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UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Preliminary Geologic Map and Sections of the Wupatki NE Quadrangle, Coconino County, Arizona

By

David V. Haines and C. Gilbert Bowles

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This report is preliminary and has not been edited or reviewed for conformity with U.S. Geological Survey standards and nomenclature.

DESCRIPTION OF MAP UNITS

| Qal | ALLUVIUM (HOLOCENE)--Sand, silt, and gravel deposits in flood-plain and channel of Little Colorado River, in tributary valleys, and on slopes flanking terraces.

| Qe | SAND (HOLOCENE)--Wind-blown blanket deposits including one climbing dune on escarpment of Ward Terrace.

| Qd | SAND DUNES (HOLOCENE)--Longitudinal and crescentic dunes north of Tohachi Wash; dunes parallel to Little Colorado River formed over levees.

| Qpy | PYROCLASTIC DEPOSITS, YOUNGER (PLEISTOCENE)--Poorly exposed indurated, moderate brown tuff overlain by black ash; underlain by younger colluvium (Qcky). Thickness about 5 feet (1.5 m). Located near Mays Wash in NW 1/4 NW 1/4 sec. 19, T. 27 N., R. 10 E. at approximate elevation 4,420 feet (1,355 m).

| Qcky | COLLUVIUM, YOUNGER (PLEISTOCENE TO HOLOCENE)--Colluvium consisting chiefly of Kaibab boulders, deposited mainly by gravity in stream channels adjacent to Black Point segment of East Kaibab monocline; derived mainly from reworking of middle colluvium deposits (Qckm); thickness 1-5 feet (0.3-1.5 m).

| Qt_1 | TERRACE GRAVELS (PLEISTOCENE)--Fluvial gravel deposits with minor sand at lowest levels adjacent to Little Colorado River, tops approximately 20-50 feet (6-15 m) above river channel at elevations about 4,210 to 4,280 feet (1283-1,305 m); no caliche zone.

Qt_2 TERRACE GRAVELS (PLEISTOCENE)--Similar to Qt_1 gravels except top surfaces are approximately 55-100 feet (17-30 m) above river channel at elevations about 4,250 to 4,325 feet (1,300-1,325 m); seldom calichified.

Qoay OLDER ALLUVIUM, YOUNGER (PLEISTOCENE)--Small conical hills in northeast part of quadrangle overlying terrace gravels Qt_3. Sand with fragments of Owl Rock limestone, hills covered by lag deposit of Owl Rock limestone. Thickness 25 feet (8 m).

Qt_3 TERRACE GRAVELS (PLEISTOCENE)--Similar to Qt_1 gravels but with more sand; lag layer of gravel at top; contains some Owl Rock fragments east of Little Colorado River; terrace tops approximately 115-160 feet (35-49 m) above river channel at elevation about 4,310 to 4,400 feet (1,320-1,345 m); majority of terraces not calichified.

Qckm COLLUVIUM, MIDDLE (PLEISTOCENE)--Colluvium consisting chiefly of boulders of Kaibab Limestone, deposited mainly by gravity on slopes below level of older colluvium (Qcko) deposits but above channels of present streams and younger colluvium (Qcky); reworked from older colluvium (Qcko) deposits; elevations less than 4,400 feet (1,345 m).

Qls LANDSLIDE DEBRIS (PLEISTOCENE)--Landslide debris below scarp on east side of Black Point basalt flow. Blocks of basalt, masses of sand and gravel, and segments of Petrified Forest Member, Chinle Formation.

Qpm PYROCLASTIC DEPOSITS, MIDDLE (PLEISTOCENE)--Cinder dunes, black cross-bedded, 5-10 feet (1.5-3 m) thick; deposits overlie older colluvium (Qcko) and a buried terrace that is in category Qt_4, and are overlain by landslide debris (Qls); locality described by Chenoweth and Cooley (1960) in surface mine cut (Navajo No. 26 mine) in SE 1/4 SW 1/4 sec. 18, T. 27 N., R. 10 E. at approximate elevation 4,465 feet (1,370 m); deposits concealed in 1968.

