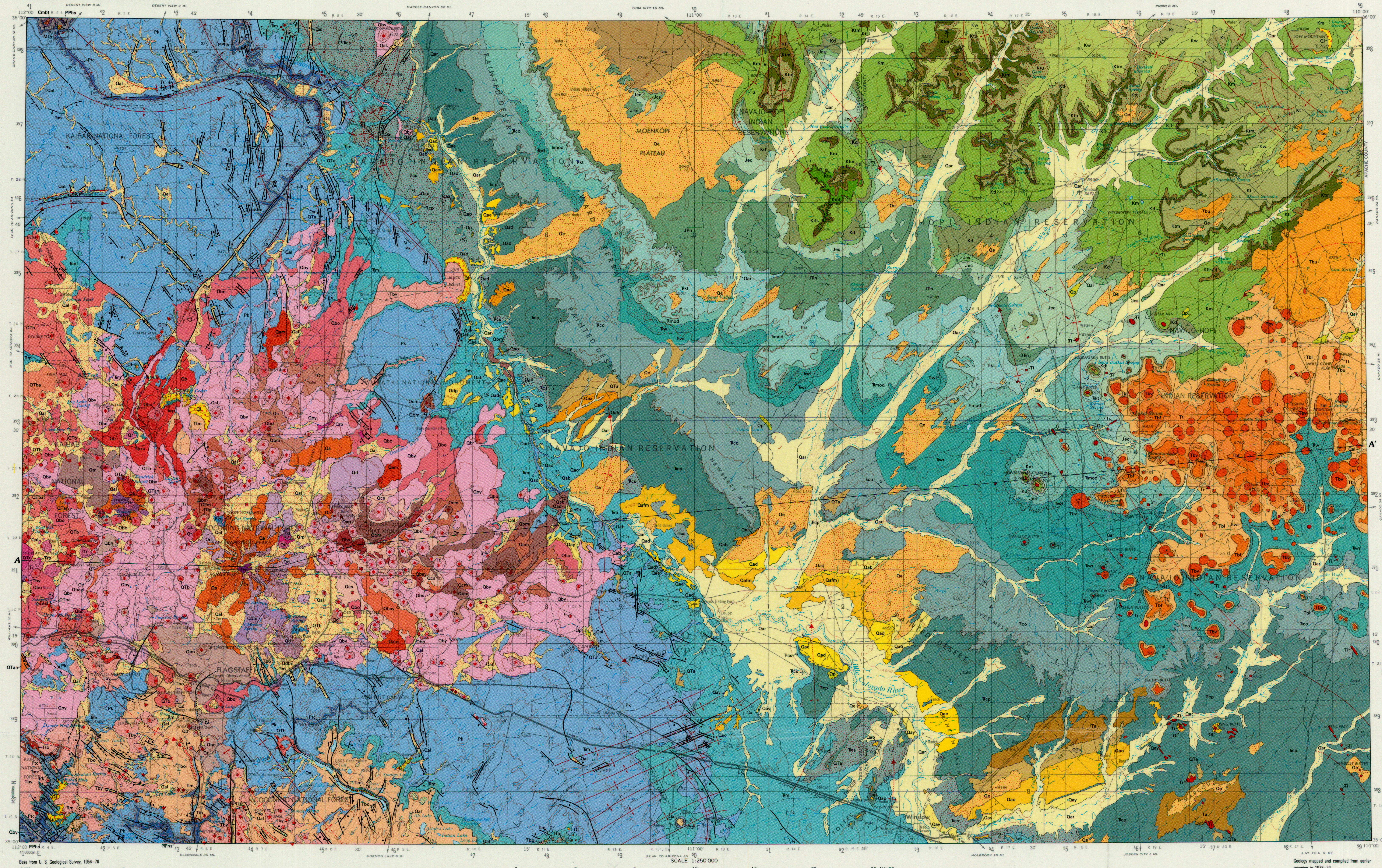
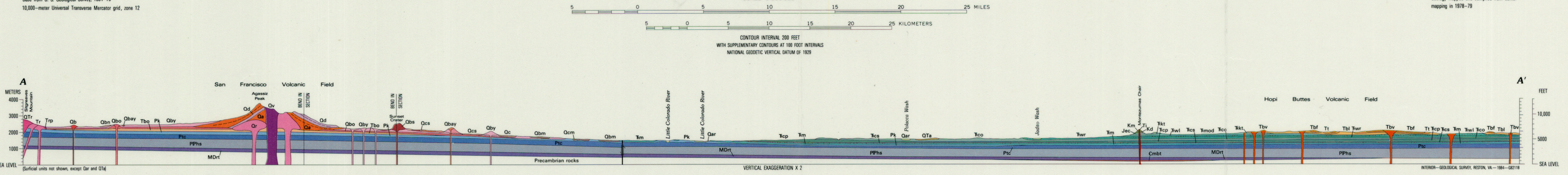
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

