DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

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MAP OF LOCATIONS OF COLLAPSE-BRECCIA PIPES IN THE GRAND CANYON REGION OF ARIZONA

By

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EXPLANATORY NOTES

This map shows the locations of all currently known collapse-breccia pipes in northwestern Arizona. The breccia pipe locations were compiled from published sources (see inset map) and from unpublished company data. Some additional pipe locations were compiled from unpublished mapping by George Billingsley and the authors.

Each pipe is represented by a solid dot on the map. Any pipe that contains a minimum of 1 vertical foot of 0.01 percent U_3O_8 is indicated by a dot enclosed by a circle. These pipes that have been named, are designated by the name. Typically a pipe may be named in one of two ways. First, the majority of the pipes that have been named were at one time or are presently staked as mining claims (e.g., Hack). Thus, the pipe subsequently acquired the claim or mine name. Six of these have been renamed by successive workers (e.g., Hidden Canyon/Near Miss, two names for the same pipe). Second, other pipes with no associated mineral claims have been given names by the geologist(s) that have studied and mapped them (e.g., Crazy Jug).

Nearly 100 different minerals have been identified in some of the pipes that host hypogene and supergene mineral deposits. Although uranium is the present commodity of interest, element enrichment includes Ag, As, Ba, Co, Cu, Fe, Mo, Ni, Pb, S, V, Zn, and many others. Breccia pipes were first prospected as far back as 1875 for their copper content (shown on the map by a (Cu) at the end of the mine name). At that time, the genesis of these deposits as breccia pipes was not known.

Breccia pipe formation was initiated by roof collapse of caverns in the Redwall Limestone. Thus, all of the pipes contain a collapse-breccia that is rooted in the Redwall. Continued failure of the cave ceiling by both mechanical and chemical processes, resulted in upward extension of the cave into a vertical cylindrical pipe. As a result, the pipes are filled by the accumulation of residual, broken fragments of the failed roof rock.

The maximum diameter of an individual pipe is less than 500 feet, but the vertical extent of a pipe is more variable. The tallest pipes extend as high as the Chinle Formation. All pipes may not have attained this height, thus as the area is eroded more pipes will be exposed. Most of the map area consists of plateaus capped by the Permian Kaibab Limestone. The pipes that crop out on these plateaus extend (beneath the surface) approximately 3,200 feet from their base in the Redwall to the top of the Kaibab surface (see fig. 1). These pipes are commonly expressed as some type of circular feature or surface collapse depression. Pipes that crop out in the Grand Canyon and its tributary canyons have been eroded down to lower stratigraphic levels along with the enclosing country rock. Pipes that crop out in strata between the Redwall and Kaibab limestones, are usually expressed as a plug-like outcrop of breccia.

The distribution of breccia pipes reflected by this map is largely a function of how well the pipe is exposed and the amount of mapping that has been completed in the area. This map shows that the greatest density of pipes lies in and around the Hualapai Reservation. For the past 7 years these pipes have been the target of an intensive Bureau of Indian Affairs mineral resource assessment program. Naturally, more pipes were found given the detailed mapping of the area. In contrast, the area cut by Route 67 on the north rim of the Grand Canyon appears devoid of pipes. Although pipes undoubtedly exist, this area is withdrawn from mineral exploration, and thus there has been no reason for anyone to search for pipes in the area.

The plateau area just west of Kanab Creek has a concentration of known uranium-bearing pipes. This Kanab Creek-Hack Canyon area has been explored solely by mining companies who have found uranium at depth through drilling. Practically all of the unnamed pipes shown by a single dot have yet to be explored deeper than their surface outcrop.

Accurate plotting of breccia pipe locations can reveal trends in the distribution of pipes, which otherwise might seem random. Some of the pipes located on the Navajo Reservation, east of the Colorado River, occur in distinct linear trends. In addition, pipes along each trend tend to show an equal spacing between successive pipes or clusters of pipes (Sutphin and Wenrich, 1988).

As more pipe locations are becoming known, additional linear trends can be seen in other areas as well. A good example is an area on the Kanab Plateau just south of Hack Canyon, where six pipes lie in an east-west line: Pinenut, Arizona 1, Lost Calf, Little Robinson, June, and Whistler. Also noticeable is the equal spacing of about 2.7 miles between each of the last five pipes. If the equal spacing holds true, there should be another breccia pipe located half way between Pinenut and Arizona 1 which are spaced about 5 miles apart.

The Redwall Limestone and overlying sandstone host strata for the breccia pipes extend geographically past the northern, eastern, western, and a short distance past the southern map boundaries. Indications are good that the pipes also geographically extend further than shown. In all directions the host strata are covered, concealing the presence of pipes. To the north and east, the host strata are covered by thick successions of Jurassic rocks, the leading edges of which form such features as the Echo and Vermillion Cliffs. To the south, the host strata are covered by thick basalt flows and various volcanic landforms associated with the San Francisco, Mt. Floyd, and Williams volcanic fields. Finally, in the west, pipes occur right up to the edge of the Grand Wash Cliffs along the western edge of the map. West of this point, the host rocks have been broken up, eroded away, and deformed by the various structural processes that created the Basin and Range Province. At least one pipe is known west of the map area. It hosts the Apex mine in the Beaver Dam Mountains of Utah. It is a severely oxidized orebody yielding Cu and Ge. Only trace amounts of galena, sphalerite, pyrite, and chalcopyrite remain of the original hypogene mineral suite. No uranium concentrations in excess of 100 ppm are known.

There are currently 1,296 breccia pipes shown on the map. Years from now if all the pipes that exist are found, this number could more than double.

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EXPLANATION

- **Breccia Pipe**--May contain exposed breccia outcrop, or when located on a plateau surface, consist of a circular depression with inward-dipping beds
- **Mineralized Breccia Pipe**--Breccia pipe containing ≥1 vertical foot of 0.01 percent U_3O_8

Hack **Name of Breccia Pipe**--Pipes are generally named by mining company personnel. Most of the pipes that lack a name are either within the Grand Canyon itself, or on Reservation land, and are thus withdrawn from mineral entry

Ridenour (Cu) **Historic mine**--Late 1800's to early 1900's mine or prospect within a breccia pipe. Mined or explored primarily for copper. Pipe structure was unknown at the time

Isopach--Thickness contours for the Redwall Limestone at 100 ft intervals (from Peirce and others, 1970, pl. 12A)

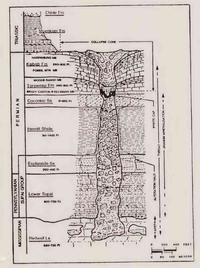


Figure 1. Schematic cross section of a breccia pipe and general stratigraphy of the host rocks (from Krewedl and Carisey, 1986).

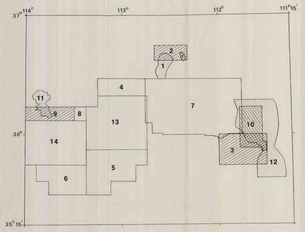
Base from U.S. Geological Survey, 1:250,000
Flagstaff, Grand Canyon, Marble Canyon,
and Williams, Arizona, 1954

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

MAP LOCATION

SCALE 1:250,000
5 0 5 10 15 20 MILES
5 0 5 10 15 20 25 30 KILOMETERS

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100 FOOT INTERVALS



INDEX OF SOURCES SHOWING PIPE LOCATIONS

1--Billingsley, personal commun.
2--Billingsley and others, 1983
3--Billingsley and others, 1985
4--Billingsley and Huntoon, 1983
5--Billingsley and others, 1986
6--Billingsley and others, in prep.
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