U.S. DEPARTMENT OF THE INTERIOR TO ACCOMPANY MF-2366
U.S. GEOLOGICAL SURVEY

GEOLOGIC MAP OF THE CANE QUADRANGLE, COCONINO COUNTY, NORTHERN ARIZONA

By George H. Billingsley

INTRODUCTION

This geologic map is part of a cooperative project between the U.S. Geological Survey and the Kaibab National Forest Service to provide geologic information for the Paradine Plains Cactus (*Pediocactus pardinei* B, W. Benson, 1957) Conservation Assessment and Strategy conducted by the Kaibab National Forest, Williams, Arizona. The map area lies within the Kaibab Plateau, a sub-physiographic province of the Colorado Plateau. This map and report completes one of several areas where uniform quality geologic mapping is needed. The geologic information in this report may be useful toward land management, range management, and flood control programs for federal, state, and private agencies.

The map area is entirely within the North Kaibab Ranger District and the Grand Canyon National Game Preserve of the Kaibab National Forest. The nearest settlement is Jacob Lake about 19 km (12 mi) northwest of the map area (fig. 1). Elevations range from about 2,500 m (8,200 ft) on the Kaibab Plateau, southwest corner of the map area, to about 1,645 m (5,400 ft) near the mouth of Seegmiller Canyon, northeast corner of the map area. Primary vehicle access is by U.S. Forest Service dirt roads that connect to U.S. Highway 89A, just north of the map area, and Highway 67 from Jacob Lake to the North Rim of the Grand Canyon (fig. 1). Four-wheel-drive roads access most of the map area and dirt roads are not passable in winter snow conditions.

The North Kaibab Ranger District in Fredonia, Arizona manages the National Forest lands within the map area. Other lands include Cane Ranch, a quarter section of private land at the mouth of Cane Canyon, along the east-central edge of the map area (U.S. Department of the Interior, 1993).

Lower elevations support a sparse growth of cactus, grass, and a variety of desert shrubs. Sagebrush, grass, cactus, cliffrose, pinion pine, juniper, ponderosa pine, and oak trees thrive at around 1,830 to 2,134 m (6,000 to 7,000 ft). Spruce, douglas fir, white pine, aspen trees, and grasses thrive at elevations above 2,228 m (7,500 ft).

Surface runoff in the map area drains eastward eroding deep canyons into the upper and lower segments of the East Kaibab Monocline. These drainages continue east toward House Rock Valley, just east of the map area, and eventually into Marble Canyon of the Colorado River at Mile 17 (17 miles downstream from Lees Ferry, Arizona).

PREVIOUS WORK

Early photoreconnaissance geologic mapping of this area was compiled by Wilson and others (1969) and later recompiled by Reynolds (1988). The map area is 3.2 km (2 mi) north of a geologic map of the eastern part of Grand Canyon National Park by Huntoon and others (1996). A geologic map of the House Rock quadrangle by Billingsley and others (2001) borders the northern edge of the map area.

MAPPING METHODS

This map was produced using 1:24,000- and 1:12,000-scale color aerial photographs from 1981 and 1986, respectively, courtesy of the U.S. Forest Service. Additional 1:24,000-scale infrared aerial photographs from 1976 were also provided courtesy of the Arizona Strip Field Office of the Bureau of Land Management, St. George, Utah. Aerial photo work was extensively field checked. Quaternary alluvial deposits having similar lithology but different geomorphic characteristics were mapped almost entirely by photogeologic methods. Stratigraphic position, soil development, and amount of erosional degradation were used to determine the relative ages of alluvial deposits.