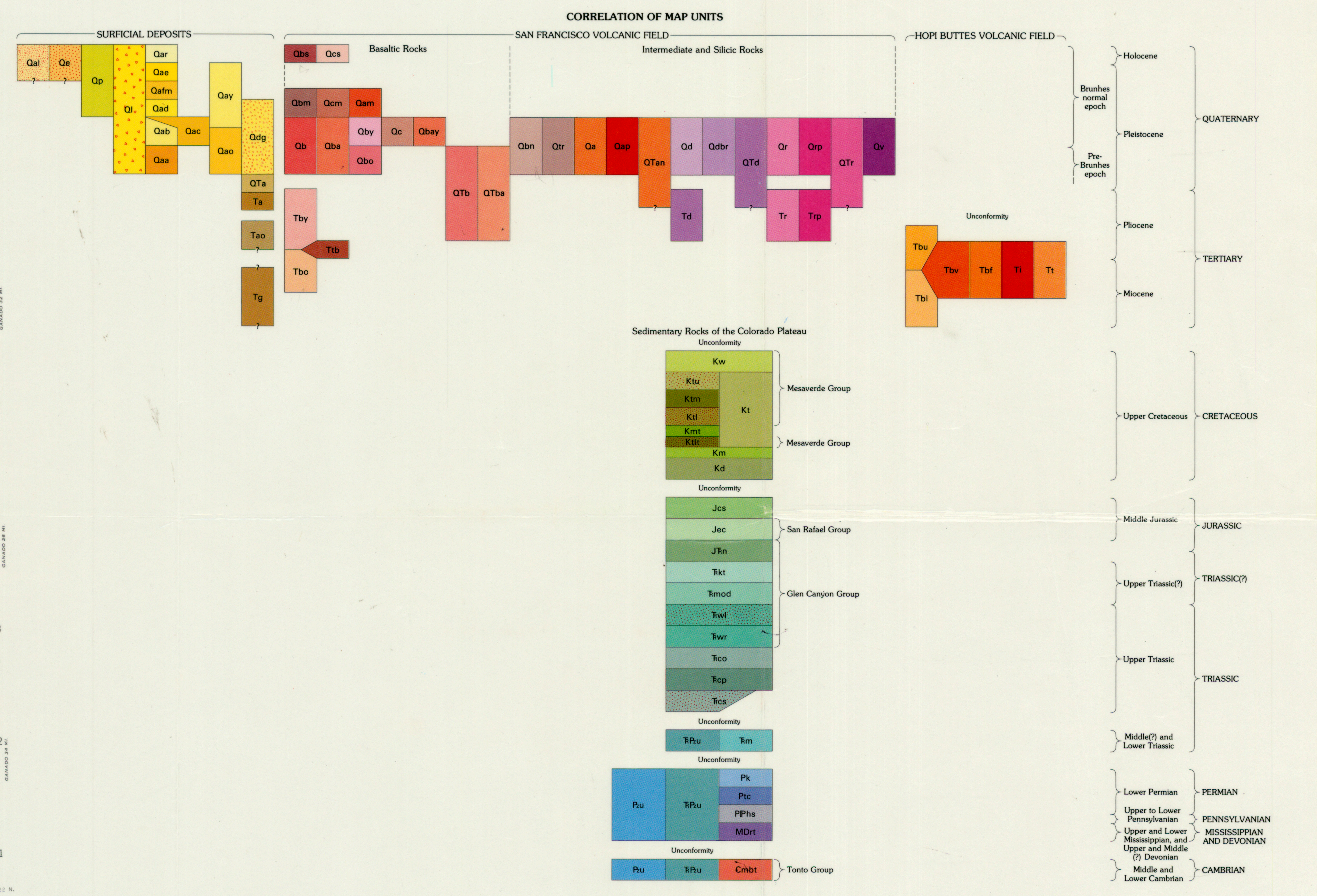
PREPARED IN COOPERATION WITH THE
UNITED STATES DEPARTMENT OF ENERGY

MISCELLANEOUS INVESTIGATIONS SERIES
MAP I-1446 (SHEET 1 OF 2)



SCALE 1:250 000





CORRELATION OF MAP UNITS

DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Qal SILT, SAND, GRAVEL, AND BOULDERS (HOLOCENE AND PLEISTOCENE)—Includes alluvium, colluvium, and eolian, glacial, and glaciofluvial (on San Francisco Mountain) deposits. Postdates bounding faults

Qe EOLIAN DEPOSITS (HOLOCENE TO PLEISTOCENE)—Sand, well-sorted. Forms extensive sand sheet between zero and more than 40 ft (13 m) thick. Most are derived from the modern floodplain of the Little Colorado River; some are derived from older alluvial deposits

Qp PLAYA DEPOSITS (HOLOCENE TO PLEISTOCENE)—Silt and clay, thinly stratified on flat floor of shallow, undrained desert lake basin

Ql LANDSLIDE DEPOSITS (HOLOCENE AND PLEISTOCENE)—Unsorted rock debris, ranging in diameter from less than 1 to 30 ft (0.1–10 m) commonly occurring as large slump blocks

Qar ALLUVIUM (HOLOCENE)—Sand, silt, and clay with minor interbedded gravel. Recent floodplain deposits of the Little Colorado River and tributaries entering from the northeast

Qae ALLUVIAL UNIT E (PLEISTOCENE)—Gravel and sand, 10 to 20 ft (3–6 m) thick. Occurs 5 to 20 ft (2–6 m) above present channel of Little Colorado River

Qafm ALLUVIAL UNIT M (PLEISTOCENE)—Silt, clay, and sand deposited as valley fill upstream from Grand Falls. Valley fill resulted from damming of the Little Colorado River by basalt flow (Qbm) from Merriam Crater area

Qad ALLUVIAL UNIT D (PLEISTOCENE)—Gravelly sand and interbedded sand and silt, locally with large blocks of limestone derived from the Permian Kaibab Formation. Unit 120 ft (40 m) thick near Black Falls

Qac ALLUVIAL UNIT C (PLEISTOCENE)—Silt, clay, and sand with several thin interbedded pebbly gravels; 100–120 ft (33–40 m) thick near Cameron. Deposition of this unit was caused by damming of the Little Colorado River at Cameron by basalt flow (Reiche, 1937) of Tappan age (0.53 ± 0.08 m.y., Damon and others, 1974)

Qab ALLUVIAL UNIT B (PLEISTOCENE)—Gravelly sand with interbedded sand and silt; 100–120 ft (33–40 m) thick near Black Falls

Qaa ALLUVIAL UNIT A (PLEISTOCENE)—Gravelly sand with interbedded sand and silt; 115 ft (38 m) thick near Black Falls

Qay YOUNGER ALLUVIUM (PLEISTOCENE)—Includes alluvial units E, D, and the upper part of B, undifferentiated