Qcko COLLUVIUM, OLDER (PLEISTOCENE)--Colluvium consisting chiefly of boulders of Kaibab Limestone, deposited on pediments truncating Triassic strata on Black Point segment of East Kaibab monocline, east of White Mesa; locally calichified, sometimes forming conglomerate; elevations 4,400 to 4,660 feet (1,345-1,425 m).

Qt_4 TERRACE GRAVELS (PLEISTOCENE)--Fluvial sand and gravel deposits; gravel subordinate in amount in thicker deposits; relatively strong calichification; tops approximately 175-235 feet (51-74 m) above channel of Little Colorado River at elevations about 4,385 to 4,470 feet (1,340-1,370 m).

Qcb TALUS (PLEISTOCENE TO HOLOCENE)--Large blocks of basalt derived from Black Point flow on slope below scarp in sec. 5, T. 26 N., R. 10 E. where apron-like deposits lie above terrace Qt_4 at elevation about 4,460 feet (1,372 m). Bulk of deposit is considered a "fossil" talus slope. Other basalt talus west of Black Point flow.

Qpo

PYROCLASTIC DEPOSITS OLDER (PLEISTOCENE)--Small, varied deposits at 5 localities on monocline south of Black Point basalt flow at elevations from about 4,460 to 4,520 feet (1,372-1,390 m); medium dark gray, bedded, poorly-consolidated tuff and lapilli locally associated with tuffaceous sandstone; overlain by older colluvium (Qcko) deposits; thickness about 4-35 feet (1.2-12 m).

Qoam

OLDER ALLUVIUM, MIDDLE (PLEISTOCENE)--Lenticular, poorly-consolidated to unconsolidated, cross-laminated, brown sandstone and sand with abundant lenses of Owl Rock limestone gravel; armored mud balls and plant casts locally present. Thickness minimum 45 feet (14 m). Occupies channel cut in older alluvium, older (Qoao) deposits of Baah Lokaa Ridge; probably overlies terrace Qt_5.

Qoao

OLDER ALLUVIUM, OLDER (PLEISTOCENE)--Purplish mudstones, siltstones, and fine-grained sandstones with lenses of Owl Rock gravel; very thin bedded, evenly bedded; maximum thickness about 135 feet (41 m); overlies basal gravel of terrace Qt_5 and probably interfingers with other units of Qt_5 above basal gravel in Baah Lokaa Ridge.

Qt_5 — TERRACE GRAVELS (PLEISTOCENE)--Fluvial and mud flow(?) deposits consisting of (1) locally calichified basal river gravel, 16 feet (5 m) thick, which is exhumed on southeast side of Baah Lokaa Ridge, (2) lenticular, cross-laminated sand and gravel with armored mud balls, channel cut-and-fill structures, and mud flow(?) debris with tuff and pumiceous lava fragments, overlain by very large boulders; approximately 70 feet (21 m) thick; upper 4 feet (1 m) strongly calichified; top is about 320 feet (98 m) above river at elevation approximately 4,550 feet (1,400 m).

Tty — TERRACE GRAVELS (PLIOCENE?)--River gravel with minor sand representing remnants of fluvial terraces; occur on top of Black Point basalt flow at approximate elevation 4,925 feet (1,510 m) and on White Mesa overlying Kaibab Limestone at approximate elevation of 4,990 feet (1,530 m); thickness ranges from about 6 inches to 5 feet (15 cm-1.5 m).

Tb — BLACK POINT BASALT FLOW (PLIOCENE?)--Medium dark gray porphyritic basalt, 60 feet (18 m) thick in drill hole RB5, vesicular in upper 6 feet (1.8 m); conspicuous phenocrysts of plagioclase from 1 mm to 2.5 inches (6 cm) in length; minor phenocrysts of olive and pyroxene; aphanitic groundmass. Basalt dated by K-Ar methods at 2.39±0.32 million years (Damon, 1966).

