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Geology of a fault-controlled cave in Precambrian crystalline rocks In Clear Creek Canyon, Jefferson County, Colorado

by

John C. Reed, Jr.
U.S. Geological Survey
MS 913, Box 25046
Federal Center
Denver, Colorado 80225

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GEOLOGY OF A FAULT-CONTROLLED CAVE IN PRECAMBRIAN CRYSTALLINE ROCKS IN CLEAR CREEK CANYON, JEFFERSON COUNTY, COLORADO

Introduction

On May 12, 1988, a construction crew working in an excavation along U.S. Highway 6 in Clear Creek Canyon west of Golden, Colorado (figure 1) encountered an opening in Precambrian metamorphic rocks about 150 feet long and as much as 50 feet high. Parts of the hanging wall of the cavern were decorated with radiating crystals, stalactites and stalagmites of aragonite, and calcite flowstone (Modreski and others, 1988; P.J. Modreski, written comm. 1989). Because of the unusual geologic setting of the cave and the beauty and variety of its decorations the discovery of the cave received considerable media attention (U.S. Geological Survey, 1988). The cave entrance was sealed on May 18, 1988, to prevent unauthorized entry. It was reopened on June 20, 1989, under the auspices of the Geology Museum of the Colorado School of Mines with the permission of the property owner, O.R. Goltra, in order to remove specimens of the cave formations for display. At that time a planetable survey of the excavation was made, a rough sketch map of the cave was prepared, and detailed study of the geology of the area was begun. This report presents the results of that investigation. The cave was resealed on June 22, 1989, and remains sealed at the present time (April, 1991).

Geologic setting

The excavation in which the cave was discovered lies in a zone of crushed and broken Precambrian rocks along the Junction Ranch fault (Sheridan, Reed, and Bryant, 1972), a major northwest-trending fault that extends for almost 30 miles, from northwest of Morrison to the the vicinity of Nederland (Bryant, McGrew, and Wobus, 1981). The Junction Ranch fault is one of a family of northwest-trending faults that cut the Proterozoic igneous and metamorphic rocks in this part of the Front Range (Wallace, 1982). The faults are all steeply dipping, and many show apparent left-lateral offset of the Proterozic units of a few hundred to several thousand feet. Movement on the faults may have been initiated as early as the Middle Proterozoic (Taylor, 1979), but they have been reactivated during the Laramide (Wallace, 1982).

Sheridan, Reed, and Bryant (1972) map the wall rocks of the fault zone in the vicinity of the excavation as migmatitic biotite gneiss locally containing lenses and layers of hornblende gneiss, amphibolite, and calc-silicate gneiss a few feet or tens of feet thick and a few hundred feet long. Their map indicates that the excavation lies at the junction of the Junction Ranch fault, which trends about S40°E and the Windy Saddle fault, which trends about S65°E.

Geology of the excavation

Most of the excavation in which the cave was discovered lies in a zone of highly fractured sugary-textured gray to pink microbreccia in which the ubiquitous fracture surfaces are coated with grayish orange (10YR 7/4) to moderate yellowish brown (10YR 5/4) limonitic material. This coating lends the entire outcrop an orange to yellow brown hue. The microbreccia consists of angular fragments of quartz and kaolinitized feldspar .05 to 2 mm in diameter set in a microcrystalline carbonate-rich groundmass. Some of the larger fragments are themselves microbreccia. The microbreccia is cut by veinlets of carbonate, and open vugs coated with drusy aragonite are common. Most of the vugs are only a few millimeters wide, but boulders of microbreccia along the construction road west of the excavation display vugs as much as several centimeters wide. Wallace (1982) has described similar carbonate-dominated breccias along the northwest-trending faults in metasedimentary rocks in this part of the Front Range.

The exposed width of the microbreccia zone is about 150 feet. It strikes about N55°W and dips 70-80° NE (plate 1, figure 2). A layer of gray flinty crush rock a few inches thick is exposed discontinuously in the microbreccia zone about 30 feet northeast of the footwall (plate 1). This rock is a microbreccia resembling the enclosing rocks but has a somewhat more siliceous groundmass.

The microbreccia is cut by many zones of light gray to blue gray highly calcareous clay gouge less than an inch to several inches thick. Many of these are subparallel to the main fault zone, but many are oblique to it. Many of the gouge zones displayed subhorizontal striae when first exposed, but most of these were quickly obliterated by desiccation of the clay gouge. Movement sense could be inferred on only a few striae, but seemed generally consistent with the left-lateral strike-slip movement suggested by Sheridan, Reed, and Bryant (1972).

