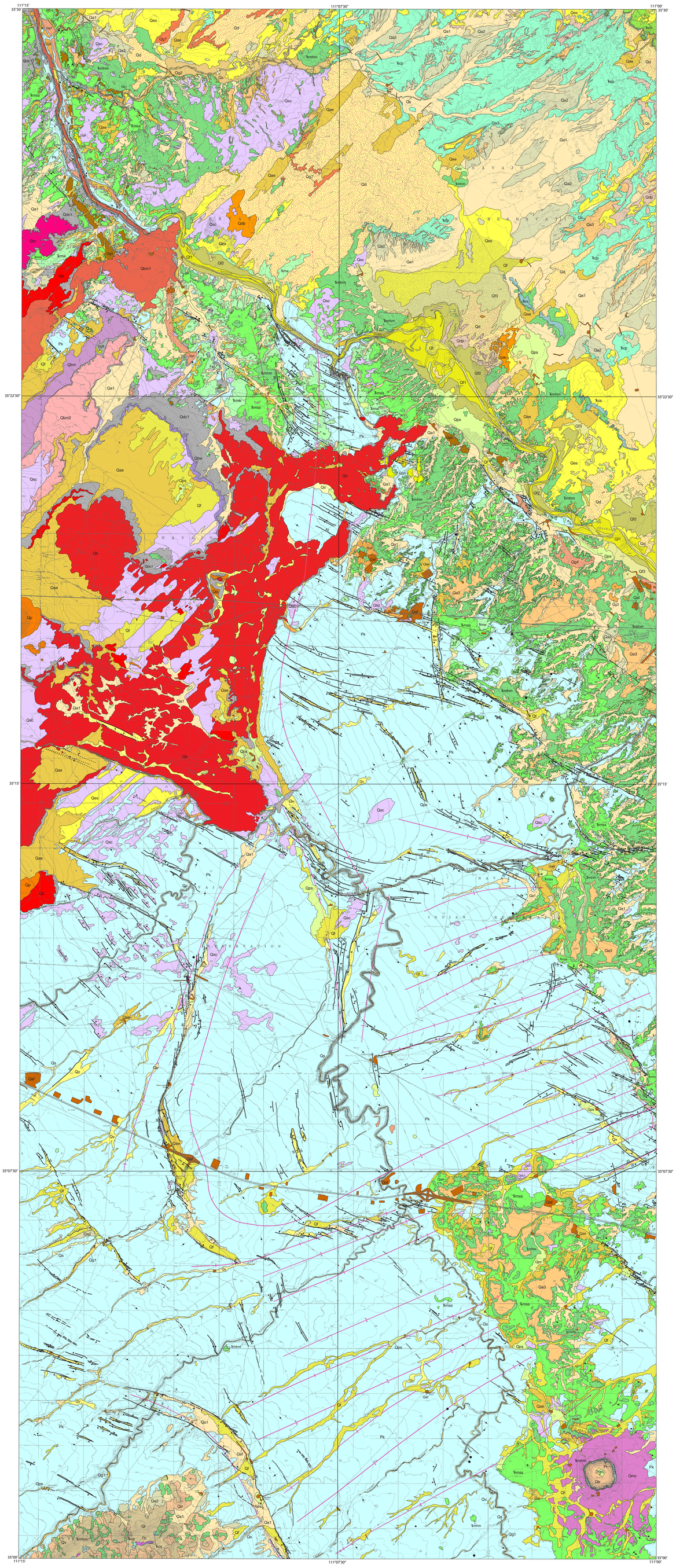
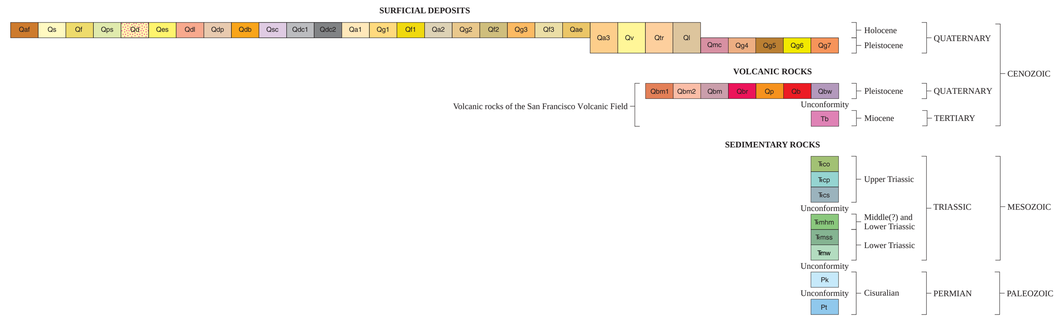
U.S. Department of the Interior
U.S. Geological Survey