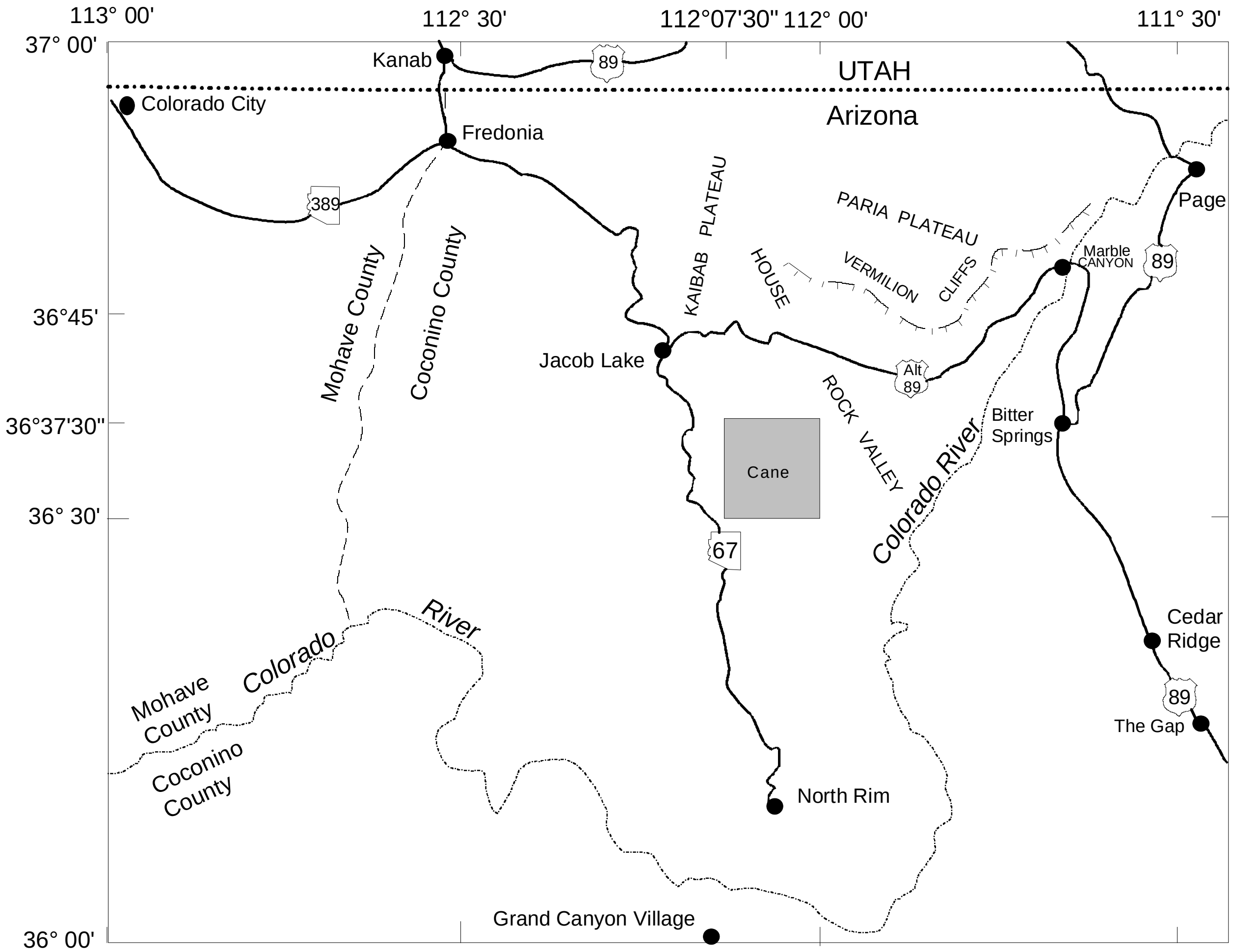

Figure 1. Map showing the location of the Cane 7.5 minute quadrangle, northern Coconino County, northern Arizona.

GEOLOGIC SETTING

The Kaibab Plateau is a subphysiographic feature of the Colorado Plateaus physiographic province (Billingsley and others, 1997). The Kaibab Plateau is characterized by gently dipping Paleozoic sedimentary strata of Lower Permian age that form a broad regional anticline or upwarp just west of the map area that has a general north-south axial trend. Permian strata on the eastern flank of the Kaibab Plateau dip as much as 21 degrees easterly at various locations on both segments of the East Kaibab Monocline. The East Kaibab Monocline bifurcates into an upper and lower segment about 19 km (12 mi) north of the map area and coalesces back into a single monocline about 6.5 km (4 mi) south of the map. Little Mountain forms the benchland plateau between the upper and lower segments of the East Kaibab Monocline on the Kaibab Plateau. The vertical physiographic relief produced by both segments of the East Kaibab Monocline in the map area is about 945 m (3,100 ft).

Quaternary surficial deposits are widely distributed in the map area and cover some areas of Paleozoic and Mesozoic strata on Little Mountain. The deposits are mapped as alluvial fans, talus slopes, and landslide masses. Map contacts between most Quaternary alluvial deposits are intertonguing and (or) gradational, both laterally and vertically. The subdivision of Quaternary alluvial units is intentionally detailed because they strongly influence road construction planning, wildlife and biological range management, flood control, and soil erosion. In addition, the Quaternary deposits provide basic geologic information for soil and biological studies such as the Paradine Plains Cactus habitat and add significant geomorphic detail to landscape development during the last several hundred thousand years. All surficial deposits in the map area are assumed to be Quaternary age because they are similar to deposits west of the map area where most alluvial deposits contain volcanic rock debris generally less than 500,000 years (Billingsley and Workman, 1999; Billingsley and Hampton, 2000).

PALEOZOIC AND MESOZOIC SEDIMENTARY ROCKS

There are about 292 m (980 ft) of Permian strata and about 10 m (30 ft) of Triassic strata in the map area. The Paleozoic and Mesozoic rocks are sedimentary and are, in order of decreasing age, the Permian Hermit Formation, Coconino Sandstone, Toroweap Formation, Kaibab Formation, and the Triassic Moenkopi Formation. The Moenkopi Formation is mostly eroded away or covered by alluvium in the map area. A small remnant remains in the northwest quarter of the map area indicating that this formation once covered the map area. These rocks are composed mostly of soft red mudstone, siltstone, and sandstone in the House Rock Valley and Paria Plateau about 32 km (20 mi) north of the map area (Billingsley and Hampton, 2001).