Qao OLDER ALLUVIUM (PLEISTOCENE)—Includes the lower part of alluvial unit B, all of unit A, and the Quaternary part of unit QTa, undifferentiated

Qdg GRAVEL AT DEADMAN WASH (PLEISTOCENE)—Gravel, pebble- to boulder-size, rounded to subrounded, with interbedded sand; clasts of silicic, intermediate, and mafic rocks derived from San Francisco Mountain; 20 to 80 ft (6–26 m) thick. Occurs as 3 separate deposits along Deadman Wash, one of which is overlain by a basalt flow dated at 0.50 ± 0.11 m.y. (P. E. Damon, written commun., 1979)

QTa ALLUVIUM (PLEISTOCENE to PLIOCENE)—Interbedded sand, silt, and clay with some interbedded gravel; 130 to 160 ft (43–53 m) thick near Rincon Basin

Ta ALLUVIUM (PLIOCENE)—Sand, silt, and clay deposits with some interbedded gravel; 130 ft (43 m) thick near Rincon Basin. Possibly equivalent to the alluvium beneath the basalt flow on Black Point (Haines and Bowles, 1976) which has been dated at 2.43 ± 0.32 m.y. by Damon and others (1974)

Tao OLDER TERTIARY ALLUVIUM (PLIOCENE)—Sand, gravel, and silt on Moenkopi Plateau. Contains pebbles, cobbles, and small boulders derived from the Cretaceous rocks on Black Mesa

Tg SANDSTONE AND GRAVEL (MIOCENE)—Weakly consolidated interbedded sand and gravel; contains clasts of Paleozoic and Precambrian rocks as much as 2 ft (0.6 m) in diameter. Underlies Miocene basalts in Sycamore and Oak Creek Canyons

ROCKS OF SAN FRANCISCO VOLCANIC FIELD

Principally basalt flows and pyroclastic deposits of alkali-olivine to hawaiitic types surrounding localized centers of intermediate to silicic lavas and pyroclastic deposits having calc-alkalic affinities

Qbs BASALT OF SUNSET CRATER ERUPTIVE SEQUENCE (HOLOCENE)—Time of eruption determined from stratigraphic, dendrochronologic, and paleomagnetic data (Smiley, 1958; Shoemaker, written commun., 1977) was approximately A.D. 1065 to 1250

Qcs BASALTIC CINDER AND ASH BLANKET FROM ERUPTION OF SUNSET CRATER (HOLOCENE)—Shown only where underlying unit cannot be seen or interpreted from topography

Qbm BASALT OF MERRIAM AGE (PLEISTOCENE)—Dated at 150,000 years old or less, by P. E. Damon, unpub. data, 1979). Flow surface is rough and unweathered; vent is sharp rimmed

Qcm BASALTIC CINDER AND ASH BLANKET FROM VENT OF MERRIAM AGE (PLEISTOCENE)—Shown only where underlying unit cannot be seen or interpreted from topography. Locally includes alluvium

Qam BASALTIC ANDESITE OF MERRIAM AGE (PLEISTOCENE)—Flow surface is very fresh and generally blocky. Cone is sharp rimmed with spatter. Composition similar to pre-Merriam basaltic andesites (see Qba); locally aphyric. Three K-Ar ages range from 51,000 to 68,000 yrs (Baksi, 1974, and P. E. Damon, unpub., 1979 data)

Qb BASALT OF PRE-MERRIAM AGE (PLEISTOCENE)—Flow is undissected and lies close to level of present drainage

Qba BASALTIC ANDESITE OF PRE-MERRIAM AGE (PLEISTOCENE)—Andesite of basaltic texture; commonly contains sieved plagioclase, augite, and olivine in partly glassy groundmass. Quartz, amphibole, or hypersthene may be present

Qby BASALT OF PRE-MERRIAM AGE AND WITHIN THE BRUNHES EPOCH (PLEISTOCENE)—Normal polarity and less than approximately 0.7 m.y. Includes flows of Tappan age (0.2–0.7 m.y.) (Moore and others, 1976)

Qbo BASALT OF PRE-BRUNHES AGE (PLEISTOCENE)—Normal or reversed polarity and between approximately 0.7 and 1.8 m.y. old. Includes most flows of Woodhouse age (0.8–3.0 m.y.) (Moore and others, 1976)

Qc BASALTIC CINDER AND ASH BLANKET FROM VENTS OF BRUNHES AGE (PLEISTOCENE)—Shown only where underlying unit cannot be seen or interpreted from topography. Locally includes alluvium

Qbay BASALTIC ANDESITE OF PRE-MERRIAM AGE AND WITHIN THE BRUNHES EPOCH (PLEISTOCENE)—Composition similar to other pre-Merriam basaltic andesite (see Qba)

QTb BASALT (PLEISTOCENE OR POSSIBLY PLIOCENE)—Flow or cone with uncertain stratigraphic relation to rocks of known age. Unit mapped west of San Francisco Mountain

QTba BASALTIC ANDESITE (PLEISTOCENE OR UPPER PLIOCENE)—Flow or cone with uncertain age; occurs at western edge of mapped area. Composition similar to pre-Merriam basaltic andesite (see Qba)

Qbn BENMOREITE (PLEISTOCENE)—High-sodium, commonly aphyric andesite; forms flow, cone, or dome west or southwest of San Francisco Mountain

Qtr TRACHYTE (PLEISTOCENE)—Large, thick (400 ft, 120 m) aphyric flow on northwest side of Kendrick Peak

Qa ANDESITE FLOW, FLOW BRECCIA, OR TUFF BRECCIA (PLEISTOCENE)—Associated with San Francisco Mountain stratovolcano

Qap ANDESITE PYROCLASTIC DEPOSITS OF O'LEARY PEAK (PLEISTOCENE)—Vent materials erupted through the O'Leary Peak dacite dome

