2B, table 1
Rhyolite or rhyodacite lava (11°08.8'S; 76°25.9'W). Collected by: D. C. Noble; dated by: E. Farrar, Queen's Univ.
(biotite) 14.6±0.4 m.y.

83. Eyzaguirre and others (1975) K-Ar
Table 1
Yantac Intrusion. Porphyritic quartz monzonite (11° 37.1'S; 76°07.9'W; Morococha mining district). Collected by: D. C. Noble and D. E. Montoya; dated by: M. L. Silberman, U. S. Geological Survey. Comment: The Yantac intrusion is believed to be a slightly older phase of the San Miguel intrusion, which is very closely related to the Toro Mocho disseminated deposit.
(biotite) 8.3±0.3 m.y.

84. Eyzaguirre and others (1975) K-Ar
Table 1
Anticona Diorite. Thin dike of quartz monzonite intruding Anticona Diorite (11°35.7'S; 76°10.7'W; Morococha mining district). Collected by: D. C. Noble and D. E. Montoya; dated by: M. L. Silberman, U. S. Geological Survey. Comment: Dike may be significantly younger than the main body of Anticona Diorite.
(biotite) 8.2±0.2 m.y.

85. Eyzaguirre and others (1975) K-Ar
Table 1
Quartz monzonite which has undergone intense potassic alteration, Toro Mocho disseminated deposit (1,000 level, approximately 100 m. NW of central shaft, Morococha mining district). Collected by: D. E. Montoya; dated by: M. L. Silberman, U. S. Geological Survey.
(whole rock) 7.2±0.3 m.y.

La Libertad Department

86. Stewart and others (1974) K-Ar
No. 6, table 1

86. (continued)
Adamellite (8°00′56″S; 78°45′28″W). Dated by: Isotope Geology Laboratory, Institute of Geological Sciences, London. (biotite) 43±2 m.y.

87. Stewart and others (1974) K-Ar
No. 7, table 1
Hornblende monzonite (8°28′S; 78°23′W). Dated by: J. F. Evernden, Univ. Calif., Berkeley. 31.1 m.y.

88. Stewart and others (1974) K-Ar
No. 5, table 1
Granodiorite (7°58′55″S; 78°39′31″W). Dated by: Isotope Geology Laboratory, Institute of Geological Sciences, London. Comment: Preferred age is 26 ± 1 m.y. (biotite) 26±1 m.y.
(hornblende) 24±4 m.y.

89. Landis and Rye (1974) Fission track
Consuzo stock. Quartz monzonite of the Cordillera Blanca batholith (8°07′30″S; 77°41′30″W). Collected by: G. P. Landis; dated by: C. Naeser, U. S. Geological Survey. (sphene) 9.5±0.2 m.y.

Lambayeque Department

90. Stewart and others (1974) K-Ar
No. 1, table 1
Adamellite of Coastal batholith (6°48′06″S; 79°33′ 31″W). Dated by: Isotope Geology Laboratory, Institute of Geological Sciences, London.
(biotite) 53±2 m.y.

Lima Department

91. Stewart and others (1974) K-Ar
No. 27, tables 1 and 2 Rb-Sr
Atacongo adamellite, Coastal batholith. Adamellite (12°31′S; 76°51′W). Dated by: Isotope Geology Laboratory, Institute of Geological Sciences, London. Comments: Rb-Sr age is from a two-point potash feldspar-whole rock isochron with an initial $^{87}Sr/^{86}Sr$ ratio of 0.7055. The preferred age, 102 ± 1 m.y. of the unit is the oldest yet reported from the Coastal batholith. (hornblende) 100±3 m.y.
(biotite) 98±3 m.y.
(isochron) 105±6 m.y.

92. Stewart and others (1974) K-Ar
No. 28, table 1
Manchay diorite, Coastal batholith. Diorite (12°09′S; 76°51′W). Dated by: Isotope Geology Laboratory, Institute of Geological Sciences, London. Comment: Preferred age 89 ± 3 m.y. (biotite) 89±3 m.y.
(hornblende) 74±12 m.y.