The Harrisburg Member of the Kaibab Formation forms the surface bedrock of Little Mountain and most of the higher terrain of the Kaibab Plateau. A complete section of the Toroweap Formation is exposed in lower Cane Canyon and in Pleasant Valley Outlet drainage. The Coconino Sandstone is not present 33 km (21 mi) north of the map area and thickens southward to as much as 48 m (160 ft) in Cane and Pleasant Valley Outlet Canyons. Only the top 60 m (200 ft) of the Hermit Formation is exposed in the bottom of Cane Canyon as a red siltstone and sandstone. Based on exposures of the Hermit Formation at Marble Canyon, 40 km (25 mi) east of the map area, the Hermit Formation is probably about 100 to 122 m (330 to 400 ft) thick in the subsurface of the map area. Details of the Paleozoic rock strata are given in the description of map units.

Partly dissected alluvial fans cover some of the flatter areas of Little Mountain near the base of the upper segment of the East Kaibab Monocline. The alluvial deposits consist of poorly sorted angular to subangular limestone, sandstone, chert, gravel, and sand locally derived from the erosion of Permian strata along the upper segment of the East Kaibab Monocline and Kaibab Plateau. Only the thickest and most extensive deposits are shown, but unmapped lag gravel from pre-existing alluvial fans extends over much of the Little Mountain area.

STRUCTURAL GEOLOGY

The East Kaibab Monocline overlies deep-seated reverse faults whose compressional forces folded the strata up-to-the-west during Late Cretaceous and early Tertiary time (Huntoon, 1990). Along some parts of the East Kaibab Monocline, late Tertiary extension has reactivated some of the deep-seated faults producing normal down-to-the-west fault separations that reverse the Cretaceous and Tertiary offset north and south of the map area (Billingsley and Hampton, 2000; Billingsley and others, 2001; Huntoon and others, 1996). The late Tertiary extension has also produced some minor down-to-the-west faulting along the crest of the Kaibab Plateau on the western edge of the map area.

There are no exposures of fault planes to determine actual direction of fault separation, but since most faults in this region cause normal high-angle vertical separations of strata, it is assumed that faults in the map area are similar. The joint trends shown on the map indicate regional stress patterns that may be related to Laramide monoclinal development and (or) more recent tensional stresses.

Circular collapse structures, minor folds, and other surface irregularities have formed by dissolution of gypsum and gypsiferous siltstone in the Kaibab or Toroweap Formations. Locally warped and bent strata in some stream drainages have formed as a result of Pleistocene and Holocene solution of gypsiferous siltstone in the Harrisburg Member of the Kaibab Formation. Gypsum dissolution in the Woods Ranch Member of the Toroweap Formation and the Harrisburg Member of the Kaibab Formation has resulted in large sinkholes and small caves on the Kaibab Plateau. The karst is probably Holocene and Pleistocene age based on the youthful appearance of sinkhole walls and young talus deposits (not mapped) within some of the karst features. Only sinkholes that form enclosed basins or depressions are indicated on the map by a triangle symbol. The higher the terrain, the more abundant are the sinkholes. This increase in sinkholes at higher elevations is probably linked to an increase in precipitation at higher altitudes.

Breccia pipe structures

Bowl-shaped depressions in the Kaibab Formation, characterized by inward-dipping strata, may be the surface expression of a breccia pipe that developed by the dissolution of the deeply buried Mississippian Redwall Limestone (Wenrich and Huntoon, 1989; Wenrich and Sutphin, 1989). Such features generally have inward dipping strata and are marked on the map by a dot and the letter C for collapse structures.

ACKNOWLEDGMENTS

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DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Surficial deposits (Holocene and Pleistocene)—Surficial deposits are differentiated from one another chiefly by photogeologic techniques on the basis of differences in morphologic character and physiographic position. Older alluvial fans generally exhibit extensive erosion and most often occupy higher terrain, whereas younger deposits are either actively accumulating material or lightly eroding and generally occupy lower terrain as observed on 1976, 1980, and 1986 aerial photographs

Qaf **Artificial fill and quarries (Holocene)**—Alluvial and bedrock material removed from pits and trenches to build stock tanks and drainage diversion dams

Qa_1 **Young alluvial fan deposits (Holocene)**—Gray-brown silt, sand, gravel, and boulders; poorly sorted, unconsolidated. Include lenses of coarse gravel composed of angular to subrounded pebbles and cobbles of limestone, chert, and sandstone locally derived from the Kaibab and Toroweap Formations along the upper and lower segments of the East Kaibab Monocline. Overlap young-intermediate and old alluvial fan (Qa_2 and Qa_3) deposits. Subject to extensive erosion by sheet wash, flash flood debris flows, and arroyo erosion. Support moderate to sparse growth of cactus and grass. About 1 to 3 m (2 to 10 ft) thick or more

