Iowa

Patricia Kambesis and Michael Lace

CONTRARY to the popular misconception of Iowa as a land solely distinguished by flat, cultivated expanses of corn and soybeans, the state is richly varied with rolling hills, deeply incised streams and valleys, and has a diverse array of caves and karst features (Prior, 1991). See Figures 4.38–4.40 for the geographic and geologic setting. The state includes more than 1300 documented caves ranging from a few meters to kilometers in length (Fig. 4.41).

Controls on Cave and Karst Development

Cavernous strata in Iowa are mainly Silurian and Ordovician carbonates, with far fewer caves in Devonian and Mississippian limestones and Cambrian sandstones (Fig. 4.40). The rocks dip gently toward the southwest, exposing the oldest units in the northeastern corner of the state (Fig. 4.39). Bedrock is mantled by a combination of pre-Pleistocene and Pleistocene glacial sediments that thicken from east to west. Most of Iowa's caves and karst features are in the eastern and northeastern part of the state, where glacial sediments are thinnest and carbonate bedrock is closest to the surface. However, caves are also scattered throughout the central and southeastern sections where glacial sediments are thin or where major surface streams have cut into the bedrock.

The Paleozoic bedrock units are highly fractured, providing paths for the initial movement of meteoric groundwater and, in places, deep-seated thermal fluids. Patterns and passage trends of solutional caves reflect the hydrogeologic regime in which they formed. Solutional cave types include dendritic forms, rectilinear mazes, and floodwater mazes, which occur in limestone, dolomite, and sandstone. Multiple glacial incursions have rearranged surface drainage and therefore the patterns of groundwater flow. Periglacial conditions during the Pleistocene also modified the karst. In that and also the present climate, freeze-thaw cycles and soil piping have triggered the spalling of cliffs and mass movement of rock and sediment. Paleokarst and relict cave features reflect the disparity between past and present karst processes. And yet, most modern streams still follow preglacial courses, and major topographic features are pre-Pleistocene in age (Hedges, 1974).

Cave Distribution

Most of Iowa's caves are located in the northwest-southeast-trending bands of bedrock defined by the Niagara, Galena and Prairie du Chien cuestas. These form the Paleozoic Plateau (where Paleozoic rocks are exposed at the surface), which is considered part of the Driftless Area

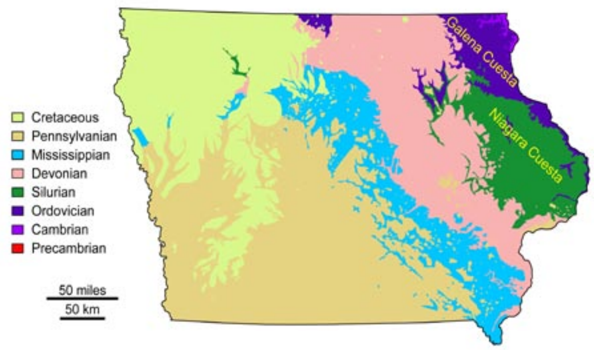

Figure 4.39: Iowa geologic map after Iowa Geological Survey Bureau geologic map.

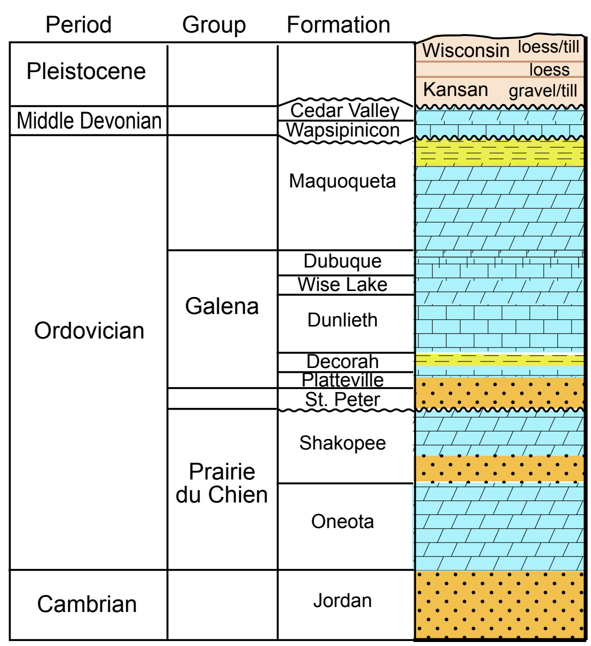

Figure 4.40: Stratigraphy of cave-forming units in Iowa.