QTan ANDESITE FLOW OR CONE (PLEISTOCENE OR PLIOCENE)— Occurring on and west of Kendrick Peak. K-Ar ages range from 1.4 to 2.5 m.y. (E. H. McKee, unpub. data, 1979) but most mapped units are believed to be Pleistocene

Qd DACITE FLOW OR DOME (PLEISTOCENE)—Associated principally with San Francisco Mountain stratovolcano and O'Leary Peak domes

Qdbr DACITE PYROCLASTIC FLOW BRECCIA (PLEISTOCENE)—From vents in San Francisco Mountain and Elden Mountain volcanoes

QTd DACITE FLOW OR DOME (PLEISTOCENE OR UPPER PLIOCENE)—Associated with Kendrick Peak volanco. K-Ar ages range from 1.8 to 2.6 m.y. (E. H. McKee, unpub. data, 1979)

Qr RHYOLITE FLOW OR DOME (PLEISTOCENE)—Locally with marginal rhyolite breccia or pumice

Qrp RHYOLITE PYROCLASTIC DEPOSITS (PLEISTOCENE)—Predominantly air-fall deposits on northeast side of San Francisco Mountain; K-Ar age is 0.80 m.y. (G. A. Izett and C. W. Naeser, written commun., 1979)

QTr RHYOLITE (PLEISTOCENE OR UPPER PLIOCENE)—Dome or flow with uncertain age; associated with rhyolite of Tertiary age (Sitgreaves Mountain) and Quaternary age (Kendrick Peak)

Qv VENT FLOWS, BRECCIAS, TUFF, AND INTRUSIVE ANDESITE, DACITE, AND RHYOLITE (PLEISTOCENE)—Combined units form part of vent complex exposed at head of central valley in San Francisco Mountain stratovolcano

Tby BASALT (PLIOCENE)—Generally smooth, alluvial-covered flows with dissected margins. Dated units are approximately 5 to 2 m.y. old (Damon and others, 1974, and Damon, unpub. data, 1979). Includes some older basalts (Tbo) at base of unit on upper walls of Sycamore Canyon

Ttb BASALTIC TUFF AND TUFF BRECCIA (PLIOCENE)—Deposits of cinders, hydrated basaltic glass, and accessory and accidental xenoliths in Sycamore and Oak Creek Canyon areas. Age is between 4.2 and 4.9 m.y. in Volunteer Canyon (Damon and others, 1974). Locally includes older basalt flows in Sycamore and Oak Creek Canyons

Tbo OLDEST BASALTS OF SAN FRANCISCO VOLCANIC FIELD (PLIOCENE AND MIOCENE)—Informally called rim basalts; in Volunteer Canyon unit includes four flows with K-Ar ages of 3.9 to 9.0 m.y. (Damon and others, 1974)

Td DACITE DOME (PLIOCENE)—Occurs on northeast flank of San Francisco Mountain stratovolcano. Age is 2.78± 0.13 m.y. (Damon and others, 1974)

Tr RHYOLITE DOME OR FLOW (PLIOCENE)—Glassy, aphyric to porphyritic rhyolite. Associated with Sitgreaves Mountain and Kendrick Peak volcanoes and isolated domes between these centers and San Francisco Mountain stratovolcano

Trp RHYOLITE PYROCLASTIC DEPOSITS (PLIOCENE)—Associated with Sitgreaves Mountain; predominantly air-fall deposits

ROCKS OF HOPI BUTTES VOLCANIC FIELD

BIDAHOCHI FORMATION (PLIOCENE AND MIOCENE)

Tbu Upper member—Sandstone, weakly consolidated, mostly fluvial in origin

Tbl Lower member—Calcareous mudstone, siltstone, sandstone, and minor rhyolitic ash. Mostly lacustrine in origin

Tbv Volcanic vent deposits—Includes tuff breccia, agglomerate, and lacustrine deposits in maar craters. Lava flows may cover vents and other deposits. Ages range from approximately 8.5 to 4.2 m.y. (P. E. Damon, unpub. data, 1979)

Tbf Monchiquite lava flow—Alkalic lamprophyre containing clinopyroxene, olivine, biotite, and analcite. Extends beyond its source, in some cases as much as several kilometers. Ages are 7 to 6 m.y. (P. E. Damon, unpub. data, 1979)

Ti Dike or neck—Monchiquite similar to lava flows (Tbf); commonly includes tuff breccia. Age range is same as for vent deposits (Tbv)

Tt Bedded monchiquite tuff—Mostly lacustrine or air-fall in origin; may extend several kilometers from the eruptive source

SEDIMENTARY ROCKS OF THE COLORADO PLATEAU

Kw WEPO FORMATION OF MESAVERDE GROUP (UPPER CRETACEOUS)—Alternating beds of olive-gray siltstone, coal, and yellowish-gray sandstone. Thickness 0–350 ft (0–107 m)

Kt TOREVA FORMATION OF MESAVERDE GROUP (UPPER CRETACEOUS)

Ktu Upper sandstone member—Yellowish-gray to grayish-orange-pink, fine-grained to very coarse grained sandstone. Thickness 0–80 ft (0–24 m)

Ktm Middle carbonaceous mudstone member—Variegated mudstone. Thickness 0–100 ft (0–30 m)

Ktl Lower sandstone member—Light-brown to pale-yellowish-gray, fine- to medium-grained sandstone. Thickness 0–120 feet (0–37 m)

Ktlt Tongue of Toreva Formation—Sandstone. Intertongues with Mancos Shale. Mapped in the Padilla Mesa area. Thickness 0–250 ft (0–76 m)

Km MANCOS SHALE (UPPER CRETACEOUS)—Light- to dark-gray claystone and siltstone. Thickness 160–725 ft (50–220 m)

Kmt Upper tongue—Light- to dark-gray claystone and siltstone. Mapped in the Padilla Mesa area. Thickness 0–50 ft (0–15 m)