Qv **Valley-fill deposits (Holocene and Pleistocene)**—Gray and light-brown silt, sand, and lenses of pebble to small-boulder gravel; partly consolidated. Include well-rounded clasts of limestone and subrounded to angular chert fragments. Represent relatively less-active, low-gradient alluvial stream-channel or shallow valley drainage deposits. Subject to sheetwash flooding and temporary ponding; cut by arroyos as much as 2 m (6 ft) deep. Support moderate growth of sagebrush, grass, and cactus. About 1 to 4 m (3 to 12 ft) thick

Qt **Talus deposits (Holocene and Pleistocene)**—Unsorted breccia debris composed of small and large angular blocks of local bedrock on steep to moderately steep slopes below outcrops in canyon drainages. Include silt, sand, and gravel partly cemented by calcite and gypsum. Intertongue with alluvial fan (Qa_1 and Qa_2) and landslide (Ql) deposits. Support sparse growth of cactus, grass, and some pinion pine and juniper trees. Only thick or extensive deposits shown. About 2 to 3 m (4 to 10 ft) thick

Ql **Landslide deposits (Holocene and Pleistocene)**—Unconsolidated masses of unsorted rock strata and angular fragmental debris within Cane Canyon and Pleasant Valley Outlet Canyon. Support sparse to moderate growth of cactus and grass at elevations below 1,675 m (5,500 ft) and sparse oak, juniper, and pinion trees at higher elevations. May become unstable in very wet conditions. Thickness about 3 to 18 m (10 to 60 ft)

Qg_2 **Old terrace-gravel deposits (Holocene and Pleistocene)**—Light-brown, pale-red, and gray silt, sand, and pebble gravel composed of well-rounded limestone and sandstone clasts and angular to subrounded chert clasts. Forms terraces about 1 to 2 m (2 to 5 ft) above modern stream bed in Pleasant Valley Outlet Canyon; forms isolated abandoned stream channel deposits on lower East Kaibab Monocline; partly consolidated. Intertongue with or locally overlain by alluvial fan (Qa_1) and valley fill (Qv) deposits. Isolated deposits on lower segment of the East Kaibab Monocline indicate abandoned stream channels due to stream capture. Approximately 2 to 5 m (5 to 15 ft) thick

Qa_2 **Young-intermediate alluvial fan deposits (Holocene and Pleistocene)**—Similar to young alluvial fan (Qa_1) deposits, but partly cemented by calcite and gypsum. Surfaces are rocky and eroded by arroyos as much as 2 m (6 ft) deep. Some thin soil has developed in low-lying areas. Very large boulders 1 to 3 m (3 to 10 ft) in diameter derived from the Kaibab Formation are commonly scattered about at the apex of fan deposits near mouths of drainages along the lower segment of the East Kaibab Monocline. Often overlapped by young alluvial fan (Qa_1) deposits. Include abundant subrounded to subangular limestone and chert clasts. Support sparse growth of sagebrush, cactus, grass, and juniper and pinion trees. Range from 2 to 10 m (5 to 30 ft) thick

Qa_3 **Old-intermediate alluvial fan deposits (Pleistocene)**—Similar to young and young-intermediate alluvial fan (Qa_1 and Qa_2) deposits; partly cemented by calcite and gypsum. Surface has developed a thin soil forming a pebbly smooth texture; eroded by arroyos as much as 1 to 2 m (2 to 6 ft) deep. Forms elevated ridges on Little Mountain. Support sparse to moderate growth of grass and cactus in lower elevations; pinion, juniper, and oak trees at higher elevations. About 2 to 6 m (6 to 20 ft) thick

Qa_4 **Older alluvial fan deposits (Pleistocene)**—Gray, gravelly alluvial deposits that may have been part of an older alluvial fan at the mouth of Cane and Seegmiller Canyons, and Pleasant Valley Outlet Canyon. Deposits are commonly about 43 m (140 ft) above young alluvial fan (Qa_1) deposits. Similar to old-intermediate alluvial fan (Qa_3) deposits north of map area. A thin surface calcrete soil has developed in most areas of unit outcrop. About 4.5 m (15 ft) thick

SEDIMENTARY ROCKS

^m **Moenkopi Formation (Middle? and Lower Triassic)—**Includes only the basal lower red member as used by Stewart and others (1972). The basal Timpoweap Member was not recognized in the map area. Consists mainly of dark-red, thin-bedded, slope-forming siltstone and sandstone and gray-white siltstone and gypsum in northeast quarter of map area. Much of the Moenkopi Formation is covered by old-intermediate alluvial fan (Qa_3) deposits on Little Mountain. Unconformable erosional contact with underlying Harrisburg Member of the Kaibab Formation; local relief up to 2 m (6 ft) in some locations. About 10 m (30 ft) of the lower Moenkopi Formation is exposed near the base of the upper segment of the East Kaibab Monocline