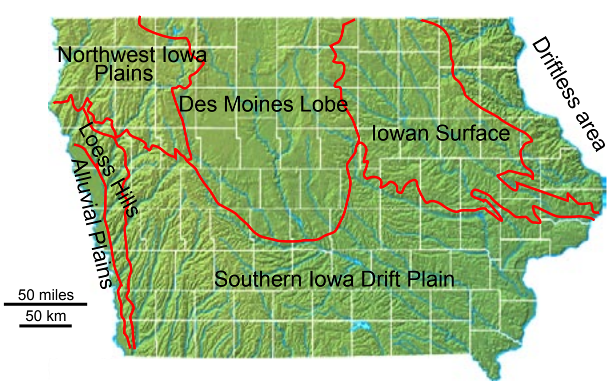

Figure 4.38: Physiographic map of Iowa.

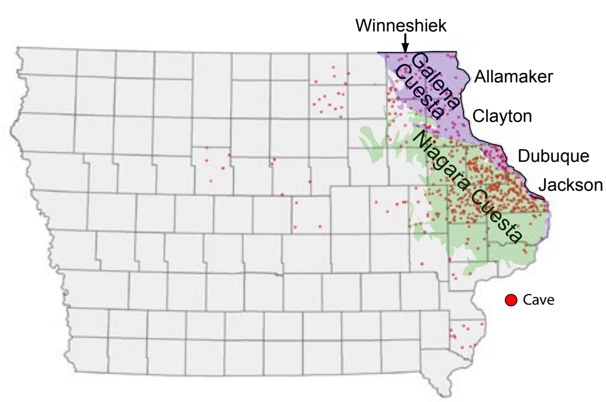

Figure 4.41: Total Iowa cave distribution with counties mentioned in text.

Figure 4.42: Resurgence entrance of stream cave along the Niagara Cuesta, formed in Silurian dolomite, eastern Iowa. Photo by Mike Lace.

Figure 4.43: One of many sinkholes on the Niagara Cuesta, eastern Iowa. Photo by Mike Lace.

(Fig. 4.21, 4.38); but the area is not truly "driftless," i.e., free of glacial sediments, because a discontinuous veneer of thin glacial sediments covers the landscape.

The Niagara Cuesta contains most of Iowa's caves (Fig. 4.41) including commercial Crystal Lake Cave and Maquoketa Caves State Park. Its steep, cliff-dominated edge is called the Niagara Escarpment. The north- and east-facing scarp extends for more than 200 km into northwestern Illinois. Glacial sediments cover much of the cuesta, but bedrock is exposed where glacial stream derangement caused superposition of rivers onto preglacial bedrock uplands (Hedges, 1974). Bedrock includes the Ordovician Maquoketa Formation and Silurian dolomites (Witzke et al., 1997). The Maquoketa is exposed in many of the deep valleys in the Niagara Escarpment and forms the gently sloping portion of the scarp. Many springs and seeps are located at the contact between the Maquoketa Formation and overlying Silurian strata. The Niagara Cuesta displays both significant karst development and mechanical cave development.

In the northern and southern parts of the cuesta, seeps, springs, and caves form at or near valley heads and are recharged by blind valleys, dolines and upland caves (Fig. 4.42; see Bounk, 1983). Caves on the cuesta and along its edges end in sumps or become impassable. Some caves are complex fracture-controlled mazes formed by backflooding during high flow. All are remnants of more extensive systems that formed during post-glacial incision of local rivers (Hedges, 1967). Passages have been modified and in places removed by collapse and by valley-head erosion.

Cave development along the edge of the escarpment is dominated by mechanical processes with some solutional overprinting. Many of their entrances are mechanically widened fissures that may have formed by periglacial ice wedging during the Pleistocene. In many fissure caves the walls are mirror images, so that passages are of uniform size, and ceilings consist of loose blocks instead of solid bedrock (Hedges, 1972). Unlike solutional features, these must be pseudokarst. Therefore these features are not formed by solutional processes and are aspects of pseudokarst.

The Niagara Cuesta contains many sinkholes (Fig. 4.43). A significant number formed by frost- and ice-wedging combined with gravity slippage of dolomitic blocks on the underlying shale accounting for the widening of joints, which in turn causes slumping and collapse of overlying material and diversion of surface drainage underground (Prior, 1991). The Niagara Escarpment also contains many joint-controlled solution caves. These caves are typically short crawlways. Talus caves are also common along the escarpment.

