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The early Oligocene Copperas Creek volcano and geology along New Mexico Highway 15 between Sapillo Creek and the Gila Cliff Dwellings National Monument, Grant and Catron counties, New Mexico

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2008, pp. 129-140. https://doi.org/10.56577/FFC-59.129

in:

Geology of the Gila Wilderness-Silver City area, Mack, Greg, Witcher, James, Lueth, Virgil W.; [eds.], New Mexico Geological Society 59 th Annual Fall Field Conference Guidebook, 210 p. https://doi.org/10.56577/FFC-59

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THE EARLY OLIGOCENE COPPERAS CREEK VOLCANO AND GEOLOGY ALONG NEW MEXICO HIGHWAY 15 BETWEEN SAPILLO CREEK AND THE GILA CLIFF DWELLINGS NATIONAL MONUMENT, GRANT AND CATRON COUNTIES, NEW MEXICO

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Abstract — New Mexico Highway 15 between Sapillo Creek and the Gila Cliff Dwellings National Monument provides a tour through the eroded remains of the ~ 30 million year old Copperas Creek volcano, as preserved between the west-northwest -trending Sapillo Creek and Gila Hot Springs grabens of Basin and Range age. Colorful exposures of altered volcanic rocks in road cuts and a scenic overlook of the Alum Mountain eruptive center are witness to the hydrothermal alteration and mineralization in a Yellowstone-type hot spring environment here in Oligocene time. New Mexico Highway 15 ends at the Gila Cliff Dwellings where alcoves in Gila Conglomerate were occupied by members of the Mogollon culture 700-800 years ago.

INTRODUCTION

The section of New Mexico Highway 15 between the intersection of NM-15 and NM 35 (aka Sapillo junction) at the south and the Gila Cliff Dwellings National Monument at the north end of NM –15 occupies an approximately 18 mile long, mile wide, corridor through the eastern part of the Gila Wilderness (Fig. 1). Whereas most of the Gila Wilderness is dominated by silicic, caldera-forming supervolcanoes of Eocene to Oligocene age, this part of NM-15 traverses a volcanic terrain of similar age, but composed mainly of intermediate composition lava flows and minor associated rhyolitic intrusions and pyroclastic rocks, which are related to the here-named Copperas Creek volcano. This volcanic complex is bounded by Basin and Range structures: on the south by the Sapillo Creek graben, and on the north by the Gila Hot Springs graben, both of which are filled with Gila Conglomerate of late Tertiary to Pleistocene(?) age. Hot springs in the Gila River valley are localized along faults in the deepest part of the Gila Hot Springs graben. The cliff dwellings of the National Monument were constructed in caves in Gila Conglomerate in the western part of the Gila Hot Springs graben. The eastern edge of the Gila Cliff Dwellings caldera is buried by younger rocks east of the cliff dwellings, but spectacular cliffs of Bloodgood Canyon Tuff, which fills the caldera, can be viewed along the West Fork of the Gila River from the trail starting at the cliff dwellings.

Although this is not intended as a formal road log, highway mileage markers (MM) will be used to locate geologic features more or less progressively from south to north along NM-15.

PREVIOUS WORK

Other than small scale geologic maps prepared for the 1964 New Mexico State Geologic Map, the first detailed reconnaissance geologic map covering this area (Ratté and Gaskill 1975; scale, 1:62,500) was prepared as part of the mineral resource appraisal of the Gila Wilderness and Primitive Areas (Ratté et al., 1979). More detailed thesis mapping(scale 1:24,000) by Krier (1980) was compiled by Farris in Elston, et al. (1981). Prior road logs include Clemons, et al. (2000), Damon,et al. (1968), Elston, (1965) and Elston et al., (1965).

The nomenclature of volcanic rocks in the Copperas Creek-Alum Mountain area that preceded the voluminous caldera-forming eruptions in the Gila Wilderness is simplified here following the usage of Ratté and Gaskill (1975). Thus, the Alum Mountain Volcanic complex (Tva), consisting largely of altered andesitic lava flows, associated rhyolitic intrusions,Tvi, and minor pyroclastic rocks are unconformably(?) overlain by the andesitic and dacitic lava flows of Gila Flat, Tgf (Fig. 1).

A more extensive break-down of the volcanic rocks east of NM-15 and the Copperas Creek corridor has been presented by Elston and students at the University of New Mexico (Krier, 1980; Elston et al.,1981). They proposed an Alum Mountain Group containing three separate formations with multiple members and several additional eruptive centers. Although part of the larger Copperas Creek volcano, most of those units are not present in the area described here, and will not be discussed further.

COPPERAS CREEK VOLCANO

The Copperas Creek volcano is a deeply eroded, compound volcano about 32 to 29 Ma, composed of multiple eruptive centers and a variety of volcanic products ranging from predominant lava flows and flow breccias to minor explosive (pyroclastic) deposits and small intrusive bodies. Compositions of the volcanic rocks range from basaltic to rhyolitic, but are mainly andesitic to dacitic.

Two major volcanic centers within the Copperas Creek volcano are recognized: the main Copperas canyon center and the satellitic Alum Mountain center (Fig.1). Both centers are composed of highly altered and mineralized rocks, which, in the past, have been targeted for precious and base metal exploration, and which, today, are believed to represent an inadequately evaluated mineral resource. Geochemical samples of the altered rocks in Copperas canyon and on Alum Mountain have shown anomalous base and precious metal values worthy of further exploration, but not of economic concentrations in the near surface (Ratté et al.