Kaibab Formation (Lower Permian)—Includes, in descending order, the Harrisburg and Fossil Mountain Members as defined by Sorauf and Billingsley (1991)

Pkh **Harrisburg Member**—Grayish-orange, ledge- and slope-forming dolomite; gray to yellowish-brown calcareous siltstone; and interbedded gypsiferous siltstone, sandstone, gypsum, and thin-bedded gray limestone and dolomite capped by a resistant, pale-yellow or orange-gray, fossiliferous (mollusks and algae) sandy limestone. Includes light-gray and red gypsiferous siltstone and fine- to medium-grained calcareous sandstone beds. Gradational and arbitrary contact with underlying Fossil Mountain Member placed near top of cliff-forming, white cherty limestone of Fossil Mountain Member. Contact is approximate in tilted strata areas of the upper and lower segments of the East Kaibab Monocline because of local erosion and forest cover. Unit thickens west and north, thins east. About 43 m (140 ft) thick

Pkf **Fossil Mountain Member**—Yellowish-gray to white, fine- to medium-grained, medium- to thick-bedded (1 to 2 m [3 to 6 ft]), fossiliferous, cliff-forming, cherty limestone and sandy limestone. Unit characterized by abundance of chert nodules in upper part and intraformational chert breccia beds as much as 1.5 m (4 to 5 ft) thick. Includes white, low-angle, crossbedded sandstone in middle part and gray-brown dolomite in lower part that weathers light gray in upper part and dark brown in lower part. Unconformable contact with underlying Woods Ranch Member of the Toroweap Formation marked by solution and channel erosion with relief as much as 2 m (6 ft) locally. Contact locally obscured by talus and minor landslide debris in Cane and Seegmiller Canyons and in Pleasant Valley Outlet Canyon. Generally uniform thickness throughout area. About 75 m (250 ft) thick

Toroweap Formation (Lower Permian)—Includes, in descending order, Woods Ranch, Brady Canyon, and Seligman Members as defined by Sorauf and Billingsley (1991)

Ptw **Woods Ranch Member—**Gray, white, slope-forming gypsum, gray gypsiferous siltstone, and pale-red to gray silty sandstone. Beds are locally distorted or wavy due to gypsum dissolution. Contact with Brady Canyon Member is gradational and arbitrarily marked between base of Woods Ranch Member slope and top of Brady Canyon Member limestone cliff. Thickness 40 to 46 m (130 to 150 ft)

Ptb **Brady Canyon Member—**Yellowish-gray, cliff-forming, medium- to thick-bedded (0.5 to 2 m [2 to 6 ft]), fine- to coarse-grained, fossiliferous limestone and dolomitic sandy limestone. Includes chert nodules in upper part. Vuggy appearance. Gradational lower contact with Seligman Member arbitrarily marked at base of limestone cliff. Unit thins east, thickens west. About 40 m (130 ft) thick in Cane Canyon

Pts **Seligman Member—**Yellowish-gray, medium- to thin-bedded, ledge- and slope-forming dolomite, sandstone, and gypsiferous sandstone; predominantly sandstone. Includes some beds of gray thin-bedded limestone. Basal part includes yellow, fine- to medium-grained, thin-bedded, low- to high-angle crossbedded and planar-bedded sandstone lenses of the Coconino Sandstone. Coconino Sandstone is mapped separately but intertongues with the basal Seligman Member of the Toroweap Formation (Rawson and Turner, 1974; Billingsley and Workman, 1999; Billingsley and Hampton, 2000). About 12 to 15 m (40 to 50 ft) thick

Pc **Coconino Sandstone (Lower Permian)**—White to yellowish-brown, fine- to coarse-grained, high-angle, crossbedded, cliff-forming sandstone. Cross-bed sets are 3 to 4.5 m (6 to 15 ft) thick. Forms gradational or sharp planar contact with flat-bedded and crossbedded sandstone within lower part of Seligman Member of the Toroweap Formation. Unconformable planner erosional contact with underlying Hermit Formation typically marked by an abrupt color change from white Coconino Sandstone to red Hermit Formation where Hermit is not bleached yellowish-white by springs and seeps. Unit pinches out in north part of map area, thickens rapidly southeastward and forms a cliff. About 25 to 48 m (80 to 160 ft) thick in Cane Canyon

Ph **Hermit Formation (Lower Permian)**—Light-red, fine- to coarse-grained, thin- to medium-bedded, slope-forming silty sandstone and siltstone. Reddish sandstone beds commonly contain yellowish-white bleached spots; some thin sandstone beds are partly or completely bleached yellowish white near contact with overlying the Coconino Sandstone. Cane Springs is at contact with Coconino Sandstone in Cane Canyon. Incomplete section, only top 60 m (200 ft) exposed in Cane Canyon

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U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

TO ACCOMPANY MAP MF-2366

DIGITAL DATABASE DESCRIPTION FOR THE GEOLOGIC MAP OF THE CANE QUADRANGLE, COCONINO COUNTY, NORTHERN ARIZONA

By
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INTRODUCTION

This pamphlet describes what is in this digital geologic map database and gives instructions for obtaining the data. There is no paper map included in this report. The report does include however, PostScript plot files containing images of the geologic map sheet and an explanation sheet as well as the accompanying text describing the geology of the area. For those interested in a paper plot of information contained in the database or in obtaining the PostScript plot files, please see the section entitled “For Those Who Don’t Use Digital Geologic Map Databases” below.