The Galena Cuesta becomes a prominent feature just north of where the Niagaran strata emerge from beneath Devonian rocks. Farther east it is not as pronounced and becomes much narrower. It is composed mainly of the Ordovician Galena Group (Fig. 4.40). The Galena grades southward from limestones to dolomites as a result of hydrothermal alteration.

At the northern end of the cuesta the upper members of the Galena Group form a deeply incised plateau that is strongly karsted. A very thin mantle of glacial sediment is present. Broad valleys are underlain by the Decorah Shale and Platteville Formations. Modern streams follow courses established in preglacial times, and many springs resurge at the top of the Decorah Shale. Active fluviokarst has developed in the region, with groundwater recharge through sinkholes and swallets that dot the landscape. Active conduits have formed in the plateau and drain toward

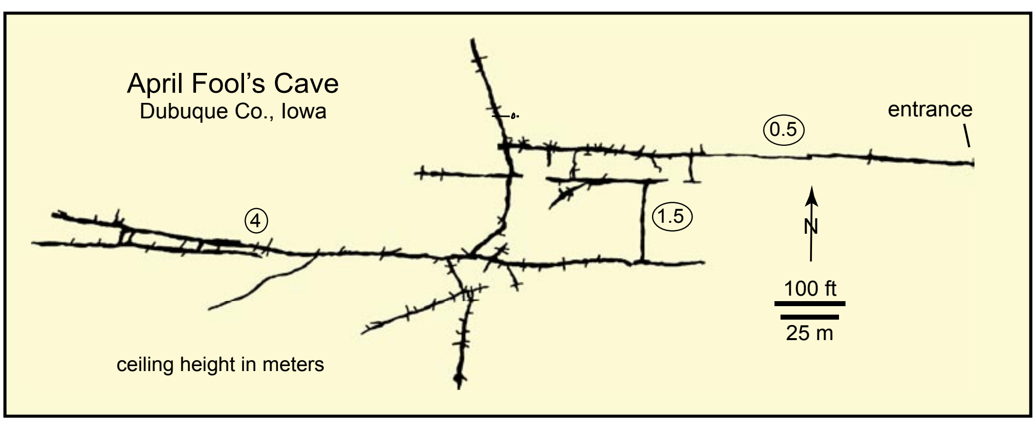

Figure 4.44: April Fool's Cave, a rectilinear maze cave formed in the Galena dolomite. Map by Marc Ohms.

Figure 4.45: Main passage of Iowa Crevice formed within the Galena Dolomite, mined for lead ore in the late 1800s. Photo by Scott Dankof.

Figure 4.46: Intricate speleothem coating calcite spar in the same cave shown in Figure 4.45. Photo by Scott Dankof.

the Iowa and Yellow Rivers. Coldwater Cave is an example of a well-developed fluviokarst system typical of the region (see next section). Coldwater and other active systems display a branchwork pattern, but in the smaller caves this pattern is poorly developed because of the limited amount of mappable passage. Sinkholes have developed throughout the Galena Cuesta and are particularly dense in Allamakee County, where the mantle of glacial sediment is extremely thin or absent.

In the Dubuque area, in the upper Mississippi Valley lead-zinc district, the Galena limestones have been altered to dolomite, and the caves are predominantly rectilinear mazes (Fig. 4.44). Solutionally enlarged fissures were filled with carbonate-hosted ores that included dolomite, calcite, quartz, marcasite, pyrite, sphalerite, and galena (Heyl et al., 1959). The caves and ores are apparently products of rising hydrothermal fluids (T>50°C), which operated on a regional scale.

The mining district was perhaps the most exploited and historically well-documented region of Iowa karst. Significant modification of existing cave features was made in the process of lead, zinc, and (to a lesser extent) iron ore extraction which began with the Indians and spanned over 250 years, peaking in the early 1800s (Heyl, 1959). More than 130 caves in Iowa alone have been altered by ore mining (Fig. 4.45). The lead-zinc area includes spectacularly decorated "spar caves" lined by calcite crystals (Fig. 4.46). Many of the caves in this mining district are thought to have formed by hypogenic processes (Morehouse, 1968). Today many of these caves contain meteoric water, including wet-weather streams.

The Galena Cuesta has its share of caves formed by mechanical processes such as frost action and gravity sliding. Decorah Ice Cave and associated caves (Fig. 4.47) are some of Iowa's best known. The main cave is also a glacière because it functions as a cold-air trap with frost and ice persisting throughout the year. Decorah Ice Cave formed as a block landslide of Galena Limestone over the Decorah Shale, triggered by undercutting of the shale by weathering and erosion. As the block slid away from the cliff it rotated to form a humanly traversable corridor.