Kd DAKOTA SANDSTONE (UPPER CRETACEOUS)—Tan, brown, and gray sandstone, conglomeratic sandstone, and conglomerate. Thickness 0–90 ft (0–27 m). Pinches out to southeast

Jcs COW SPRINGS SANDSTONE (MIDDLE JURASSIC)—Greenish-gray to light-yellowish-gray, fine- to medium-grained, cross-stratified sandstone. Thickness 0–285 ft (0–87 m) where exposed; 470 ft (143 m) thick in well at Keams Canyon. Pinches out to southeast

Jec ENTRADA SANDSTONE AND CARMEL FORMATION (MIDDLE JURASSIC)—Reddish-brown siltstone and sandstone, and white cross-stratified sandstone. Thickness 0–395 ft (0–120 m)

JTRn NAVAJO SANDSTONE (JURASSIC AND TRIASSIC?)—Grayish-orange-pink, even-grained, thickly cross-stratified sandstone. Thickness 0–465 ft (0–142 m). Pinches out to east

TRkt KAYENTA FORMATION (UPPER TRIASSIC?)—Silty facies, grayish-red mudstone, siltstone, and silty sandstone. Thickness 0–600 ft (0–183 m). Pinches out to southeast

TRmod DINOSAUR CANYON SANDSTONE MEMBER OF MOENAVE FORMATION (UPPER TRIASSIC?)—Orangish-red, cross-stratified and flat-bedded sandstone and sandy siltstone. Thickness 100–400 ft (30–122 m). Pinches out eastward beneath Hopi Buttes volcanic field

WINGATE SANDSTONE (UPPER TRIASSIC)

TRwl Lukachukai Member—Reddish-brown fine-grained, cross-stratified sandstone. Thickness 0–255 ft (0–78 m). Pinches out to northwest

TRwr Rock Point Member—Reddish-brown siltstone and mudstone. Thickness 0–800 ft (0–245 m). Pinches out to northwest

CHINLE FORMATION (UPPER TRIASSIC)

TRco Owl Rock Member—Mottled light-gray and grayish-pink interbedded limestone and calcareous siltstone. Thickens from 330 ft (100 m) near Little Colorado River to 620 ft (190 m) beneath Black Mesa

TRcp Petrified Forest Member—Claystone, siltstone, and minor sandstone, variegated. Thickness 0–920 ft (0–280 m)

TRcs Shinarump Member—Light-gray to yellowish-gray sandstone and conglomerate. Thickness 0–70 ft (0–21 m)

TRm MOENKOPI FORMATION (MIDDLE? AND LOWER TRIASSIC)—Reddish-brown mudstone, siltstone, silty sandstone, and sandstone. Thickness 0–370 ft (0–113 m)

TRPzu MIDDLE(?) AND LOWER TRIASSIC AND PALEOZOIC SEDIMENTARY ROCKS, UNDIVIDED—Sandstone, shale, siltstone, limestone, dolomitic limestone, and dolomite; upturned on east side of Slate Mountain rhyolite dome (Qr)

Pzu PALEOZOIC SEDIMENTARY ROCKS, UNDIVIDED—Sandstone, shale, siltstone, limestone, dolomitic limestone, and dolomite; upturned around northern part of Elden Mountain dacite dome (Qd)

Pk KAIBAB FORMATION (LOWER PERMIAN)—Yellowish-gray to light-gray silty dolomite, dolomitic sandstone, minor sandstone and dolomitic limestone. locally map unit includes lower part of Moenkopi Formation. Thickness 0–510 ft (0–155 m). Thickest in southwest corner of area; pinches out eastward

Ptc TOROWEAP FORMATION AND COCONINO SANDSTONE (LOWER PERMIAN)—Light-colored, cross-stratified sandstone; facies of siltstone, sandstone, and dolomite occur in the Toroweap on western edge of map. Coconino laterally equivalent to De Chelly Sandstone to north and east. Thickness 360–1,050 ft (110–320 m)

PPhs HERMIT SHALE (LOWER PERMIAN) AND SUPAI FORMATION (LOWER PERMIAN TO LOWER PENNSYLVANIAN)—Combined thickness 1230–2385 ft (375–727 m)

Hermit Shale—Reddish shale and interbedded sandstone and shale. Present in northwest corner only

Supai Formation—Reddish siltstone, cross-stratified sandstone; some limestone in the lower part

MDrt REDWALL LIMESTONE (UPPER AND LOWER MISSISSIPPIAN) AND TEMPLE BUTTE LIMESTONE (UPPER AND MIDDLE? DEVONIAN)—Combined thickness 0–665 ft (0–203 m). Units pinch out to southeast

Redwall Limestone—Massive light-gray limestone and dolomite

Temple Butte Limestone—Dolomite, reddish siltstone, sandy limestone, and gray sandstone.

Cmbt MUAV LIMESTONE AND BRIGHT ANGEL SHALE (MIDDLE CAMBRIAN) AND TAPEATS SANDSTONE (MIDDLE AND LOWER CAMBRIAN) OF TONTO GROUP—Tonto Group absent in subsurface in southern half of area. Combined thickness 0–340 ft (0–104 m)

Muav Limestone—Mottled-gray and purple dolomitic limestone. Lower part of Muav intertongues with upper part of Bright Angel

Bright Angel Shale—Mainly green, purple, and reddish-brown siltstone interbedded with light-brown sandstone in the lower part

Tapeats Sandstone—Medium- to coarse-grained sandstone and pebble conglomerate, commonly crossbedded

EXPLANATION

CONTACT—Dashed to show subdivisions of lava flows in the San Francisco volcanic field

FAULT—Dashed where inferred; dotted where concealed; bar and ball on downthrown side. Predates alluvium where shown bounding it

STRIKE AND DIP OF BEDS—Dips in fractions of degrees in Little Colorado River valley determined by plane table on resistant layers