This digital map database, compiled from previously published and unpublished data, and new mapping by the author, represents the general distribution of bedrock and surficial deposits in the Cane quadrangle. Together with the accompanying text file (canegeo.txt or canegeo.pdf), it provides current information on the geologic structure and stratigraphy of the area covered. The database delineates map units that are identified by general age and lithology following the spatial resolution (scale) of the database to 1:24,000 or smaller. The content and character of the database, as well as three methods of obtaining the database, are described below.

FOR THOSE WHO DON’T USE DIGITAL GEOLOGIC MAP DATABASES

Two sets of plotfiles containing images of much of the information in the database are available to those who do not use an ARC/INFO compatible Geographic Information System (GIS). Each set contains an image of a geologic map sheet and the accompanying explanatory pamphlet. There is a set available in PostScript format, and another in Acrobat PDF format. (See sections below). Those who have computer capability can access the plotfile packages in either of the two ways described below, however, these packages do require ZIP utilities to access the plot files. Requests for a tape copy of the digital database or plotfiles can be made by sending a tape with request and return address to: Database Coordinator, U.S. Geological Survey, 345 Middlefield Road, M/S 975, Menlo Park, CA 94025. Plot files can also be acquired online at http://geopubs.wr.usgs.gov/map-mf/mf2366

Those without computer capability can obtain plots of the map files through USGS Plot-On-Demand service for digital geologic maps. To obtain plots of the map sheet and accompanying pamphlet, contact the USGS Information Services office at the following address: U. S. Geological Survey Information Services, Box 25286, Federal Center, Denver, CO 80225-0046. Or by phone (303)202-4200, fax (303)202-4695, or e-mail: infoservices@usgs.gov. Be sure to include the map reference MF-2366.

DATABASE CONTENTS

This digital database package consists of the geologic map database and supporting data including base maps, map explanation, geologic description, and references. A second package consists of PostScript plot files of a geologic map and geologic description.

Digital Database Package

The first package is composed of geologic map database files for the Cane quadrangle. The coverages and their associated INFO directory have been converted into ARC/INFO export files. These export files are uncompressed and are easily handled and compatible with some Geographic Information Systems other than ARC/INFO. The export files included are:

ARC/INFO export file	Resultant coverage	Description
cane_poly.e00	cane_poly/	Faults, folds, depositional contacts and geologic units
cane_dip.e00	cane_dip/	Strike, dip and bedding information and other point features
cane_anno.e00	cane_anno/	Unit annotation, fold names, fault separation values

The database package also contains the following other export files with extraneous data used in the construction of the database

ARC/INFO export file	Resultant coverage	Description
geo.lin.e00	geo.lin	Lineset
geo.mrk.e00	geo.mrk	Markerset
color524.e00	color524.e00	Solid color fills, shadeset
pattern.e00	pattern.e00	Pattern fills, shadeset
geolin.lut.e00	geolin.lut	Lineset lookup table
geomrk.lut.e00	geomrk.lut	Markerset lookup table
canepoly.lut.e00	canepoly.lut	Fill color lookup table

canehyps.tif.gz	Zipped background hypsography image
canehyps.tfw	World file accompanying canehyps.tif

PostScript Plotfile Package

The second digital data package available contains the PostScript images described below:

canemap.eps
: Encapsulated PostScript plottable file containing complete map composition with geology, symbology, annotation and base map of the Cane quadrangle

canegeo.doc
: A MS Word document of this report and the report containing detailed unit descriptions and geological information, plus sources of data and references cited.

PDF Plotfile Package

This package contains the Adobe Acrobat (.pdf) portable document format files described below:

canemap.pdf
: PDF of complete map sheet of the Cane quadrangle

canogeo.pdf

PDF of this report including the geologic information and references

The Acrobat files were created from corresponding PostScript files and are compatible with Adobe Acrobat version 3.0 and higher.

ACCESSING DATABASE CONTENTS

ARC/INFO Export Files

ARC export files are converted to their proper ARC/INFO format using the ARC command 'import' with the option proper for the format desired. To ease conversion and preserve naming convention, an AML is enclosed that will convert all the export files in the database to coverages and graphic files and will also create and associated INFO directory. From the ARC command line type:

Arc: &run import.aml

ARC export files can by read by other Geographic Information Systems. Refer to your documentation for proper procedure for retrieval of data.