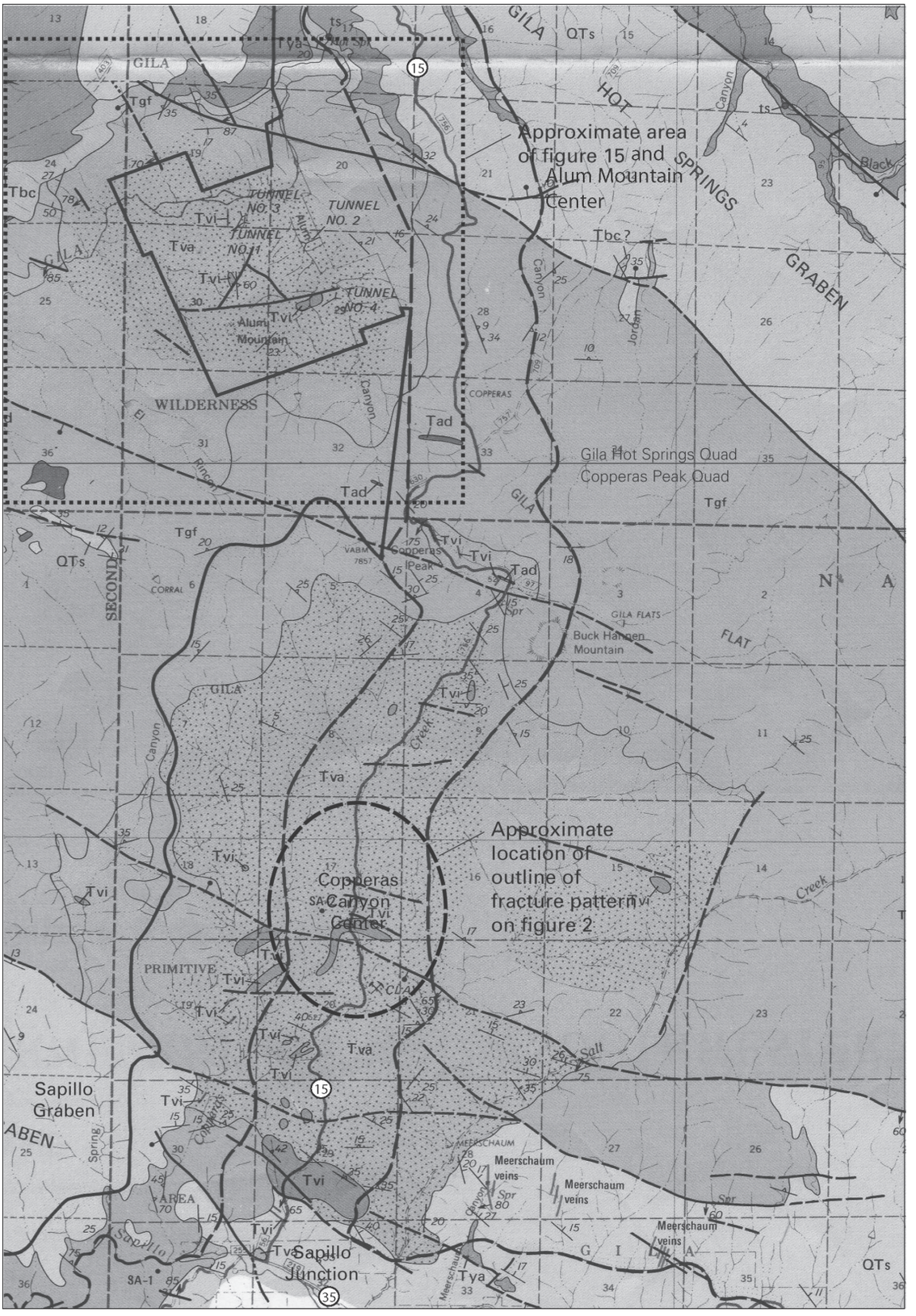


FIGURE 1. Geologic map showing the Copperas Canyon and Alum Mountain eruptive centers of the Copperas Creek Volcano. Scale: 1: 63,360. Modified from Ratté and Gaskill (1975). Qag, alluvium; QTs, Gila conglomerate; Tya, younger andesite, includes Bearwallow Mountain Andesite and Wall Lake dacite; Tbc, Bloodgood canyon Tuff; Tmh, andesitic and basaltic flows of Murtocks Hole; Tsp, Shelley Peak Tuff; Tgf, lava flows of Gila flat; Tva Alum Mountain Volcanic Complex; Tvi, rhyolite intrusions; Tad, andesitic dikes. Red dot pattern shows approximate distribution of altered and mineralized rocks; thermal springs - ts. See Plate 8 on page 68 for a color version of this figure.

1979; R. Northrup, personal commun. 1978). However, further exploration is discouraged because the most favorable ground is included in the Gila Wilderness, leaving only the mile-wide corridor of NM-15 available for resource development. At the least, the area should be included in any inventory of areas with a known potential for mineral resources.

THE COPPERAS CANYON ERUPTIVE CENTER

The Copperas canyon eruptive center is believed to be the major center of eruptive activity because of the greater area of altered rocks associated with it, and, perhaps more importantly, because of the conspicuous rectilinear/orthogonal fracture pattern visible on air photos (Fig. 2), which can be interpreted as representing stresses caused by an underlying intrusive body. This distinctive fracture pattern begins about where NM-15 crosses Copperas Creek, 1.7 miles north of Sapillo junction, and ends, or is greatly diminished, at about MM-29. The fracture pattern appears to be roughly circular with a diameter of about 1.5 miles. Rocks of the Copperas Creek volcano within and adjacent to the fracture pattern, consist of, 1) pervasive, propylitically-altered andesitic lava flows and breccias, 2) resistant, silicified knobs, some of which may be rhyolitic intrusions, and 3) areas of argillic to advanced argillic, solfatarically-altered rocks.

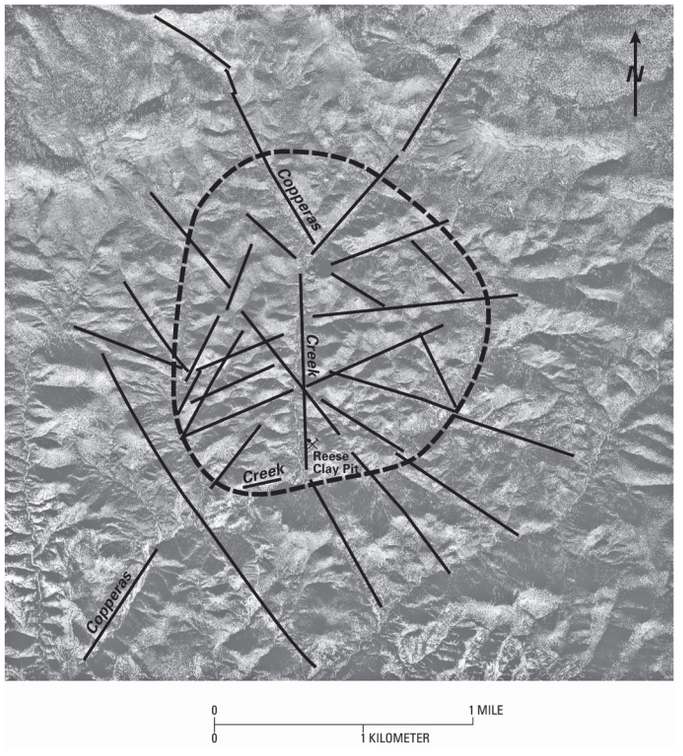


FIGURE 2. Air-photo of the Copperas Creek area showing a prominent rectilinear to orthogonal fracture pattern having an apparent radial component. The resulting lineaments are concentrated in a circular area about 1.5 miles in diameter, which coincides with the area of most intensely altered rock in what is interpreted here as the major eruptive center of the proposed Copperas Creek volcano. The fracture pattern is here speculated to be the result of stresses related to an underlying intrusion, possibly superimposed on the northwest-trending structural grain, which is prevalent throughout the Mogollon Range (Ratté and Gaskill, 1975).

Northrup and Whitney (1984) interpreted the altered rocks to represent three successive stages of alteration that occurred at different times, rather than zoned alteration related to a single event: 1) widespread smectite-pyrite-alteration, 2) mica alteration adjacent to rhyolite intrusions, and 3) kaolinite-sulfate alteration believed to be the result of vapor-dominated boiling. The pervasive, smectite-pyrite altered rocks can be seen in deep road cuts 1.3 and 2.3 miles north of Sapillo junction, between MM-28 and MM-29 (Figs 3A, B).

Zoned kaolinite-sulfate altered rocks at the Reese clay pit on the east side of the highway were described in detail by Northrup and Whitney (1984), who cited kaolinite, halloysite and natroalunite in the clay assemblage. A parking area on the left, just 0.1 miles beyond the second steep road cut and 2.4 miles north of Sapillo junction, affords access to the abandoned clay pit, which is in the trees about 100 yards east of the highway (Fig. 4).