MONOCLINE, SHOWING TRACE OF AXIS—Located approximately midway between top and bottom hinges of fold. Length of arrow indicates distance between hinges. Dotted where concealed

ANTICLINE, SHOWING TRACE OF AXIS—Dotted where concealed

SYNCLINE, SHOWING TRACE OF AXIS—Dotted where concealed

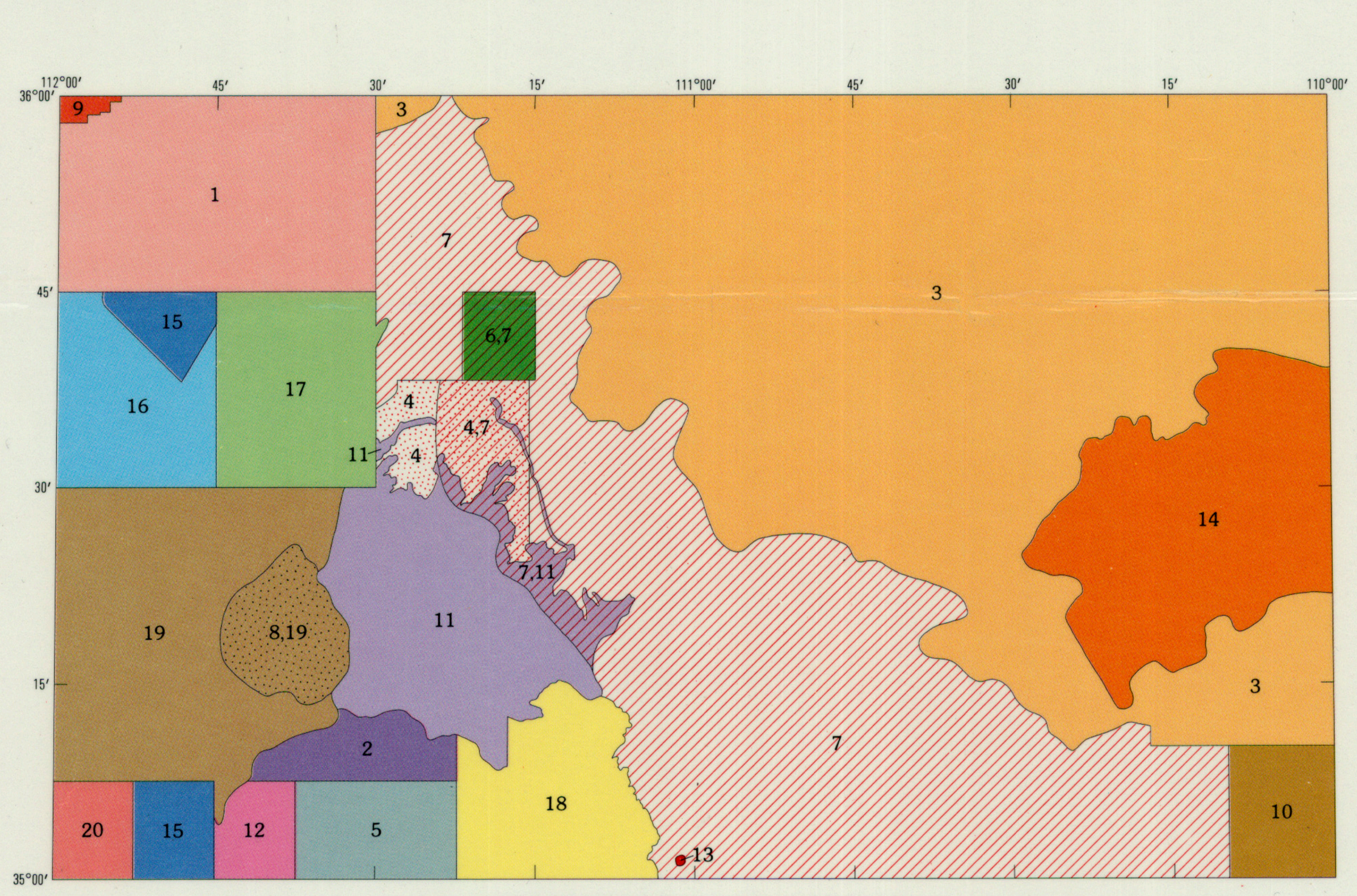
CINDER AND/OR SPATTER CONE OF BASALTIC COMPOSITION

FISSURE-CONTROLLED LAVA RIDGE

HYDRATED TUFF AND TUFF BRECCIA OF BASALTIC COMPOSITION IN SAN FRANCISCO VOLCANIC FIELD—Forms tuff ring or maar where explosive in origin; locally contains abundant xenoliths. Elsewhere forms oxidized and indurated part of cinder cone. Occurs in various amounts within basaltic vents of various ages