PostScript and Portable Document Format Files

These files are packaged separately. PDF files come 'as is' and can be downloaded or copied directly to your hard drive with no conversion aside from opening the file from Adobe Acrobat. The PostScript documents are zipped and compressed to a smaller file size. They can be decompressed using Winzip.

DATABASE SPECIFICS

Procedure Used

Stable-base maps were scanned at the Flagstaff USGS Field site using the Optronics 5040 raster scanner at a resolution of 50 microns (508 dpi). The resulting raster file was in RLE format and converted to the RLC format using the "rle2rlc" program written by Marilyn Flynn. The RLC file was subsequently converted to an ARC/INFO Grid in ARC/INFO. The linework was vectorized in bulk using the ARC command 'gridline.' A tic file was created in latitude and longitude, and projected into Universal Transverse Mercator to correspond with the base map. The tic file was used to transform the grid into UTM. ARC/INFO generated an RMS report after transforming the grid into UTM.

Scale (X,Y) = (1.199,1.200) Skew (degrees) = (0.034)
Rotation (degrees) = (-0.843) Translation = (412335.048,4038228.778)
RMS Error (input,output) = (2.349,2.816)

Affine X = Ax + By + C
Y = Dx + Ey + F
A = 1.199
B = 0.018
C = 412335.048
D =-0.018
E =1.200
F =4038228.778

tic id	input x	input	output x	output y	x error	y error
1	-10937.047	1144.938	399245.994	4039794.643	-2.672	0.880
2	-1595.394	1177.875	410441.240	4039671.139	2.671	-0.880
3	-1656.591	12734.283	410585.417	4053537.056	-2.678	0.882
4	-10974.245	12698.898	399408.200	4053660.724	2.679	-0.883

Lines, points, polygons, and annotation were edited using ARCEDIT.

Map Projection:

Parameter	Description
Projection	UTM
Units	Meters on the ground
Zone	12
Datum	NAD27

The content of the geologic database can be described in terms of the lines and the areas that compose the map. Descriptions of the database fields use the terms explained below.

Database Fields

Parameter	Description
Item Name	name of database field
Width	maximum number of characters or digits stored
Output	output width
Type	B – binary integer; F – binary floating point number; I - ASCII integer; C – ASCII character string
N.Dec	number of decimal places maintained for floating point numbers

LINES

The arcs are recorded as strings of vectors and described in the arc attribute table (AAT). They define the boundaries of the map units, faults, and map boundaries in CANE_POLY. Folds are defined in CANE_FOLD. These distinctions and the geologic identities of the boundaries are stored in the LTYPE field according to their line type. Arc Attribute tables for each are identical except for fields CANE_POLY# which is replaced by CANE_FOLD# and CANE_POLY-ID replaced by CANE_FOLD-ID as appropriate.

Arc Attribute Table Definition:

DATAFILE NAME: CANE_POLY.AAT

COLUMN	ITEM NAME	WIDTH	OUTPUT	TYPE	N.DEC
1	FNODE#	4	5	B	-
5	TNODE#	4	5	B	-
9	LPOLY#	4	5	B	-
13	RPOLY#	4	5	B	-
17	LENGTH	8	18	F	5
25	CANE_POLY#	4	5	B	-
29	CANE_POLY-ID	4	5	B	-
33	LTYPE	35	35	C	-
68	PTTYPE	35	35	C	-

Description of AAT Items:

Item	Description
FNODE#	Starting node of the arc
TNODE#	Ending node of the arc
LPOLY#	Polygon to the left of arc
RPOLY#	Polygon to the right of arc
LENGTH	Length of the arc in meters
CANE_POLY#	Unique internal number
CANE_POLY-ID	Unique identification number
LTYPE	Line type
PTTYPE	Point type

The geologic line types relate to geologic line symbols in the lineset GEO.LIN according to the lookup table GEOLIN.LUT

Domain of Line Types recorded in LTYPE field:

- CANE_POLY
  - map_boundary
  - contact_certain
  - normal_flt_certain
  - normal_flt_concealed
- CANE_FOLD
  - syncline_certain
  - syncline_concealed
  - monocline_certain
  - monocline_concealed
  - anticline_certain
- CANE_ANNO
  - leader

Domain of Point Types recorded in PTTYPE field:

- CANE_POLY
  - fault_ball_fill
  - xx
- CANE_FOLD
  - anticline
  - monocline
  - syncline
  - xx

Arcs with PTTYPE value ‘xx’ indicate that there is no symbol attached to the arc.

POLYGONS

Map units (polygons) are described in the polygon attribute table (PAT). Geologic unit symbols are recorded in the PTYPE field by map label. Individual map units are described more fully in the accompanying text.