Rhyolitic intrusions related to the Copperas canyon center can be examined at several localities along NM Highway 15 between the junction of highways 15 and 35 at Sapillo Creek and MM-30: 1) a gray, iron-stained, fine-grained, rhyolite intrusion forms a ledge about 0.25 mile wide along the west side of NM-15 (Fig 5), between Sapillo Junction and MM-26. The rhyolite contains rare, tiny sanidine phenocrysts, which have given a K-Ar radiometric age of 29-30 Ma. 2) smaller rhyolite dikes crop-out on the west side of the highway near MM-28 and MM-29 (Fig.6), and 0.7 miles beyond MM-29. As pointed out by Northrup (personal commun. 1978) some linear zones of argillic-altered andesite may appear to be chalky rhyolite dikes, but actual dikes may be identified by blocky jointing and weakly developed flow bands.

The altered rocks of the Alum Mountain Volcanic Complex, Tva on Figure 1, are overlain by the lava flows of Gila Flat (Gila Flat Formation of the Alum Mountain Group, Elston et al., 1981). The Gila Flat flows cap Buck Hannen Mountain and Copperas Peak, as viewed from NM-15 (Fig.1). The base of the lava flows of Gila Flat is here defined as overlying the pink and white layers of explosive volcanic breccias believed to be the final eruptions from the Alum Mountain eruptive center as seen in outcrops on the lower flanks of Buck Hannen Mountain east of NM-15, about 0.4 miles beyond MM-30 (Fig 7). The same layers are exposed in road cuts around a sharp curve to the left, on the west side of the highway just ahead (Fig. 8).

These bedded rocks are considered critical to the interpretation of the eruptive history of the Copperas Creek volcano. They include a sequence of very coarse to very fine breccia beds interpreted as pyroclastic, explosion breccias that may be the most widespread, initial, *or final*, eruptions of the Alum Mountain center. Around the next sharp curve to left, olive-tan volcaniclastic sandstone beds, at least 10-20 ft thick (Fig. 9) overlie the bedded pyroclastic rocks. Where present, the brown sandstone marks the base of, and is mapped with, the andesitic to dacitic lava flows that constitute the lava flows of Gila Flat. This bedded sequence of pyroclastic breccia and sandstone is believed to be the only mappable stratigraphic break of any continuity that has



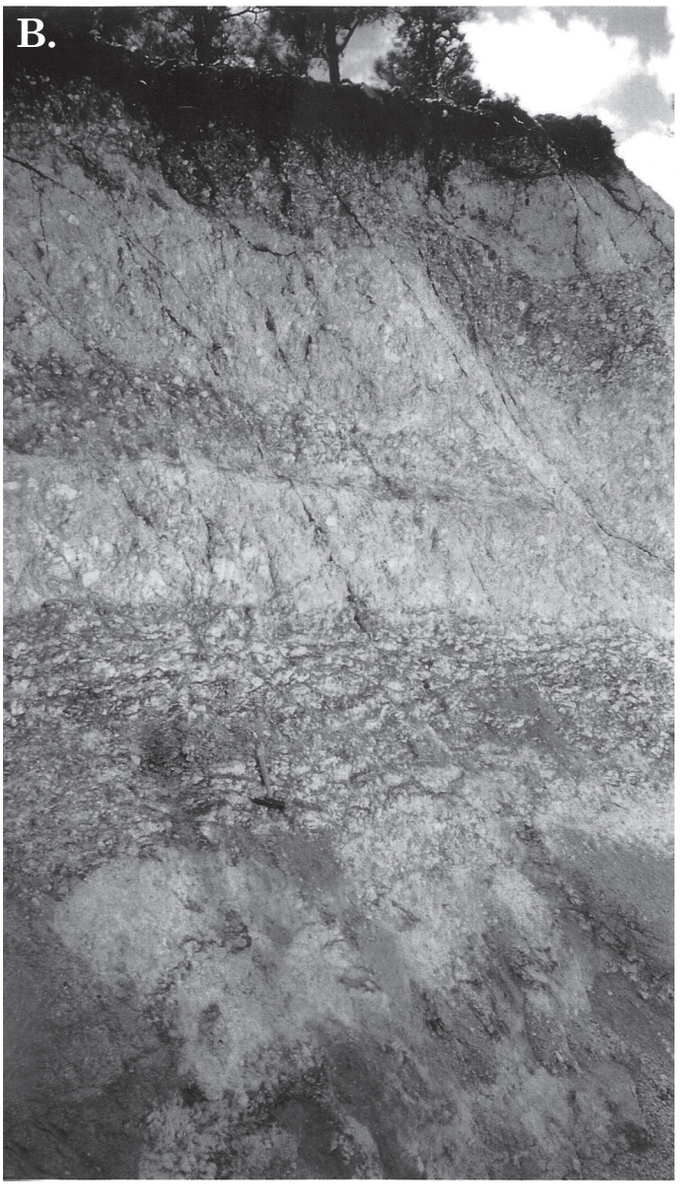


FIGURE 3. Photos of argillically altered andesite in road cuts on NM-15. A-shows relatively unaltered blocks enclosed in pervasively altered rocks. B-close-up of pervasively altered andesite showing layers of concentrated iron oxides(?) offset by small faults.



FIGURE 4. Photo of Reese clay pit prior to landscape rehabilitation following abandoned quarry operations.

been recognized on the Copperas Creek volcano in this or other studies. The sandstone is as much as 100 ft thick where exposed discontinuously beneath the west-facing rim of Gila Flat lava flows that encircle the Alum Mountain eruptive center (Fig.1). These relatively soft, bedded rocks at the base of the Gila Flat flows probably are responsible for the extensive Quaternary landslides that encircle much of the Alum Mountain eruptive center.



FIGURE 5. Photo showing south end of altered rhyolite intrusive body that is exposed for about 0.25 miles along NM-15.



FIGURE 6. Photo of small rhyolite intrusion showing blocky joints and enclosed by relatively fresh andesite.



FIGURE 8. Photo of fine-grained, pyroclastic breccia layers in roadside outcrops beneath Gila Flat flows. These beds are underlain by much coarser pyroclastic breccia just 50-100 feet south of these outcrops.

On the next right-angle curve to the left the sandstone beds are overlain by tan to brown breccias thought in the past to be mudflows or lahars, but now interpreted as more likely to be flow breccias (W.C.McIntosh, personal commun., 2007), that are interlayered with the lava flows. Outcrops continuing along the highway on the left show massive lava flows breaking-up locally into flow breccia (Fig.10). Beneath the surface weathering, both lava and breccia blocks commonly consist of black vitrophyre. Another example of a vitrophyre lava flow breaking-up into flow breccia can be examined in outcrops of a ramped flow-front on the west side of the highway, just before the entrance to the Clinton P. Anderson overlook (Fig.11).

THE SATELLITIC ALUM MOUNTAIN ERUPTIVE CENTER

The Alum Mountain eruptive center (Figs.1,12), is interpreted to be an intrusive-extrusive rhyolite lava dome on the basis of flow layering in rhyolite lava, and associated rhyolite carapace breccia on Alum Mountain, and west of the Gila River. The rocks on Alum Mountain are everywhere altered except for a triangular block of dark-colored lava flow near the mountain top, which is shown as a fault-bounded body on the geologic map (Fig.1), but may be better interpreted as an outlier, or roof pendant, of probable Gila Flat lava flows on the Alum Mountain dome (Fig.