COLLAPSE STRUCTURE—Breccia pipe(?) at depth

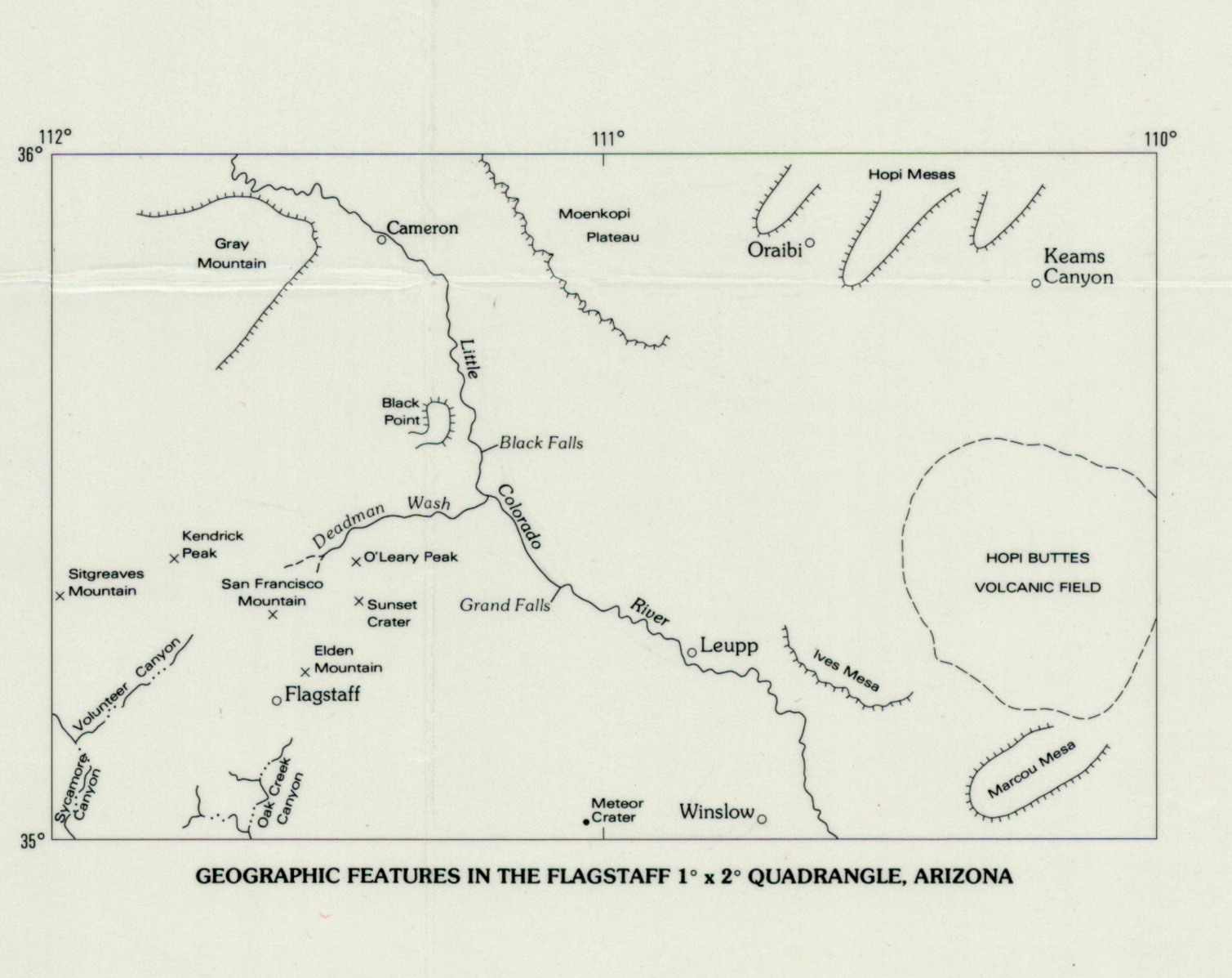
BRECCIA PIPE—A collapse structure with exposed breccia