The wallrocks northeast of the fault zone are chiefly biotite gneiss, much of it highly migmatitic, containing layers and lenses of amphibolite and calc-silicate rocks. Foliation, which is generally parallel to layering, strikes N70-80^{o}W and dips moderately to steeply southwest, at an appreciable angle to the hanging wall of the fault zone. The gneiss is cut by an irregular discordant body of coarse pegmatite as much as 50 feet thick which is truncated by the fault zone (plate 1).

The wallrocks southwest of the fault zone are chiefly biotite gneisses similar to those in the hanging wall, but also include a body of weakly foliated gray to pink granitic gneiss exposed in the gulley north of the highway. Foliation in both the granitic gneiss and the biotite gneiss in the footwall strike N75-80^{o}W and dip steeply to moderately north. The reversal in foliation dip across the fault zone, which Sheridan, Reed, and Bryant (1972) show as persisting for as much as a mile, is probably a result of strike-slip displacement.

In an irregular zone ranging in width from 0 to as much as 100 feet the wallrocks on both sides of the fault zone are hydrothermally altered. Ferromagnesian minerals are replaced by limonite and chlorite, feldspars are kaolinitized, and joint and fracture surfaces are coated with limonite. In a narrower zone, carbonate minerals are conspicuous in joints and fractures.

The cave lies in a thick zone of calcareous clay gouge that splays from the hanging wall of the microbreccia zone into altered country rocks near the northwest contact of the large pegmatite body. The maximum width of gouge observed in the cave was about five feet, but the gouge zone could be several times as thick. Both the hanging wall and the foot wall of the opening are relatively smooth and are parallel to the trend of the gouge zone, which can be traced continuously in the back (roof) of the cave. The smoothness of the walls and the continuity of the gouge zone suggest that the opening is primarily the result of solution and groundwater flushing of the carbonate-rich gouge rather than to downslope movement of large surficial blocks or movement on mismatched fault surfaces.

Physiographic setting of the cave

The opening through which the cave was entered lies at an elevation of about 6270 feet, about 170 feet above the present level of Clear Creek (figure 3). The lowest accessible part of the cave floor lies at an elevation of about 6210 feet. Terrace gravel is exposed on a topographic nose on the north side of Clear Creek about 1000 feet east of the cave. The top of this gravel lies at an elevation of about 6190 feet. If the top of the gravel is projected upstream at the same slope as the present gradient of Clear Creek, the surface of the gravel would lie at approximately the same elevation as the lowest part of the cave floor. Cuts along a pioneer road in the tributary gulley 500 to 700 feet west of the cave expose poorly sorted but well bedded sediments that are interpreted as gulley-fill deposits (M.C. Reheis, personal comm., 1989). If the upper surface of these deposits and the axis of the trough defined by the internal bedding is projected eastward, the upper surface would lie approximately at the level of the highest part of the cave opening. These relations suggest that water may have entered the gouge zone at the edge of the alluvial gulley fill and flowed downward to emerge through the terrace gravel along Clear Creek, dissolving the carbonate component of the gouge and flushing out the clay component to produce the cave opening. The flow may have been channeled by the large mass of pegmatite that cuts the rocks in the hanging wall of the fault zone at the southeast end of the cave, or it may be that gouge adjacent to the pegmatite is less subject to solution, so that excavation did not extend farther to the southeast.

The terrace gravel east of the cave lies about the same distance above Clear Creek as the outwash gravels related to the Bull Lake moraine near Lawson, about 18 miles upstream (G.M. Richmond, personal. comm., 1991). If the gravel is correlative with the Bull Lake outwash, the cave was probably excavated during deglaciation following the Bull Lake glacial maximum. This deglaciation is dated at about 130,000 years ago (Richmond, 1986, chart 1A).