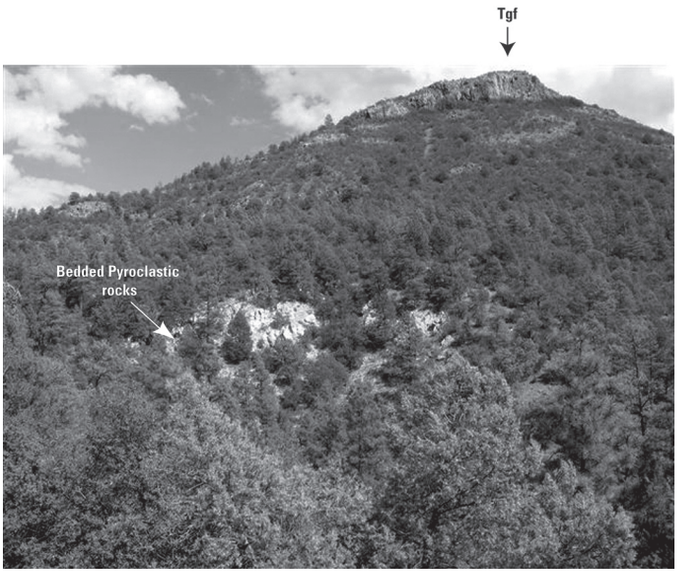


FIGURE 7. Photo of Buck Hannen Mountain showing flows of Gila Flat on mountain top and pink to white bedded rocks in lower slope beneath the flows.



FIGURE 9. Photo of volcaniclastic sandstone beds that separate the pyroclastic breccias in Figure 8 from the flows of Gila Flat.



FIGURE 10. Photo of flow breccia and unbroken flow remnant, typical of the interlayered flows and flow breccia in the lower part of the Gila Flat flows.

13). Much of the altered rock on Alum Mountain is of uncertain origin. Liesegang bands produced by secondary solutions commonly are overprinted on layered rocks, which may be fluidal rhyolite intrusions, bedded pyroclastic rocks, or reworked volcaniclastic deposits.

The Alum Mountain center is surrounded by younger volcanic rocks including the lava flows of Gila Flat, which may or may not be related to the Copperas Creek volcano. The Gila Flat flows on the northern and western flanks of the Alum Mountain center are overlain by Shelley Peak and Bloodgood Canyon tuffs, which are separated locally by the andesitic to basaltic lava flows of Murtocks Hole, and overlain by Bearwallow Mountain Andesite and Gila Conglomerate (Figs. 1,12, 13).

The Anderson Overlook provides the first views of the Alum Mountain eruptive center and the overlapping, younger volcanic units west of the Gila River, but somewhat more open views are available from Copperas Vista within an easy walk about 500 feet up the highway. However, Anderson Lookout has more available parking and somewhat safer access back onto NM-15 than Copperas Vista.

From Copperas Vista one has grand views of the colorful, altered rocks of the Alum Mountain eruptive center, and down Alum Canyon and across the river to the younger rocks that lap onto the Alum Mountain center. The timing and relationship between the Alum Mountain center and the overlapping Gila Flat lava flows are uncertain. Two scenarios seem viable: (1) Andesitic lavas, Tva (Fig.1), erupted from Copperas canyon eruptive center, followed by pyroclastic deposits that introduced a new phase of volcanism from the Alum Mountain center, accompanied by alteration and mineralization in a hot spring environment, followed unconformably by the andesitic to dacitic lava flows of Gila Flat from sources east of the Copperas Creek area (Krier, 1980) or from unknown sources. Several mafic dikes exposed in the canyon walls of the Gila River downstream from Alum Mountain are a likely alternate source. (2) Andesitic lavas erupted from the Copperas Creek center, *including* the lava flows of Gila Flat, followed by rhyolitic intrusions, and associated mineralization in the Copperas Creek area and at Alum Mountain beneath a *cap* of Gila Flat lava flows (Northrup and Whitney, 1984). But, if the altered rocks are related to surface hot spring activity as suggested by Northrup and Whitney, then the Gila Flat flows would seem to have to be younger than the alteration. Rare occurrences of altered rocks that may be at the base of the Gila Flat flows could support the Gila Flat cap interpretation of events, or could be explained as post-Gila Flat, supergene alteration, perhaps related to more recent hot spring activity.

Beginning at the Clinton P. Anderson Overlook at MM-32, and continuing to the extensive parking area at the Alum Canyon trailhead (Forest Trail No.788) approaching MM-36, many colorful views of the Alum Mountain eruptive center and the overlapping younger rocks are available from the west side of the highway. Numerous outcrops on the right side show various aspects of Gila Flat flows, from red, oxidized flow breccia and spatter, with bombs, to gray weathering, flow-banded black glass.

The contact between the Gila Flat flows and the overlying Gila Conglomerate can be seen 2.7 miles beyond Copperas Vista, less than 0.25 mile before MM- 35. The contact appears to be a buttress unconformity, with little apparent offset of Gila conglomerate, which, however, abuts and overlaps an older fault scarp that may correspond to the hinged, southwest side of the Gila Hot Springs graben (Figs.1, 12).

The Alum Canyon trailhead (Fig.14) provides a view down the Gila River with the Alum Mountain eruptive center to the east and overlapping younger rocks across the Gila River to the west. Extensive paleolandslide deposits encircle Alum Mountain beneath the rim-forming Gila Flat lava flows. Recent, but previously unpublished mapping of this slide terrain by the author (Fig.15) shows a break-away zone at the base of the Gila Flat flows where the thin-bedded sandstones locally are as much as 50-100 ft thick. The landslide-filled “moat” that now encircles



FIGURE 11. Photo of folded vitrophyre at Gila Flat flow –front, which is transitional with flow breccia on the left.