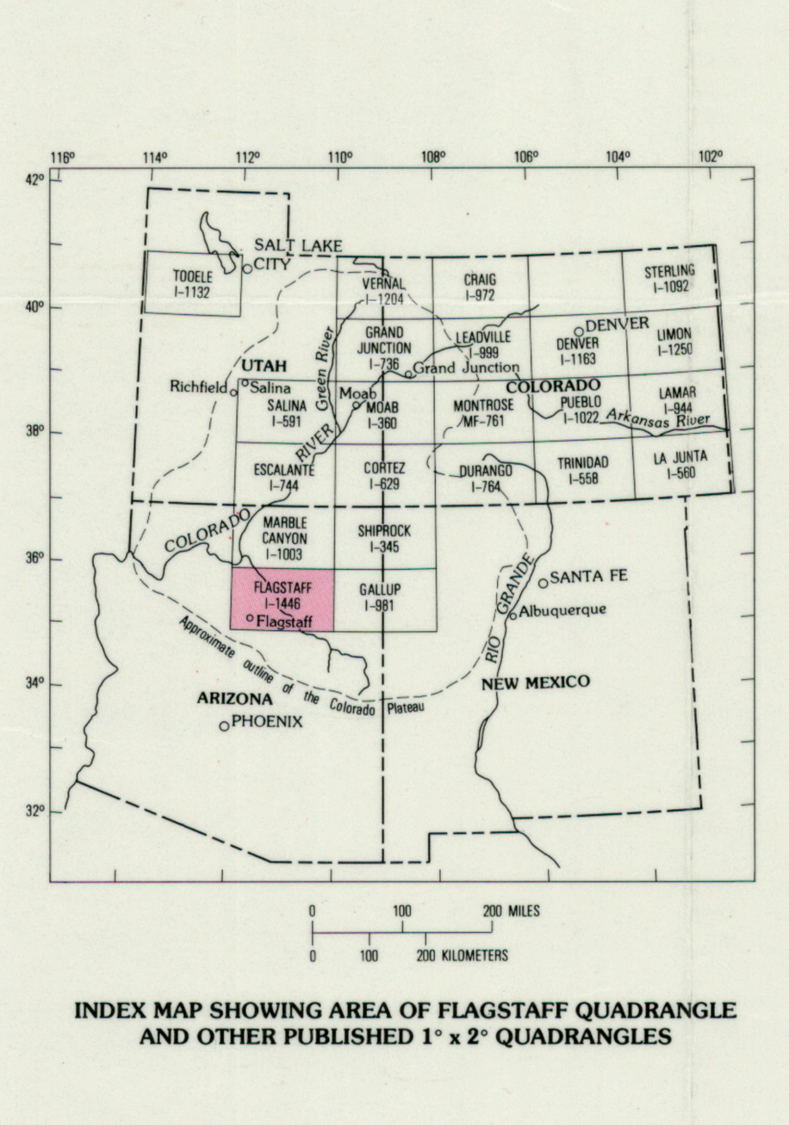
INDEX MAP SHOWING GEOLOGIC SOURCES

GEOLOGIC SOURCES

1. G. H. Billingsley, C. W. Barnes, and G. E. Ulrich, unpub. mapping, 1:62,500,1979.
2. G. H. Billingsley, unpub. mapping, 1:24,000, 1979.
3. Cooley and others, 1969, pl. 1, sheets 2 and 4, 1:125,000.
4. Cosner, 1962, pl. 20, 1:63,360.
5. R. L. Eastwood and L. D. Nealey, unpub. mapping, 1:24,000, 1979.
6. Haines and Bowles, 1976, 1:24,000.
7. Hereford, 1979, 1:250,000.
8. R. F. Holm, unpub. mapping, 1:24,000, 1980.
9. Huntoon and others, 1976, 1:62,500.
10. Mann, 1976, pl. 1, 1:250,000.
11. Moore and Wolfe, 1976, 1:50,000.
12. L. D. Nealey and E. W. Wolfe, unpub. mapping, 1:24,000, 1979.
13. Shoemaker, 1960, figure 2, 1:25,000.
14. R. L. Sutton, unpub. mapping, 1:62,500, 1968.
15. G. E. Ulrich, unpub. mapping, 1:24,000, 1979.
16. G. E. Ulrich and E. W. Wolfe, unpub. mapping, 1:50,000, 1979.
17. Ulrich and Bailey, 1974, 1:50,000.
18. J. Weber, unpub. mapping, 1:24,000, 1979.
19. E. W. Wolfe, G. E. Ulrich, and C. G. Newhall, unpub. mapping, 1:50,000, 1975–1979.
20. E. W. Wolfe and D. A. Hahn, unpub. mapping, 1:24,000, 1979.



GEOGRAPHIC FEATURES IN THE FLAGSTAFF 1° x 2° QUADRANGLE, ARIZONA



INDEX MAP SHOWING AREA OF FLAGSTAFF QUADRANGLE AND OTHER PUBLISHED 1° x 2° QUADRANGLES

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA.—1984—G82118

REFERENCES

Baksi, A. K., 1974, K-Ar study of the S. P. flow: Canadian Journal of Earth Science, v. 11, p. 1350–1356.

Cooley, M. E., Harshbarger, J. W., Akers, J. P., and Hardt, W. F., 1969, Regional hydrogeology of the Navajo and Hopi Indian Reservations, Arizona, New Mexico, and Utah: U. S. Geological Survey Professional Paper 521–A, 61 p.

Cosner, O. J., 1962, Ground water in the Wupatki and Sunset Crater National Monuments, Coconino County, Arizona: U. S. Geological Survey Water-Supply Paper 1475–J, p. 357–374.

Damon, P. E., Shafiqullah, M., and Leventhal, J. S., 1974, K-Ar chronology for the San Francisco volcanic field and rate of erosion of the Little Colorado River, *in* Karlstrom T. N. V., Swann, G. A., and Eastwood, R. L., eds., pt. 1 of Geology of Northern Arizona: Geological Society of America Guidebook for Rocky Mountain Section Meeting Flagstaff, Arizona, v. 6, no. 5, p. 221–235. [Ages have been corrected for recently revised decay constants.]

Haines, D. V., and Bowles, C. G., 1976, Preliminary geologic map of the Wupatki NE quadrangle, Arizona: U. S. Geological Survey Open–File Report 76–703, scale 1:24,000.

Hereford, Richard, 1979, Preliminary geologic map of the Little Colorado River Valley between Cameron and Winslow, Arizona: U. S. Geological Survey Open–File Report 79–1574 scale 1:250,000.

Huntoon, P. W., Billingsley, G. H., Breed, W. J., Sears, J. S., Ford, T. D., Clark, M. D., Babcock, R. S., and Brown, E. H., 1976, Geologic map of the Grand Canyon National Park, Arizona: Grand Canyon Natural History Association and Museum of Northern Arizona, scale 1:62,500.

Mann, L. J., 1976, Ground Water resources and water use in southern Navajo County, Arizona: Arizona Water Commission Bulletin 10, 106 p.

Moore, R. B., and Wolfe, E. W., 1976, Geologic map of the eastern San Francisco volcanic field, Arizona: U. S. Geological Survey Miscellaneous Investigations Series Map I–953, scale 1:50,000.

Moore, R. B., Wolfe, E. W., and Ulrich, G. E., 1976, Volcanic rocks of the eastern and northern parts of the San Francisco volcanic field, Arizona: U. S. Geological Survey Journal of Research, v. 4, no. 5, p. 549–560.

Reiche, Parry, 1937, Quaternary deformation in the Cameron district of the plateau province: American Journal of Science, v. 34, no. 200, p. 128–138.

Shoemaker, E. M., 1960, Penetration mechanics of high velocity meteorites, illustrated by Meteor Crater, Arizona: International Geological Congress, 21st Session, pt. 18, Copenhagen, p. 418–434.

Smiley, T. L., 1958, The geology and dating of Sunset Crater, Flagstaff, Arizona, *in* Guidebook of the Black Mesa Basin: New Mexico Geological Society, 9th Field Conference Guidebook, p. 186–190.

Ulrich, G. E., and Bailey, N. G., 1974, Geologic map of the SP Mountain quadrangle, Coconino County, Arizona: U. S. Geological Survey Open–File Report 74–5, scale 1:50,000.

Wilson, E. D., Moore, R. T., and Cooper, J. R., 1969, Geologic map of Arizona: Arizona Bureau of Mines and U. S. Geological Survey, scale 1:500,000.

Geologic Map
MAP SHOWING GEOLOGY, STRUCTURE, AND URANIUM DEPOSITS OF THE FLAGSTAFF 1° x 2° QUADRANGLE, ARIZONA

Compiled by
G. E. Ulrich, G. H. Billingsley, Richard Hereford, E. W. Wolfe,
L. D. Nealey, and R. L. Sutton

1984