Acknowledgements

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FIGURES

PLATE

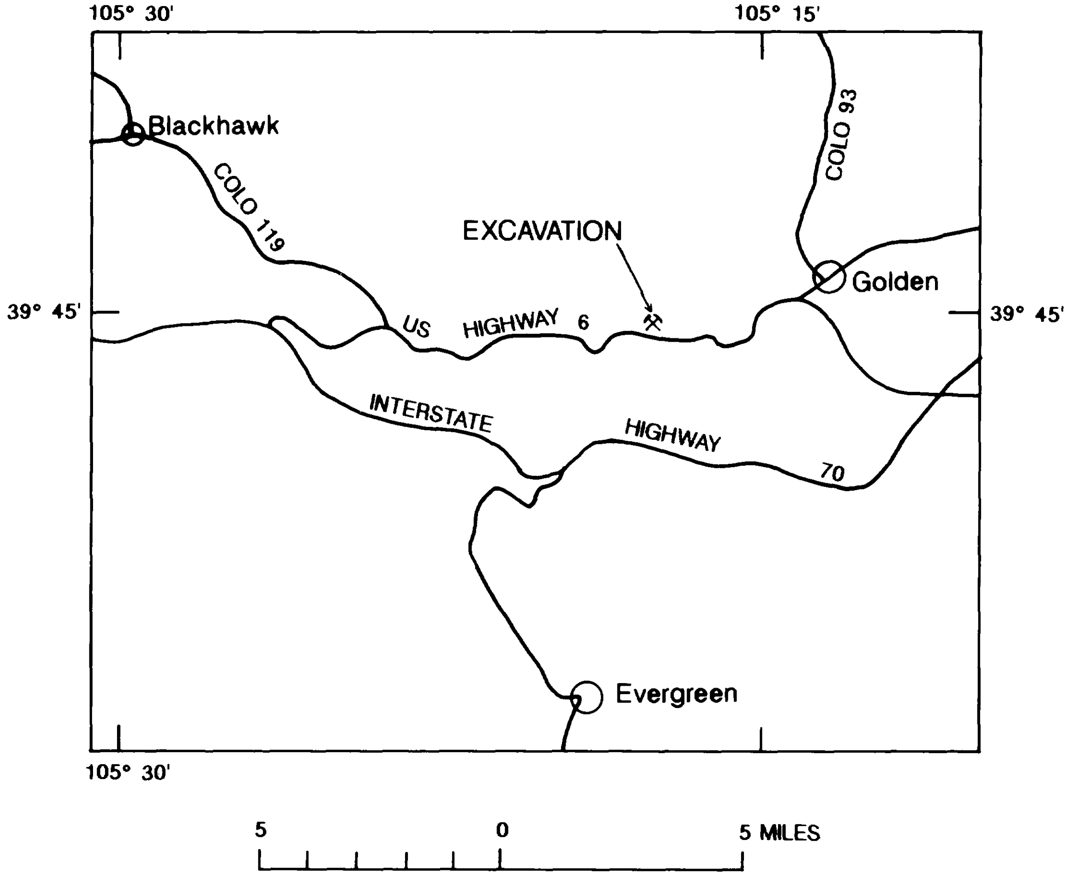

Figure 1.--Map showing location of the excavation along U.S. Highway 6 in which the cave was discovered