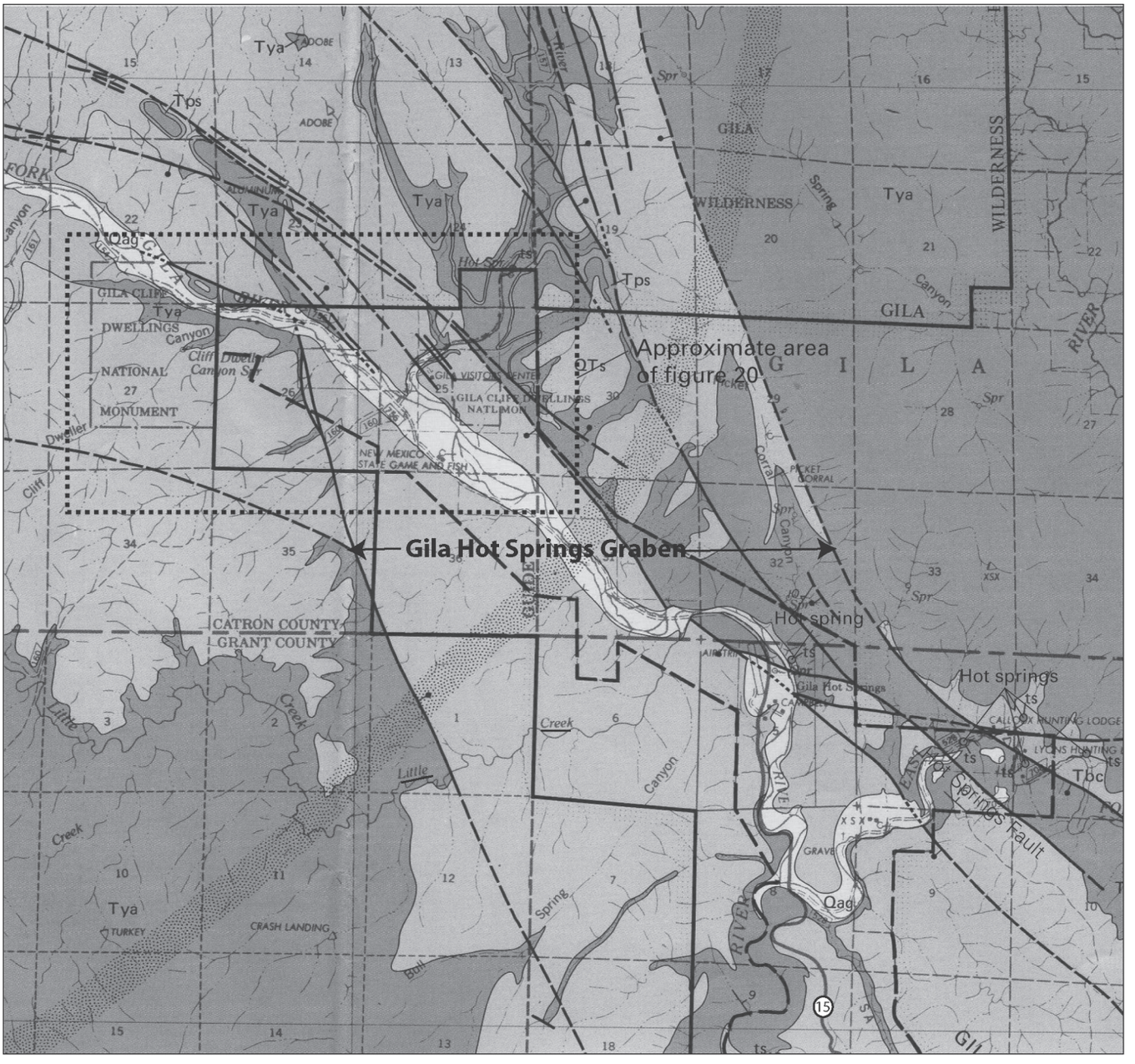


FIGURE 12. Geologic map of the Gila Hot Springs graben. Letter symbols for geologic units are the same as for Figure 1, except for the addition of Tps, which is the volcaniclastic sandstone that separates the Bearwallow Mountain Andesite and the younger Wall Lake Dacite, shown together here as Tya. See Plate 9 on page 69 for a color version of this figure.

Alum Mountain east of the Gila River may mark a former course of the river by which the sandstone at the base of the Gila Flat cliffs was undermined to initiate the slides, but no river gravels have been observed to support the idea. West of the river, altered rocks of the Alum Mountain center are overlapped successively by Bloodgood Canyon Tuff, Bearwallow Mountain Andesite, and Gila Conglomerate (Fig. 15). In the foreground, on the north side of the Alum Mountain center, rocks tentatively identified as 31 Ma Davis Canyon Tuff are found in the slumped terrane overlapping the center.

Secondary aluminum–bearing minerals, halotrichite and alunogen, were mined from the Alum Mountain center for testing as an aluminum resource in the early years of the past century, particularly during WW-I and WW-II, when the U.S. was largely dependent on foreign sources for this strategic metal. Both minerals are supergene hydrous aluminum sulfates, soluble in water, and astringent to the taste. Figure 16 shows halotrichite and alunogen as drapery on cliffs in Alum Canyon, and Figure 17 shows the layered form of halotrichite as deposited on the walls of mine openings. The layering probably is related to seasonal fluctuations



FIGURE 13. Photo of Alum Mountain, looking across Alum Canyon from NM-15. Triangular block of unaltered Gila Flat (?) flows forms a shoulder on the right-hand side of Alum Mountain. Brushy Mountain, on the skyline west of the Gila River, consists of Bearwallow Mountain Andesite and other rocks that overlap the altered rocks of the Alum Mountain eruptive center.

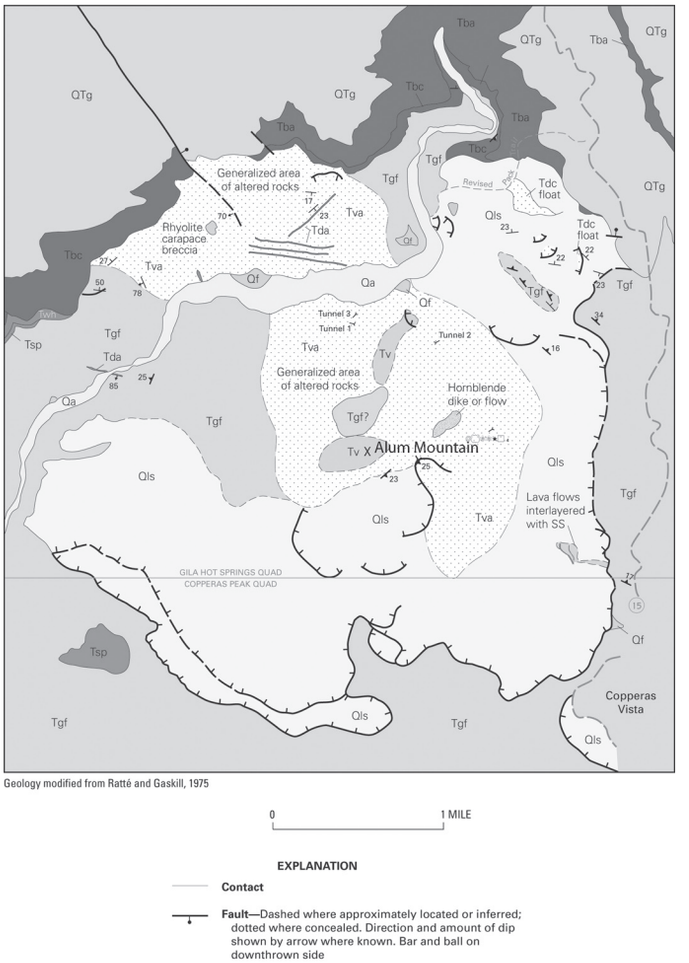
in the availability of groundwater. Alunite and jarosite have been cited as common alteration minerals at Alum Mountain (Weber, in Elston et al., 1965, p 53), but subsequent searches have not found datable amounts of either.

GILA HOT SPRINGS GRABEN

Following the volcanic activity of the late Eocene and Oligocene epochs, Basin and Range faulting was accompanied by deposition of Gila Conglomerate in local basins and down-



FIGURE 14. Photo of Alum Mountain from the Alum Canyon trailhead, looking down the Gila River. Granny Mountain is on the skyline, down river. Gila Flat flows form the rim on the skyline behind Alum Mountain, which is completely encircled by slumps and landslides on the east side of the river.



Geology modified from Ratté and Gaskill, 1975

FIGURE 15. Geologic sketch map of Alum Mountain showing the extent of encircling landslides. Qa, Quaternary landslides and colluvium; Qf, Quaternary fan deposits; Qt, Quaternary terrace gravels; QTg, Neogene-Pleistocene (?) Gila conglomerate; Tba, Oligocene-early Miocene Bearwallow Mountain Andesite; Tbc, Oligocene (28.0 Ma) Bloodgood Canyon Tuff; Tmh, Oligocene basaltic lava flows of Murtocks Hole; Tsp, Oligocene (28.1 Ma) Shelley Peak Tuff;Tdc, Oligocene (29.1 Ma) Davis Canyon Tuff; Tgf, dacitic-andesitic lava flows of Gila Flat; Tvi, rhyolite intrusive rocks; Tad, andesitic-basaltic dikes; stipple pattern, altered rocks; hachured lines, landslide scarps. See Plate 10A on page 70 for a color version of this figure.

dropped, linear fault blocks, such as the west to northwest trending Sapillo Creek and Gila Hot Springs grabens (Figs.1, 12). Erosion to the present landscape and deep circulation of groundwater along major faults resulted in the geothermal resources present in the area.