Prepared in cooperation with the
Navajo Nation Minerals Department

Scientific Investigations Map 3279
Pamphlet accompanies map



CORRELATION OF MAP UNITS



LIST OF MAP UNITS

[See Description of Map Units (in pamphlet) for complete unit descriptions. Quaternary and Tertiary units are positioned only to indicate their general stratigraphic relations]

SURFICIAL DEPOSITS

- **Qaf** Artificial fill and quarries (Holocene)
- **Qs** Stream-channel deposits (Holocene)
- **Qf** Modern flood-plain deposits (Holocene)
- **Qps** Ponded sediments (Holocene)
- **Qd** Dune-sand and sand-sheet deposits (Holocene)
- **Qes** Young eolian sand-sheet deposits (Holocene)
- **Qdl** Linear dune deposits (Holocene)
- **Qdp** Parabolic dune deposits (Holocene)
- **Qdb** Barchan dune and sand-sheet deposits (Holocene)
- **Qsc** Eolian cinder sand-sheet deposits (Holocene)
- **Qdc1** Unconsolidated cinder-dune deposits (Holocene)
- **Qdc2** Consolidated cinder-dune deposits (Holocene)
- **Qa1** Young alluvial fan deposits (Holocene)
- **Qg1** Young terrace-gravel deposits (Holocene)
- **Qf1** Young flood-plain deposits (Holocene)
- **Qa2** Intermediate-age alluvial fan deposits (Holocene)
- **Qg2** Intermediate-age terrace-gravel deposits (Holocene)
- **Qf2** Intermediate-age flood-plain deposits (Holocene)
- **Qg3** Old terrace-gravel deposits (Holocene)
- **Qf3** Old flood-plain deposits (Holocene)
- **Qae** Mixed alluvium and eolian deposits (Holocene)
- **Qa3** Old alluvial fan deposits (Holocene and Pleistocene(?))
- **Qv** Valley-fill deposits (Holocene and Pleistocene(?))
- **Qtr** Talus and rock-fall deposits (Holocene and Pleistocene)
- **Ql** Landslide deposits (Holocene and Pleistocene)
- **Qmc** Meteor Crater impact debris (Pleistocene)
- **Qg4** Older terrace-gravel deposits (Pleistocene)
- **Qg5** Young Little Colorado River deposits (Pleistocene)
- **Qg6** Intermediate-age Little Colorado River deposits (Pleistocene)
- **Qg7** Old Little Colorado River deposits (Pleistocene)

VOLCANIC ROCKS

Volcanic rocks of the San Francisco Volcanic Field (Pleistocene)—Modified from Moore and Wolfe (1976)

- **Qbm1** The Sprout basalt flow of Merriam Crater (Pleistocene)
- **Qbm2** East vent basalt flow of Merriam Crater (Pleistocene)
- **Qbm** Basalt flow of Merriam Crater (Pleistocene)
- **Qbr** Basalt flow of Roden Crater (Pleistocene)
- **Qp** Pyroclastic deposits, undivided (Pleistocene)
- **Qb** Quaternary basalt flows, undivided (Pleistocene)
- **Qbw** Basalt flow of Woodhouse age (Pleistocene)
- **Tb** Tertiary basalt flow (Miocene)

SEDIMENTARY ROCKS

Chinle Formation (Upper Triassic)

- **Tkco** Owl Rock Member (Upper Triassic)
- **Tkcp** Petrified Forest Member (Upper Triassic)
- **Tkcs** Shinarump Member (Upper Triassic)

Moenkopi Formation (Middle(?) and Lower Triassic)

- **Trmhm** Holbrook and Moqui Members, undivided (Middle(?) and Lower Triassic)
- **Trmss** Lower massive sandstone member (Lower Triassic)
- **Trmw** Wupatki Member (Lower Triassic)
- **Pk** Kaibab Formation (Cisuralian)
- **Pt** Toroweap Formation (Cisuralian)

EXPLANATION OF MAP SYMBOLS

- **Contact**—Contacts between all alluvial and eolian units are approximate and arbitrary
- **Fault**—Dashed where inferred or approximately located; dotted where concealed; bar and ball on downthrown side. Predates alluvium or eolian deposits where shown bounding them or ending within them. Number is estimated fault separation in feet
- **Fracture**—Open fracture (0.5 to 5 m wide)
- **Folds**—Showing trace of axial surface and direction of plunge; dotted where location is concealed
- **Anticline**
- **Plunging anticline**—Showing direction of plunge
- **Syncline**
- **Plunging syncline**—Showing direction of plunge
- **Monocline**