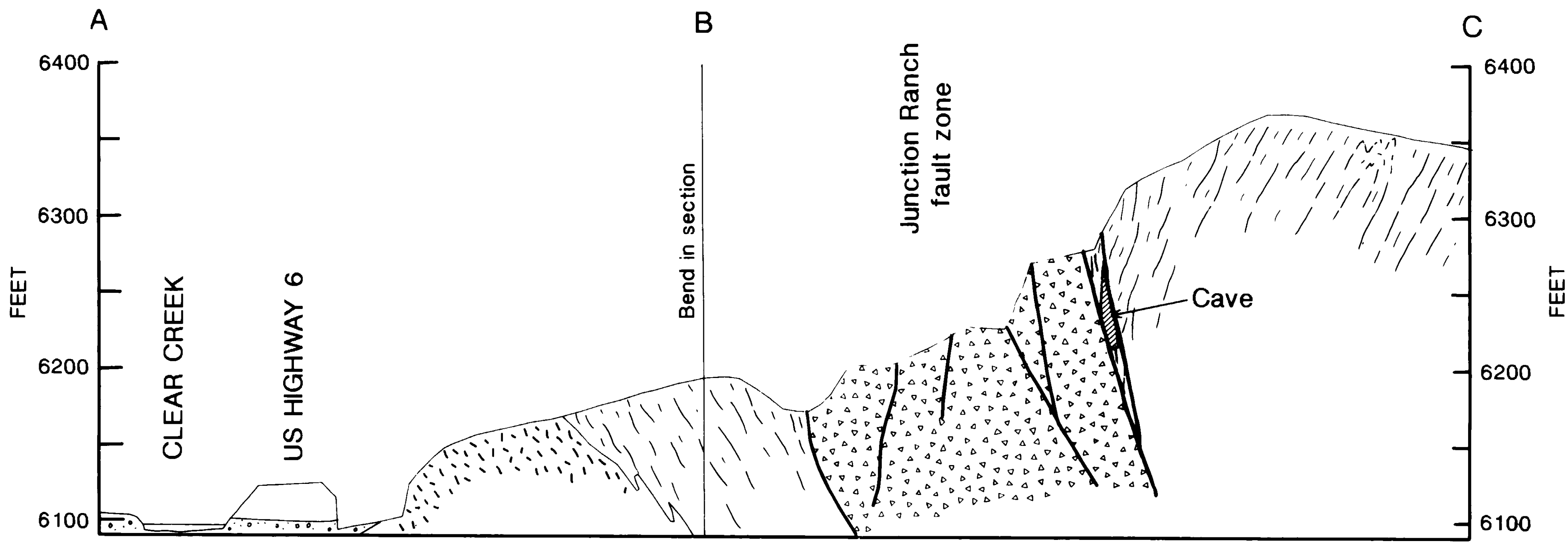

Figure 2.--Geologic cross section of the excavation

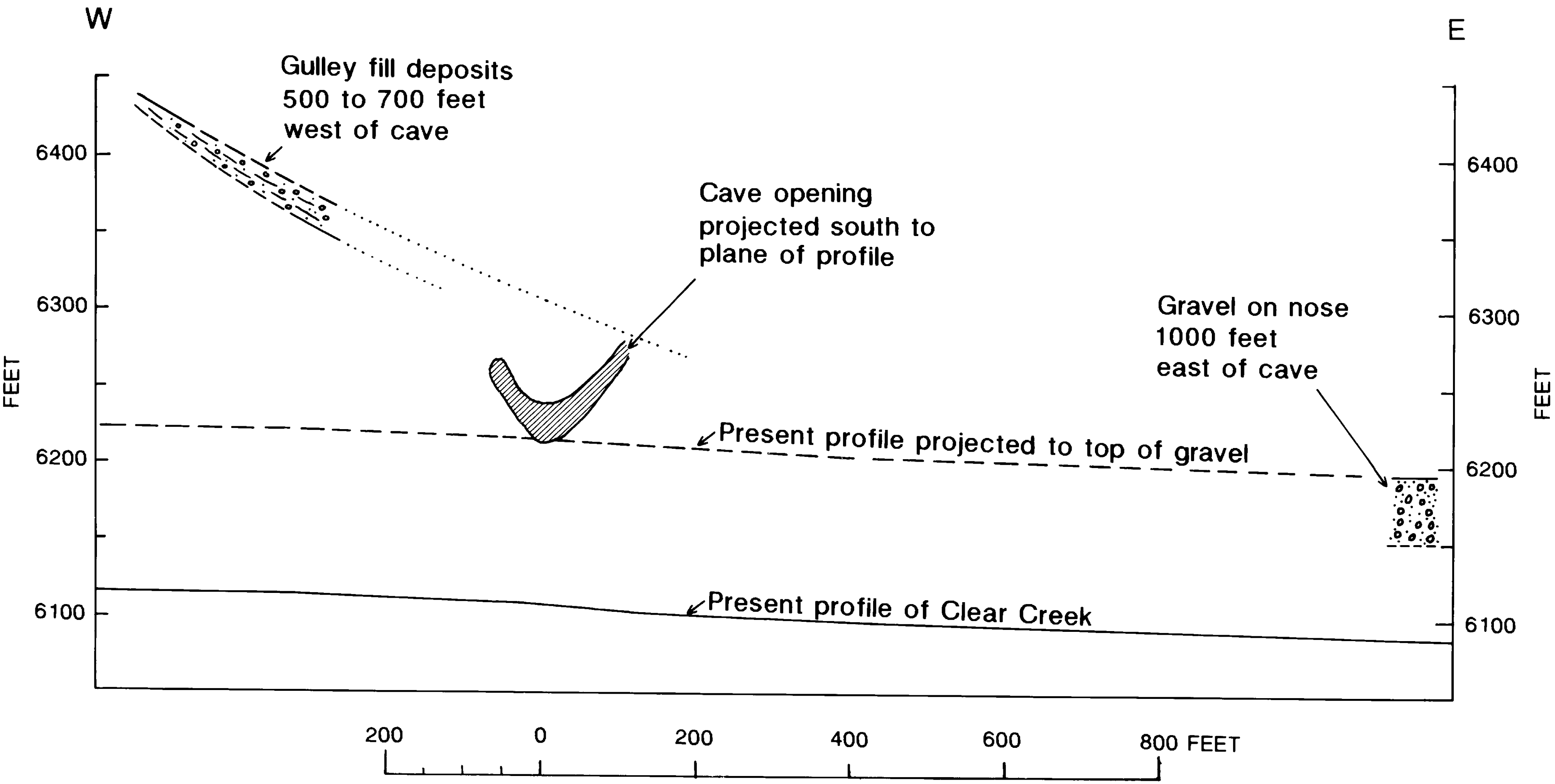

Figure 3.--Diagram showing relations of the cave to terrace gravel along Clear Creek and gulley fill deposits