93. Stewart and others (1974) K-Ar
No. 22, table 1
Granodiorite of Coastal batholith (11°17′S; 77°19′W). Dated by: Isotope Geology Laboratory, Institute of Geological Sciences, London. Comment: Preferred age is 76 ± 3 m.y. (hornblende) 87±12 m.y.
(biotite) 75±3 m.y.

94. Stewart and others (1974) K-Ar
No. 26, table 1
Granite of Coastal batholith (11°39′S; 76°47′W). Dated by: J. F. Evernden, Univ. Calif., Berkeley.
(biotite) 72.0 m.y.

95. Stewart and others (1974) K-Ar
No. 18, table 1
Granite vein, Coastal batholith (10°23′S; 77°42′W). Dated by: J. F. Evernden, Univ. Calif., Berkeley.
(biotite) 63.1 m.y.

96. Stewart and others (1974) K-Ar
No. 29, table 1
"Granite," Coastal batholith (11°56′S; 76°40′W). Dated by: J. F. Evernden, Univ. Calif., Berkeley.
(biotite) 60.5 m.y.

97. Giletti and Day (1968) K-Ar
No. 2, table 1
Stewart and others (1974)
No. 30, table 1
Aplite dike cutting Coastal batholith (11°55′S; 76° 43′W; Chosica). Collected by: J. Fernandez C., A. Ballon, and/or R. Sprague; dated by: B. J. Giletti and H. W. Day, Brown Univ. (biotite) 53±3 m.y.

98. Stewart and others (1974) K-Ar
No. 23, table 1
Granodiorite (11°16′S; 76°48′W). Dated by: Isotope Geology Laboratory, Institute of Geological Sciences, London. (hornblende) 35±3 m.y.

99. Stewart and others (1974) K-Ar
No. 21, table 1
Adamellite (11°03′30″S; 77°09′00″W). Dated by: Isotope Geology Laboratory, Institute of Geological Sciences, London. (biotite) 33±1 m.y.

100. Stewart and others (1974) K-Ar
No. 20, table 1
"Diorite" (10°59′S; 77°07′W). Dated by: J. F. Evernden, Univ. Calif., Berkeley. (biotite) 32.4 m.y.

101. Noble and others (1977) K-Ar
No. 2, table 1
Rhyodacite or rhyolite tuff (12°12.4′S; 76°30.0′W). Collected by: H. Salazar; dated by: E. Farrar, Queen's Univ. (biotite) and E. H. McKee, U. S. Geological Survey (plagioclase). Comments: Tuff unconformably overlies eroded granitic rocks of the Coastal batholith. Preferred age is 28.0 ± 2 m.y. (biotite) 26.1±0.4 m.y.
(plagioclase) 31.0±2 m.y.

102. Giletti and Day (1968) K-Ar
No. 6, table 1
Stewart and others (1974)
No. 31, table 1
Quartz diorite from small intrusive (11°52'S; 76°27' W; Surco). Collected by: J. Fernandez C., A. Ballon and/or R. Sprague; dated by: B. J. Giletti and H. W. Day, Brown Univ. (biotite) 18±1 m.y.

103. Stewart and others (1974) K-Ar
No. 19, table 1
Tonalite (10°44'S; 76°52'W). Dated by: Isotope Geology Laboratory, Institute of Geological Sciences, London. Comment: Preferred age is 13 ± 1 m.y.
(biotite) 13±1 m.y.
(hornblende) 12±5 m.y.

104. Giletti and Day (1968) K-Ar
No. 4, table 1
Stewart and others (1974)
No. 32, table 1
Yauricocha intrusive, quartz monzonite (12°19'40"S; 75°42'45"W; Yauricocha). Collected by: J. Fernandez C., A. Ballon, and/or R. Sprague; dated by: B. J. Giletti and H. W. Day, Brown Univ.
(biotite) 7.7 m.y.