Tto

TERRACE GRAVELS (PLIOCENE?)--Fluvial sand and gravel beneath Black Point basalt flow; thickness 73 feet (22 m) in drill hole RB5.

CHINLE FORMATION (UPPER TRIASSIC)

Ꞧ co

Owl Rock Member--Predominately purplish sandstone, mudstone, and siltstone interbedded with very light gray limestone; exposed in Tloi Eechii Cliffs on Ward Terrace.

Ꞧ cp

Ꞧ cpb

Petrified Forest Member, undifferentiated--Consists of three units, in ascending order: (1) bluish-gray bentonitic mudstone, about 60 feet (18 m) thick, (2) gray sandstone and mudstone, about 230 feet (70 m) thick and (3) red-brown mudstone unit, about 350 feet (107 m) thick (Wilson, 1956). Contains petrified logs, carbonaceous plant remains, and vertebrate bones. Lower bentonitic mudstone unit (Ꞧ cpb) mapped west of Little Colorado River and north of Black Point basalt flow.

Ꞧcss	Sandstone and siltstone member--Thick bedded, mottled sandstone, siltstone, and mudtone characterized by rapid facies changes; generally capped by pebbly, cliff-forming, quartzite sandstone with local ironstone concretions averaging 5 mm in diameter; thickness about 30 feet (9 m).
Ꞧcs	Shinarump Member--Consists of (1) a basal, cliff-forming, clayey conglomeratic sandstone, brownish-gray, persistent, with numerous fractures and joints, about 7 feet (2.2 m) thick, prominent in southeast part of quadrangle, (2) a medial, slope-forming, varicolored mudstone unit of variable thickness, approximately 0-40 feet (0-12 m), locally absent; and (3) a white, capping, cliff-forming, clayey conglomeratic sandstone, about 29 feet (9 m) thick, prominent in northwest part of quadrangle, thins to southeast and interfingers with underlying mudstone.
Ꞧmu	MOENKOPI FORMATION (MIDDLE[?] AND LOWER TRIASSIC)--Undivided
Ꞧmh	Holbrook Member--Thin- to medium-bedded greenish, reddish brown, yellowish brown, and grayish mudstone, siltstone, and sandstone interbedded with thick-bedded to very thick-bedded, cliff-forming pinkish to reddish sandstone; locally eroded and generally incompletely exposed; thickness about 60 feet (18 m) (incomplete).

Ɽmm	Moqui Member--Thin-bedded siltstone and mudstone, predominately slope-forming, with thick-bedded to very thick-bedded, ledge-forming sandstone beds; gypsum in layers, lenses, nodules, and veins; rapid facies changes; beds greenish, brownish, and reddish. Thickness is about 190 feet (58 m).
Ɽmw	Wupatki Member--Thin-bedded, brown to reddish-brown, slope-forming mudstones interbedded with grayish to pale red, resistant sandstones; thickness ranges from about 75 to 120 feet (23-37 m); uppermost bed is a prominent, persistent, very thick-bedded, cliff-forming pinkish gray sandstone 11 to 37 feet (3.4-11 m) thick; exposed only on monocline south of Black Point.
Ɽmb	Basal breccia member--Predominantly pinkish gray or light gray, thick-bedded breccia of poorly-sorted, well-cemented, predominantly pebble-size, angular fragments of chert and Kaibab Limestone in a calcareous, coarsely-arenaceous to argillaceous matrix; locally underlain by boulder- and cobble-size breccia; thickness 1-12 feet (0.3-3.7 m). Outcrop width exaggerated to show location of member. Member shown as dotted line in cross section BB'.

Pk KAIBAB LIMESTONE (PERMIAN)--Arenaceous dolomitic limestone, even-bedded, generally very thick-bedded, well-indurated, very finely crystalline, grayish pink. Thickness about 340 feet (120 m).