From the Alum Canyon trailhead, NM-15 provides a steep, winding descent through Gila Conglomerate into the Gila Hot Springs graben. Various facies, from coarse proximal to axial, and fine-grained overbank deposits, are present in the road cuts, and cm-thick sandstone dikes and imbricate structure can be seen locally. A somewhat more detailed description of the Gila Hot Springs graben is presented in a thesis by Cross (1993).

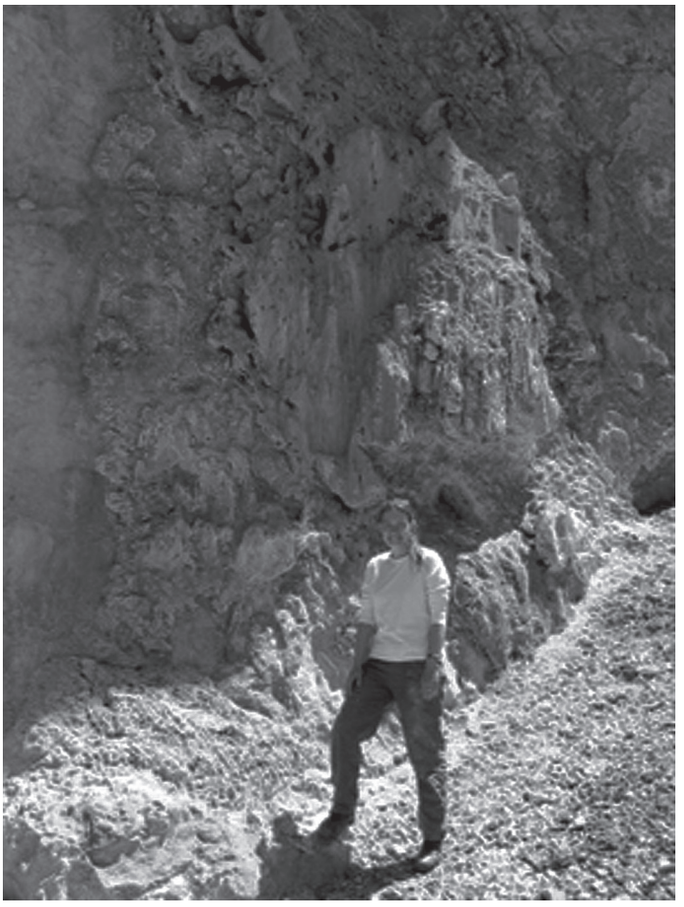


FIGURE 16. Photo of fluted drapery of alunogen and halotrichite on walls in Alum Canyon.

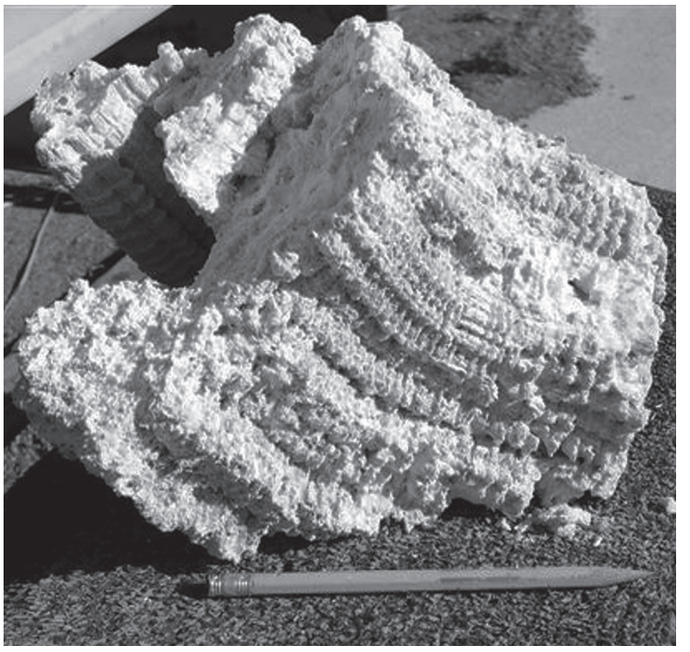


FIGURE 17. Photo of halotrichite specimen showing annual(?) layers.

NM-15 crosses the contact between the Gila Conglomerate and the underlying Bearwallow Mountain Andesite about 0.5 mile beyond MM-37. The Bearwallow Mountain flows are dark gray to reddish-brown, vesicular to amygdaloidal andesite to basaltic andesite, and are related to numerous shield volcanoes that are commonly, but not always, aligned along major fault zones throughout the Mogollon-Datil volcanic field. The rocks typically have tiny, red specks, where mm-size olivine grains are altered to iddingsite, thus imparting "iddingsite measles"!

Quaternary river gravels are present on terrace remnants cut on Bearwallow Mountain flows on the left side of NM-15 as it approaches the Gila River. At MM-38, across the East Fork bridge, an excellent exposure of the Gila-Bearwallow contact shows a dip of about 5 degrees northeast (Fig.18).

The hot springs localized within the Gila Hot Spring graben have been described most thoroughly by Summers and Colpitts (1980) in a private report to the Campbell family, which they kindly permitted to be copied and quoted, and by Witcher and Lund (2002). The Campbells, and several others in the Gila River valley, have developed some of the hot springs for heating and other domestic uses, and bathing pools, as at the Hot Springs Tourist Lodge.

Viewed from the highway, by the parking lot at Doc Campbell's Post, several faults displace the Gila Conglomerate and the underlying Bearwallow Mountain Andesite in the cliffs across the river (Fig. 19). Most of the major hot springs are located on or adjacent to the Hot Springs fault, here in the deepest part of the Gila Hot Springs graben.

Various explanations have been offered for the source of the thermal waters, but the most thorough existing studies of Summers and Colpitts (1980) and Witcher and Lund (2002) favor deep circulation of groundwater along faults, with ponding per-



FIGURE 18. Photo of contact between Gila Conglomerate and underlying Bearwallow Mountain Andesite along NM-15 near confluence of Gila River and East Fork.

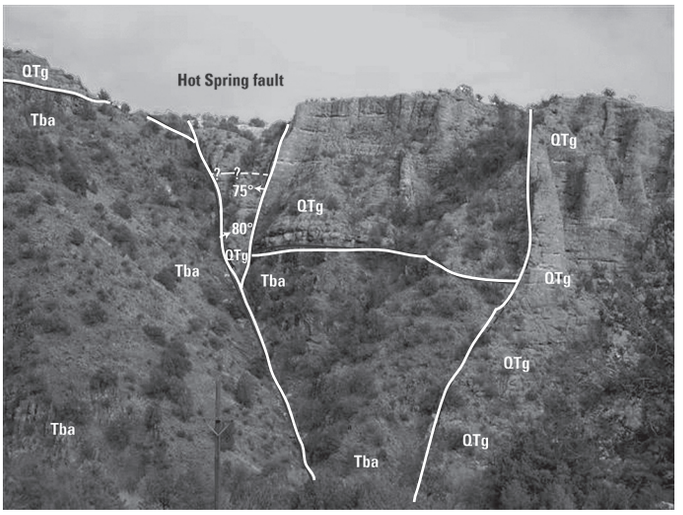


FIGURE 19. Photo showing faults of Gila Hot Springs graben in cliffs on north side of Gila River as viewed from NM-15 near "Doc" Campbell's Trading Post. Tba, Bearwallow Mtn. Andesite; QTg, Gila Conglomerate.

haps in more pervious zones of the Bloodgood Canyon and, or, Bearwallow Mountain formations, and an abnormal geothermal gradient in this region

Beyond Doc Campbells Post, cliffs on the left side of the highway expose hydrothermally altered, pinkish-white Bloodgood Canyon Tuff, which gives way around a sharp curve to the left to Bearwallow Mountain Andesite on the east side of the Hot Springs fault. The fault trace crosses the highway about at the mouth of Little Creek (Fig.12). NM-15 continues along a terrace above the floodplain of the Gila River and parallel to an inferred fault scarp in Gila Conglomerate on the west side of the highway.