105. Giletti and Day (1968) K-Ar
No. 5, table 1
Stewart and others (1974)
No. 33, table 1
Exito intrusive, quartz monzonite (12°22'S; 75°42'W; Yauricocha area). Collected by: J. Fernandez C., A. Ballon, and/or R. Sprague; dated by: B. J. Giletti and H. W. Day, Brown Univ. (biotite) 6.9±0.4 m.y.

Loreto Department

106. Stewart and others (1974) K-Ar
No. 39, table 1
Phonolite plug (8°00'S; 73°50'W). Collected by: R. Fuentes and A. Salazar, Standard Oil Co.; dated by: Isotope Geology Laboratory, Institute of Geological Sciences, London. Comment: Potash feldspar identified as cryptoperthite by Stewart (1971).
(potash feldspar) 5.4±0.2 m.y.

107. Stewart and others (1974) K-Ar
No. 40, table 1
Phonolite plug (8°00'S; 73°50'W). Collected by: R. Fuentes and A. Salazar, Standard Oil Co.; dated by: Isotope Geology Laboratory, Institute of Geological Sciences, London. Comment: Potash feldspar identified as cryptoperthite by Stewart (1971).
(potash feldspar) 4.4±0.2 m.y.

Moquegua Department

108. Laharie (1973) K-Ar
Volcánico Quellaveco, Tacaza Group. Tuff (road between Toquepala and Quellaveco). Comment: Unconformably overlies granitic rocks of the Arequipa batholith and volcanic rocks of the Toquepala Group.
35.2±1.3 m.y.

109. Laharie (1973) K-Ar
Volcánico Huaylillas. Ash-flow tuff (north of Toquepala, near the Cuajone Mine). Comment: Unconformably overlies the Volcánico Quellaveco.
15.8±1 m.y.

Pasco Department

110. Silberman and Noble (1977) K-Ar
No. 4, table 2
"Cerro quartz monzonite porphyry." Dike of porphyritic quartz latite (10°39.9'S; 76°15.7'W, Cerro de Pasco mining district). Collected by: D. C. Noble; dated by: M. L. Silberman, U. S. Geological Survey.
(sanidine) 15.2±0.2 m.y.

111. Silberman and Noble (1977) K-Ar
No. 2, table 2
"Cerro quartz monzonite porphyry." Dike of porphyritic quartz latite (10°39.8'S; 76°16.5'W, Cerro de Pasco mining district). Collected by: D. C. Noble; dated by: M. L. Silberman, U. S. Geological Survey. Comment: Preferred age is 14.8 ± 0.3 m.y.
(plagioclase) 15.0±0.5 m.y.
(biotite) 14.6±0.4 m.y.

112. Silberman and Noble (1977) K-Ar
No. 1, table 2
"Cerro quartz monzonite porphyry." Protrusive dome of quartz latite composition (10°39.7'S; 76° 16.6'W, Cerro de Pasco mining district). Collected by: D. C. Noble; dated by: M. L. Silberman, U. S. Geological Survey. Comment: Preferred age is 14.4 ± 0.4 m.y. (plagioclase) 14.0±0.4 m.y.
(biotite) 14.8±0.4 m.y.

113. Silberman and Noble (1977) K-Ar
No. 3, table 2
"Cerro quartz monzonite porphyry." Dike of quartz latite (10°40.0'S; 76°16.5'W, Cerro de Pasco mining district). Collected by: D. C. Noble; dated by: M. L. Silberman, U. S. Geological Survey.
(sanidine) 14.2±0.4 m.y.

114. Stewart and others (1974) K-Ar
No. 24, table 1

114. (continued)
Porphyritic "granite" (11°01′S; 76°21′W; at Huayllay). Dated by: J. F. Evernden, Univ. Calif., Berkeley. (biotite) 5.3 m.y.