B MUDFLOW(?) DEPOSITS (PLEISTOCENE)--Very large angular boulders of Kaibab Limestone, Shinarump conglomeratic sandstone, and Moenkopi siltstone and sandstone; boulders to 1,000 tons or more; occur embedded in surface of Qt_5 terrace on Baah Lokaa Ridge, but are also present as let-down "erratics" at lower elevations on both sides of Little Colorado River and north of Baah Lokaa Ridge.

CONTACT--Dashed where approximately located.

7 FAULT--Dashed where approximately located; bar and ball on downthrown side with measured displacement in feet.

FOLD AXES IN TRIASSIC-PERMIAN ROCKS

Anticline

Syncline

Anticlinal bend of monocline south of Black Point flow; longer arrow indicates flatter dip; dashed where approximately located.

Synclinal bend of monocline south of Black Point flow; longer arrow indicates flatter dip; dashed where approximately located.

4 STRIKE AND DIP OF BEDS

Inclined

JOINTS

80 — Strike and dip of joints

Strike of vertical joints

ABANDONED RIVER CHANNEL

TRENCH

MINE, uranium, inactive or abandoned

OPEN-PIT MINE, uranium, inactive or abandoned

MINE DUMP

X PROSPECT PIT, uranium

Mn Δ MANGANESE OCCURRENCE

SHAFT, vertical

DRILL HOLE

WATER WELL

ECONOMIC GEOLOGY

Uranium

The map area includes the southern part of the Cameron uranium mining district. Uranium deposits in the quadrangle occur within the sandstone and siltstone member of the Chinle Formation, in the lower 60 feet of the Petrified Forest Member of the Chinle Formation, and in the Riverview breccia pipe which surfaces in the Wupatki Member of the Moenkopi Formation. Production from the quadrangle in the period 1953-1963 amounted to 117,821 tons (106,863 metric tons) grading 0.206 percent U_3O_8, essentially all of which came from the Petrified Forest Member.

The bedded ore deposits occur within elongated, lenticular sandstone channel fills containing carbonaceous matter and fossil logs. A comprehensive description of the mineralogy of the deposits is given by Austin (1964). Ore consists chiefly of secondary uranium minerals filling pore spaces in sandstone with occasional uraniferous logs in various stages of oxidation. Unoxidized portions of logs contain uraninite and sulfide minerals in a matrix of carbonaceous material. As many as three ore zones may be present in a vertical section. Individual ore bodies contain up to 40,000 tons (36,000 metric tons) of ore but the average is about 5,000 tons (4,550 metric tons). The most productive mine in the quadrangle is the Charles Huskon No. 4 with a production of about 34,000 tons (31,000 metric tons) of ore. The largest open pit is the pit common to Ramco 20-22 and Ryan 2 mines which is about 2,200 feet (670 m) in length and up to 97 feet (30 m) deep. With the exception of two shafts, all mining in the quadrangle has been by open pit methods.

Production from the sandstone and siltstone member has been minor. The largest producer in the quadrangle from this member is the New Liba mine which yielded about 2,000 tons (1,800 metric tons) of ore. The Huskon 11 mine, just north of the quadrangle, was the largest producer in the district at 2,800 tons (2,550 metric tons) of ore. The sandstone and siltstone member includes strata formerly placed in the upper part of the Shinarump Member by Hinckley (1957), Bollin and Kerr (1958), Chenoweth and Blakemore (1961), Chenoweth (1962), Abdel-Gawad and Kerr (1963), and Austin (1964).

The Riverview mine shaft was sunk to a depth of 55 feet (16.8 m) and produced a few hundred tons of ore from a breccia pipe (Chenoweth and Blakemore, 1961). Core from exploratory drill holes indicates that the breccia of clastic rocks and limestone extends to a depth of about 450 feet (138 m) and terminates near the base of the Kaibab Limestone. Uranium occurred in blocks of the sandstone and siltstone member of the Chinle Formation in the center of the pipe and in Moenkopi breccia within the shaft located near the margin of the structure.