About 0.5 miles past MM-42, highway 15 turns left at a junction with the road across the river to the Gila Cliff Dwellings National Monument Visitor Center. The Middle Fork of the Gila River emerges from a canyon to the right of NM-15 and joins the main stream west of the intersection. At MM-43, the road crosses from the Gila Hot Springs to the Little Turkey Park Quadrangle. The next bridge across the Gila River has been washed out by periodic floods, the latest in **January, 2008!**

Outcrops of Wall Lake Dacite flows and breccia are underlain by several feet of reddish-brown, volcaniclastic sedimentary rocks in roadcuts on the right, at the mouth of Adobe Canyon, just beyond the cattle guard past the bridge. These rocks, which overlie Bearwallow Mountain Andesite locally, thicken to the northeast, but pinch-out between here and the Cliff Dwellings. The mixture of reddish-brown, oxidized, sedimentary rock and lava flows in these road-cuts indicates that the hot lava flows plowed into and mixed with the underlying wet sediments to form peperite. Wall Lake flows are distinguished from Bearwallow Mountain flows by the presence of small, green, pyroxene phenocrysts, and quartz xenocrysts, which have pyroxene reaction rims.

Between the lower and upper Scorpion Campgrounds, the road crosses a pair of northwest-trending faults that drop a Gila Conglomerate block down against Wall Lake Dacite, on the northeast side in the lower campground, and Bearwallow Mountain Andesite on the southwest side, in the hill on the north side of the Cliff Dwellings parking lot (Fig.20).

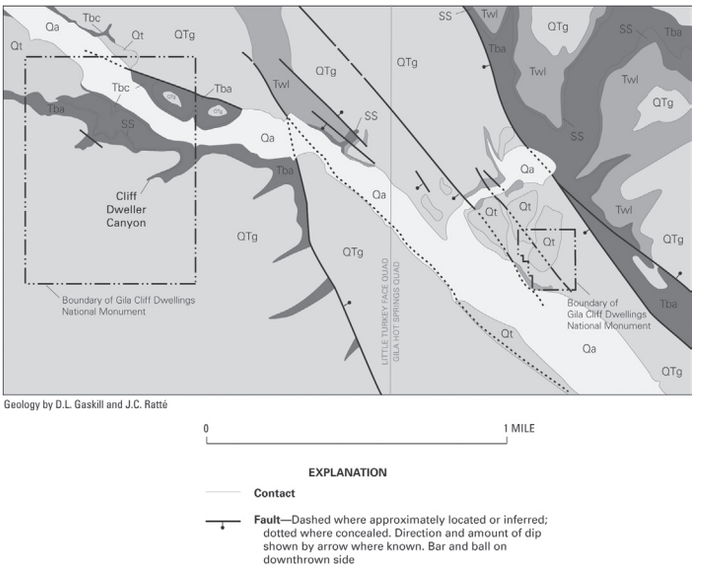


FIGURE 20. Geologic sketch map of Gila Cliff Dwellings National Monument and vicinity. Qa, Quaternary alluvium; Qt, Quaternary terrace gravels; QTg, Neogene-Quaternary volcaniclastic deposits; Twl; Oligocene(?) Wall Lake andesitic-dacitic lava flows; Tba, Oligocene-early Miocene Bearwallow Mountain Andesite; Tbc, Oligocene (28.1) Ma Bloodgood Canyon Tuff; ss, volcaniclastic sandstone interlayered withi Twl and Tba. Scale 1:24,000. See Plate 10B on p. 70 for a color version of this figure.

On the north side of the parking lot, at the entrance to the Cliff Dwellings, the upper 10 to 20 ft of the light-colored, partially welded top of the 28 Ma Bloodgood Canyon Tuff is overlain by dark-colored flows of Bearwallow Mountain Andesite (Fig. 21), which in turn is overlain on top of the hill by Gila Conglomerate, the rock in which the cliff dwellings across the river are located.

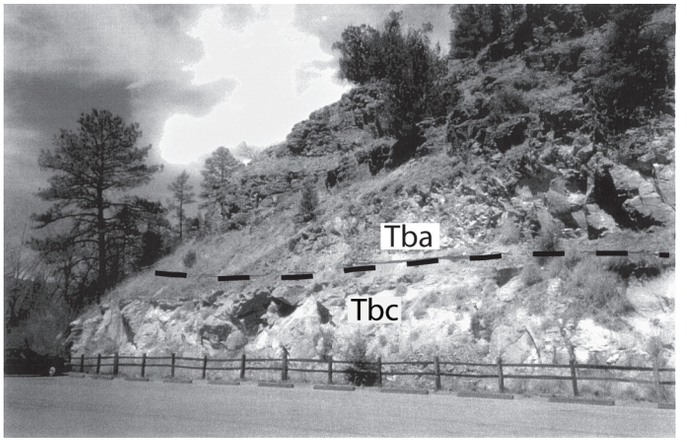


FIGURE 21. Photo of dark-brown Bearwallow Mountain Andesite, Tba, ~ 23-25 Ma, on top of light-gray to white Bloodgood Canyon Rhyolite Tuff, Tbc, 28.1 Ma, in the parking lot for the Gila Cliff Dwellings.

The trail to the Cliff Dwellings, in Cliff Dweller Canyon, starts in amygdaloidal Bearwallow Mountain Andesite, then climbs into Gila Conglomerate, which consists mainly of Bloodgood Canyon clasts, from sand-size to boulders, that were eroded from the surrounding mountains and deposited by streams in low-lying areas. When the sun is right, one can often see the blue reflectance of sanidine crystals in the tuff clasts as one ascends the trail. Along the return trail from the Cliff Dwellings, the contact between the conglomerate and the underlying andesitic flows is well exposed, and the conglomerate includes abundant fragments of the underlying andesite regolith on which it was deposited.

The Cliff Dwellings parking lot also provides access to Gila Wilderness trail No. 51, along the West Fork of the Gila River. It is one of the main trails into the Wilderness from the east side. The Bloodgood Canyon Tuff exposed in the parking lot provides only a glimpse of the top of this ignimbrite, which fills the Gila Cliff Dwellings caldera and forms spectacular cliffs on both sides of the river along the West Fork Trail. At Hells Hole, about 14 miles up-river, Bloodgood Canyon Tuff is at least 1100 ft thick, and the bottom is not exposed. Also at Hells Hole, the thick, Bloodgood Canyon Tuff is cut-off by the eastern wall of the slightly younger, but also 28 Ma Bursum caldera, which extends from Hells Hole all the way across the Gila Wilderness to the vicinity of Glenwood and Mogollon, 25 miles (40 km) to the west. The Bursum caldera is filled by Apache Spring Tuff, which is slightly younger than Bloodgood Canyon Tuff, and has not been found outside of the resurgent Bursum caldera. The Bloodgood Canyon and Apache Spring tuffs are compositionally zoned tuffs from the same magma chamber. The Bloodgood was erupted first, and filled the older Gila Hot Springs caldera, which probably formed by collapse after the eruption of one of the older regional ignimbrites of the Mogollon Range for which no source has been identified. Possible candidates include 28.1 Ma Shelley Peak Tuff and 29.0 Ma Davis Canyon Tuff, among others (Ratté, et al., 1984).