115. Farrar and Noble (1976) K-Ar
No. 3, table 1
Silicic ash-flow tuff (tuff of the Rock Forest) (10° 57.6′S; 76°19.2′W). Collected by: D. C. Noble; dated by: E. Farrar, Queen's Univ.
(biotite) 5.20±0.20 m.y.

116. Stewart and others (1974) K-Ar
No. 25, table 1
Felsic lava (11°01′S; 76°21′W; at Huayllay). Dated by: J. F. Evernden, Univ. Calif., Berkeley.
(potash feldspar) 4.7 m.y.

Puno Department

117. Evernden and Kistler (1970) K-Ar
No. 1145, table 5
Stewart and others (1974)
No. 64, table 1
Cumbre de Achasiri granite. Porphyritic granite (14° 06′S; 70°02′W, Cumbre de Achasiri-Coasa. Dated by: J. F. Evernden, Univ. Calif., Berkeley. Comment: Intrudes Pennsylvanian and older rocks.
(biotite) 207 m.y.

118. Evernden and Kistler (1970) K-Ar
No. 1159, table 5
Stewart and others (1974)
No. 63, table 1
Nepheline syenite (13°52′S; 70°22′W; Oscuyo-Ayapata). Dated by: J. F. Evernden, Univ. Calif., Berkeley. Comments: Cuts Mitu Group and is intruded by granite (specimen No. PU-1) dated at 207 m.y. The age thus is anomalously low.
(biotite) 180 m.y.

119. Stewart and others (1974) K-Ar
No. 65, table 1
Granite (14°11′S; 69°43′W). Dated by: J. F. Evernden, Univ. Calif., Berkeley. (biotite) 164 m.y.

120. Stewart and others (1974) K-Ar
No. 66, table 1
Granodiorite (14°11′S; 69°43′W). Dated by: J. F. Evernden, Univ. Calif., Berkeley. 40.0 m.y.

121. Fleischer and Price (1964) Fission track
Table 3
Macusanite (nonhydrated natural silicic glass) (14° 00′S; 70°30′W, Macusani). Collected by: V. E. Barnes; dated by: R. L. Fleischer and P. B. Price.
(natural glass) 4.3±0.4 m.y.

122. Barnes and others (1970) K-Ar
Table 1
Macusanite (nonhydrated natural silicic glass) (14° 00′S; 70°30′W; Macusani). Collected by: V. E. Barnes; dated by: G. Edwards and W. A. McLaughlin, Shell Development Co., Houston. Comment: Barnes and others conclude that macusanite is a volcanic glass of terrestrial origin. (whole rock) 4.2±1.5 m.y.

123. Barnes and others (1970) K-Ar
Table 1
Sillar (ash-flow tuff) (14°00′S; 70°30′W; Macusani). Collected by: V. E. Barnes; dated by: G. Edwards and W. A. McLaughlin, Shell Development Co., Houston. (biotite) 4.1±1.0 m.y.

Tacna Department

124. Evernden and Kistler (1970) K-Ar
No. 1466, table 5
Stewart and others (1974)
No. 59, table 1
Gneiss (17°43′S; 70°03′W, Cerro Machani). Dated by: J. F. Evernden, Univ. Calif., Berkeley. Comments: Minimum age. Sample is from basement gneiss underlying late Triassic sediments. The age is probably hybrid, reflecting outgassing by a nearby pluton of Mesozoic or Tertiary age.
(muscovite) 187 m.y.

125. Laughlin and others (1968) K-Ar
No. PED-1-66, table 1
Stewart and others (1974)
No. 58, table 1
"Diorite," Arequipa batholith (17°15′03″S; 70°36′ 38″W; about 5,000 ft northwest of Toquepala pit, Toquepala mining district). Dated by: Geochronology Laboratories, Univ. Ariz., Tucson.
(biotite) 58.7±1.8 m.y.

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