Strike and dip of beds

- **Inclined bedding**—Showing strike and dip where measured in the field
- **Implied bedding**—Showing approximate strike as interpreted from aerial photographs; dip amount not determined
- **Strike of vertical and subvertical joints**—Interpreted from aerial photographs; symbol placed where joints are most visible on aerial photos
- **Collapse structure**—Circular collapse structure characterized by strata dipping inward toward a central point
- **Sinkhole**—Enclosed depression or cave. Sinkholes breached by drainages are not shown
- **Volcanic vent**

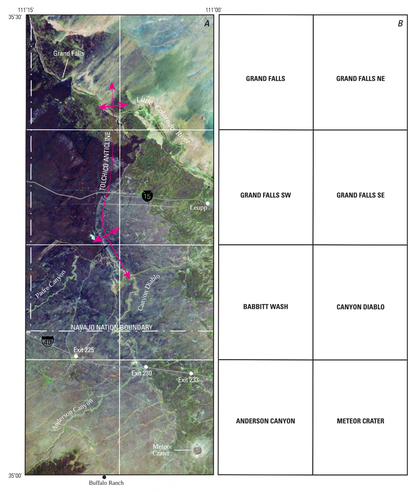


Figure 1. (*A*) Map showing physiographic, cultural, and geologic features and 1:24,000-scale quadrangle boundaries with (B) associated quadrangle names in the eastern quarter of the Flagstaff 30′ x 60′ quadrangle.

Figure 2. Photo looking southeast at Meteor Crater, Arizona. Visitor's center is at lower left. Crater is 600 ft (180 m) deep and ~0.75 mi (1.2 km) in diameter. The meteor impact (~50,000 years ago; Kargel, 1998) formed an elevated ridge or rim around the crater that rises 100 to 200 ft (30 to 60 m) above the surrounding plain. Photo by Debra Block, 2009.

Figure 3. Photo looking northwest at Grand Falls and downriver from overlook on basalt dam over the Little Colorado River canyon. Water falls 200 ft (60 m) over ledges of the Kaibab Formation. The red hill in upper right is Wupatki Member (slope) capped by lower massive sandstone member (ledge) of the Moenkopi Formation. Water flows mostly during the early spring of each year. Photo courtesy of Kevin Reid, Flagstaff, Arizona, 2008.

Figure 4. Photo looking west and downstream at consolidated cinder dunes filling Tolchico canyon, an abandoned canyon of the Little Colorado River about 7 miles (11 km) upstream of Grand Falls (fig. 3). View is 1 mi (1.6 km) downstream from the basalt dam that blocked this canyon. Photo by G.H. Billingsley, 2011.

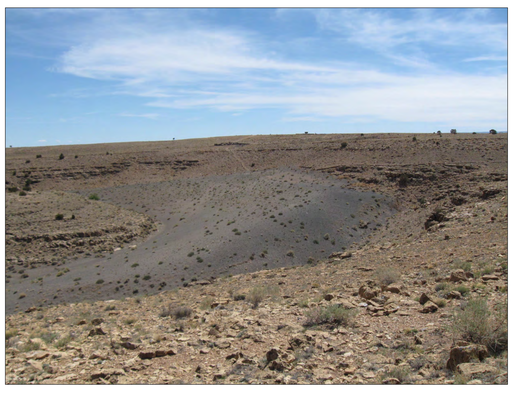


Figure 5. Photo looking southwest at a cinder dune dam that blocked Padre Canyon drainage about 2 mi (3 km) upstream of its junction with Canyon Diablo. The dune is about 80 ft (24 m) thick and well consolidated. Photo by G.H. Billingsley, 2011.

Figure 6. Photo looking at one of several open-crack fissures in the Kaibab Formation about 5 mi (8 km) southwest of Leupp, Arizona, east-central part of map area. This open-fissure is about 15 ft (4.5 m) wide and an unknown depth. Note people for scale. Photo by G.H. Billingsley, 2011.

Base modified from U.S. Geological Survey, Grand Falls, 1969; Grand Falls NE, 1969; Grand Falls SW, 1969; Grand Falls SE, 1969; Babbitt Wash, 1968; Canyon Diablo, 1968; Anderson Canyon, 1968; Meteor Crater, 1968, 1:24,000
Universal Transverse Mercator projection

SCALE 1:50 000

APPROXIMATE MEAN DECLINATION, 2013

CONTOUR INTERVAL 10–20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

MAP LOCATION

Geology mapped by G.H. Billingsley, 2010-2012
Manuscript approved for publication November 21, 2013

Geologic Map of the Eastern Quarter of the Flagstaff 30′ x 60′ Quadrangle, Coconino County, Northern Arizona

By
George H. Billingsley, Debra Block, and Margaret Hiza Redsteer
2013

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