Polygon Attribute Table Definition

DATAFILE NAME: CANE_POLY.PAT

COLUMN	ITEM NAME	WIDTH	OUTPUT	TYPE	N.DEC
1	AREA	8	18	F	5
9	PERIMETER	8	18	F	5
17	CANE_POLY#	4	5	B	-
21	CANE_POLY-ID	4	5	B	-
25	PTYPE	5	5	C	-
30	PATTERN	3	3	I	-

Description of PAT Items

Item Name	Description
AREA	Area of polygon in square meters
PERIMETER	Perimeter of polygon in meters
CANE_POLY#	Unique internal number
CANE_POLY-ID	Unique identification number
PTYPE	Unit label
PATTERN	Fill pattern used

Domain of PTYPE (map units):

Qaf	Qa1	Qa2	Qa3	Qa4
Qv	Qt	Qg2	Ql	Trm
Pkf	Pkh	Ptw	Pts	Ptb
Pc	Ph			

P represents Permian strata, Tr represents Triassic strata, and Q represents Quaternary strata. Polygons were assigned colors based on their geologic unit. The colors were assigned from the shadeset COLOR524.SHD and are related to the lookup table CANEPOLY.LUT.

In only one unit was a pattern used for differentiation. The unit “Ql” is assigned both a color, and a pattern which overlays the color fill to signify the lithology of the unit.

POINTS

Strike and dip information is recorded as coordinate data with related information. This information is described in the Point Attribute Table (PAT). ARC/INFO coverages cannot hold both point and polygon information, thus CANE_DIP has only a point attribute table, and CANE_POLY has only a polygon attribute table.

Point Attribute Table Definition

COLUMN	ITEM NAME	WIDTH	OUTPUT	TYPE	N.DEC
1	AREA	8	18	F	5
9	PERIMETER	8	18	F	5
17	CANE_DIP#	4	5	B	-
21	CANE_DIP-ID	4	5	B	-
25	PTTYPE	35	35	C	-
60	DIP	3	3	I	-
63	STRIKE	3	3	I	-

Description of PAT items

Item Name	Description
AREA	
PERIMETER	
CANE_DIP#	Unique internal number
CANE_DIP-ID	Unique identification number
PTTYPE	Point type
DIP	Dip angle in azimuth degrees
STRIKE	Strike angle in degrees

The coverage CANE_DIP contains strike and dip data and other pertinent structural data represented by point symbology, including collapses and sinkholes. These point types are related to the lookup table GEOMRK.LUT and are from the symbolset GEO.MRK.

Domain of PTTYPE:

bedding
vertical_joint
collapse
sinkhole

ANNOTATION

The coverage CANE_ANNO is strictly annotation to the polygon coverage. It is defined somewhat differently from the polygon and dip coverages. The arc attribute table is of negligible importance, as arcs are only used as leaders from a unit annotation to the related polygon. CANE_ANNO contains annotation with unit labels, fault separation values, and monocline names. All annotation was in feature subclass anno.unit.

The textset used for all annotation was GEOFONT.TXT, specifically symbolset 30. Use of this textset allows for proper symbol notation for unit symbols. The default ARC/INFO textset does not allow for a proper geologic symbol indicating 'Triassic.' By using this alternate text set, the character pattern '^m' prints instead as ^m. The only nonconventional text symbol used was the '^' (carat) indicating Triassic.

BASE MAP PROCEDURE

The base map image was prepared from a DRG obtained from the ARIA image archive website located at 'http://landsat.ece.arizona.edu/images/'. The raster image was registered using a world file and imported into ARC/INFO where it was then converted to a grid. Area colors were drained from the file, resulting in a three- color image in ARC/INFO. No elements of the base layer are attributed and the base map is provided solely for reference.

SPATIAL RESOLUTION

Use of this digital geologic map database should not violate the spatial resolution of the data. Although the digital form of the data removes the constraint imposed by the scale of a paper map, the detail and accuracy inherent in map scale are also present in the digital data. This database was created and edited at a scale of 1:24,000, which means that higher resolution data is generally not present. Plotting at scales of greater than 1:24,000 will not yield greater real detail but may reveal fine-scale irregularities below the intended resolution.

OTHER FILES

The lineset used to display the appropriate line weight and symbology is GEO.LIN. It is related to the database by a lookup table called GEOLIN.LUT. Similarly, the markerset for this database is GEO.MRK and it's lookup table is

GEOMRK.LUT. Colors in the polygon coverage (CANE_POLY) are assigned based on the PTYPE and were chosen from a shadeset called COLOR524.SHD and a lookup table CANEPOLY.LUT. Some geologic units also display a fill pattern over the color set. For example, “Ql” is a quaternary landslide unit, and a small breccia pattern (hollow triangles) is displayed over the light brown color. These patterns come from a patternset called PATTERN.SHD. Because so few patterns were used, no lookup table was created, and the pattern assignments are made directly in the polygon attribute table item PATTERN. Annotation (unit labels, text labels, and printed numerical values) were displayed using a font entitled GEOFONT.TXT which has capabilities for displaying proper notation of geologic text symbols.

Also enclosed in this database is CANE.MET, the FGDC standard metadata for the database, and CANEMET.REV, a revision list with current information on the status of all files described in this report and found in the database.