FIGURE 22. Photo of cliffs on east side of Middle Fork from road to Monument residence area and parking at trailhead for Middle Fork Wall Lake Dacite, Twl, in upper cliffs is separated from Bearwallow Mountain Andesite, Tba in lower cliffs by 10-20 ft of volcaniclastic sandstone, vcss, the same as at the mouth of Adobe Canyon on the road to the cliff dwellings.

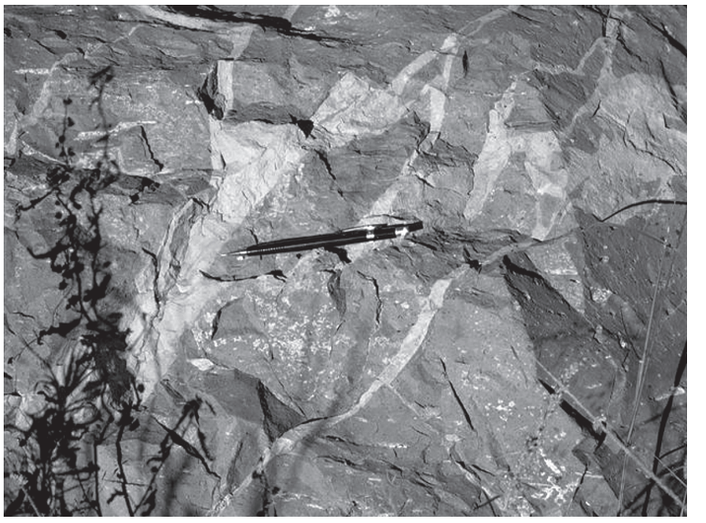


FIGURE 23. Photo showing sandstone dikes in large block of Wall Lake Dacite at south end of Middle Fork parking area. More dikes can be found in the cliffs underlying the parking lot, and elsewhere in Wall Lake outcrops across and down the Middle Fork in this area .

A further look at the Gila Hot Springs graben and associated hot springs may be acquired by a short, one mile hike up the Middle Fork of the Gila River from behind the Visitor Center to the spring known locally as “Light Feather” hot spring. The trailhead and parking are located on the left, about 0.25 miles up the road between the Visitor Center and the National Monument Residence Area (Fig. 22). The parking area is on top of a ledge of Wall Lake Dacite (Fig. 23), which contains numerous sandstone dikes here and elsewhere in this area. The dikes range from a few to several inches in thickness, and may contain small clasts of Bloodgood Canyon Tuff or other rocks. The abundance of sandstone dikes in Wall Lake Dacite in this area of pervasive faulting in the Gila Hot Springs graben may be the result of liquefaction of sediments beneath or above the dacite during faulting.



FIGURE 24. Photo of travertine ledge on east side of Middle Fork, directly above Light Feather hot spring, at river level.

From the parking lot, the view up the Middle Fork shows Bearwallow Mountain Andesite in the lower cliffs overlain by a few feet of reddish-brown volcaniclastic sandstone beneath about 80-100 ft of Wall Lake Dacite, and about 140- ft of Gila Conglomerate in the uppermost cliffs. One of the Gila Hot Springs graben faults separates Wall Lake Dacite in the parking lot from that in the cliffs up river, where it is about 200 ft higher (Fig. 20). On this side of the fault, Gila Conglomerate crops out in the trail beneath a rubble of Quaternary terrace gravel as it leaves the parking area, and is abundantly exposed in the low ground in front of the cliffs east of the river. At most times, the river is little more than ankle deep at the two crossings on the way to the Light Feather hot spring, which is on the east side of the river beneath a conspicuous, gray travertine ledge (Fig.24). The travertine was presumably deposited from the thermal spring waters when the river was at a higher elevation sometime in the past. This spring, which has a temperature of about 150 F°, is not located on any major fault, but may be related to a small fault that has an apparent offset of a few feet in the upper cliffs on the west side of the river (Fig. 25).

The geology of the Copperas Creek volcano, and the Gila Hot Springs graben, as viewed from a tour along New Mexico Highway 15 from Sapillo Creek junction to the Gila Cliff Dwellings National Monument, is a preview of the geology of the Gila Hot Springs and Copperas Peak 7 ½ minute quadrangles. The former is in compilation stage, but the Copperas Peak Quadrangle requires additional work to reconcile the Copperas Creek volcano, as presented here, with the previous mapping of additional eruptive centers and the volcanic stratigraphy in the eastern part of the quadrangle as presented by Krier (1980).

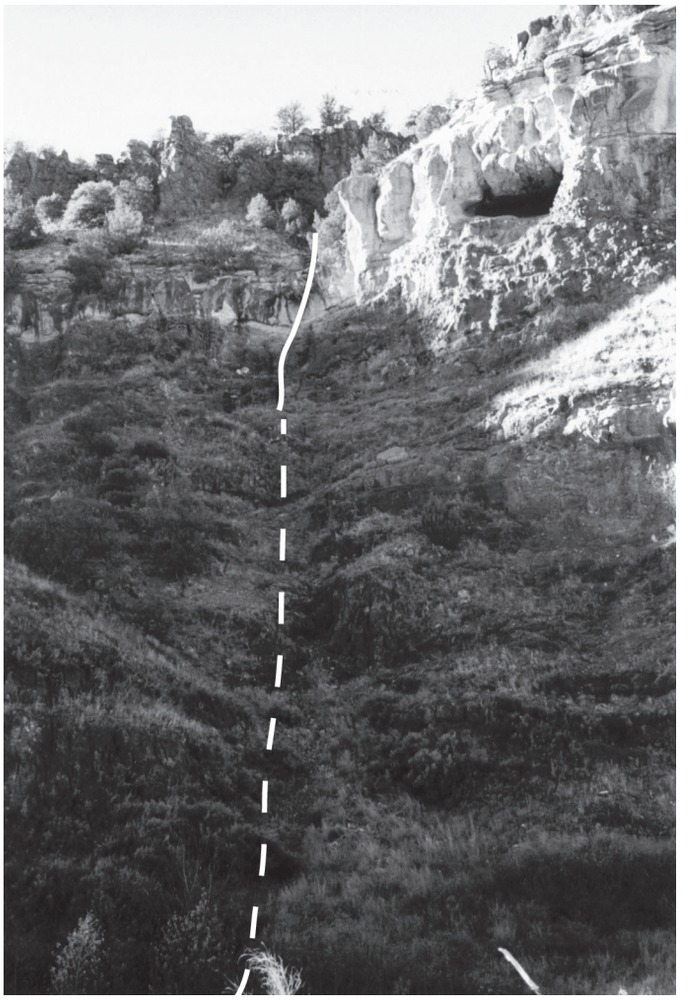


FIGURE 25. Photo showing small fault offset in upper cliffs west of Middle Fork directly opposite Light Feather hot spring.

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