Manganese

A small occurrence of manganese-bearing rock occurs at Universal Transverse Mercator coordinates $^{4}74^{700}$ m.E. and $^{39}46^{750}$ m.N. on the southeast side of Baah Lokaa Ridge. The deposit consists of angular fragments of dark-gray, tough rock of relatively high density, which forms a lag deposit on a conical hill eroded in the red-brown mudstone unit of the Petrified Forest Member, Chinle Formation. The deposit appears to have been a lens about 2 inches (5 cm) thick which was weathered out and fractured during erosion of the host rock. Spectrochemical analysis of a sample of the dark-gray rock indicates the following constituents in weight percent: MnO 43.28, SiO_2 30.5, Al_2O_3 4.8, Fe (total) 1.65, K_2O 1.25, Na_2O 1.07, CaO 0.78, MgO 0.54, TiO_2 0.20, P_2O_5 0.06, ignition loss 10.77 (Analysts: D. Emmons, L. Dexter, T. Simpson, U.S. Geological Survey, Flagstaff, Ariz.). X-ray diffraction analysis of a sample indicates that the manganese-bearing rock contains quartz, plagioclase, psilomelane, and pyrolusite.

Sand and gravel

Sand and gravel is obtained from a fluvial terrace deposit in section 22, T. 27 N., R. 10 E. and at other similar localities on the north side of the Black Point flow. Pit operations are carried out intermittently by means of portable equipment; the material is used in highway construction.

Bentonite

Potential commercial deposits of bentonitic clay occur in the bentonitic mudstone unit of the Petrified Forest Member, Chinle Formation. The clay, however, does not expand sufficiently to be considered a swelling bentonite, and it does not appear to be suitable for absorptive uses. Dispersive properties of the clay may make it suitable for lining cattle tanks, small reservoirs, and canals (Kiersch, 1955; Wilson, 1965).

Miscellaneous deposits

Flagstone and building stone obtained from the Moenkopi Formation have been used in construction of buildings at Cameron and Flagstaff.

Potential sources of crushed and broken stone include the Black Point basalt, Kaibab Limestone, Shinarump sandstone and conglomerate, and oversize cobbles from sand and gravel operations.

Water resources

Surface water for stock is provided by the Little Colorado River and by small dams constructed across the ephemeral tributaries of the Little Colorado River. Only a few water wells are present within the quadrangle. Wells draw water from alluvium, the sandstone and siltstone member of the Chinle Formation, and Coconino Sandstone, a formation of Permian age that underlies the Kaibab Limestone. Water from a well drilled to the Coconino Sandstone in the NE 1/4 SE 1/4 SW 1/4 sec. 9, T. 26 N., R. 10 E. is a sodium chloride type. The static water level in this well is reported to be 259 feet (78 m) below the surface. Water from a dug well in sec. 6, T. 27 N., R. 10 E., just off the quadrangle, is from the sandstone and siltstone member of the Chinle Formation and is a sodium bicarbonate type. Analyses of water from these two wells reported by McGavock (1968) are as follows:

	Well (A-26-10)9cda (Coconino Sandstone)	Well (A-27-10)6abc (Sandstone and siltstone member of Chinle Formation)
	(ppm)	
Silica, SiO_2	12	16
Iron, Fe*	.02	.02
Calcium, Ca	146	8.0
Magnesium, Mg	91	2.4
Sodium, Na } Potassium, K }	2,600	236
Bicarbonate, HCO_3	284	370
Carbonate, CO_3	0	0
Sulfate, SO_4	450	148
Chloride, Cl	4,200	54
Fluoride, F	.4	3.8
Dissolved solids	7,640	766
Hardness as $CaCO_3$		
Ca, Mg	740	30
Non-carbonate	508	0
	micromhos	
Specific conductance	12,900	1,050
pH	7.9	7.7

*In solution at time of analysis.

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CORRELATION OF MAP UNITS