Praire du Chien Cuesta

The Praire du Chien Cuesta, located in eastern Allamakee and Clayton Counties, consists of the lower Ordovician and Cambrian rocks below the Galena Group (Fig. 4.40). An active karst has developed on the Prairie du Chien strata, with many sinkholes, swallets, small caves, and karst springs. Solution caves have also formed in the Oneota Dolomite and St. Peter Sandstone. Sandstone shelter caves have formed at the contact between the Prairie du Chien Group and the friable underlying Cambrian sandstones along the upper Iowa and Yellow Rivers.

Karst in Devonian Strata

Devonian rocks are exposed in a NW-SE trend across the center of Iowa. A large number of sinkholes have formed here, but known caves are sparse. Small solutional caves have formed at the bottoms of some sinkholes with small catchments. During wet weather some of the caves carry water to small springs.

Other Caves

Unassociated with the major karst regions of the state is a smattering of caves in the Des Moines Lobe and Southern Iowa Drift Plain. They are mostly clustered around entrenched surface streams. They include small solution caves, rock shelters, and talus caves. There are also some caves along the Mississippi River.

Local cavers have worked closely with private landowners and public land managers in the preservation of Iowa's caves and karst features. This approach has been successful over the past 50 years.

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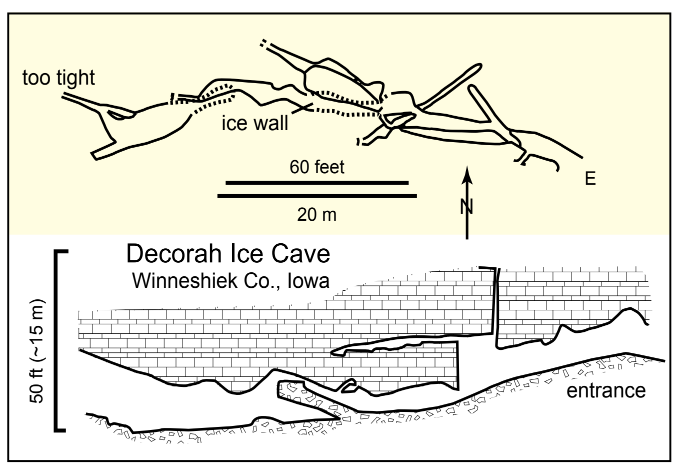

Figure 4.47 : Decorah Ice Cave, Winneshiek County, Iowa, an example of a cave formed by mechanical activity: Cartography by James Hedges.

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Coldwater Cave System, Winneshiek County, Iowa

Patricia Kambesis

Coldwater Cave, in northeastern Iowa, is the largest and most significant cave in the state, and a stellar example of the hydrologic systems that drain the Paleozoic Galena Cuesta (Figs. 4.41; see Kambesis and Bain, 1988, Kambesis, 2003). In 1987 it was designated as a National Natural Landmark by the U.S. Department of the Interior.

Physical Setting

The landscape around Coldwater Cave contains deeply incised stream valleys, steep-sided bluffs and a thin mantle of Quaternary glacial sediments. Nearly flat-lying carbonates of the Galena Group form a resistant cap that supports the Galena Cuesta. The cave is developed in the Ordovician Dunlieth Formation of the Galena Group (Fig. 4.40).

The Coldwater Cave groundwater basin, which includes the cave and its surface recharge, extends from northeastern Winneshiek County, Iowa, north into southeastern Fillmore County, Minnesota (Fig. 4.48). The basin underlies the Coldwater Creek and Pine Creek surface watersheds, both of which contribute to the subsurface system via swallets, losing streams, and sinkholes. The cave stream emerges at two perennial springs and an overflow spring. The main resurgences are Coldwater Cave Spring, with a base flow of 9 liters/sec, and Carolan Spring with 2.7 liters/sec. Both form streams that drain to the Upper Iowa River a kilometer to the southeast.

The thickness of Quaternary glacial sediments above the cave determines the mode of recharge for the cave system (Fig. 4.49). They are 15 to 20 m thick in the north part of the groundwater basin and thin to 2 m or less toward the southwest. Where the sediments exceed 8 m the basin displays both diffuse allogenic and concentrated allogenic recharge. The diffuse type includes seeps and wetlands that drain perched aquifers composed of till and loess and which recharge the surface streams. The concentrated type consists of surface streams that flow across mantled bedrock and sink where the sediment thins to less than about 8 m. Where glacial sediment is thin or absent, autogenic recharge dominates and water enters the system through losing streams, sinkholes, solutional fissures, and fractures.

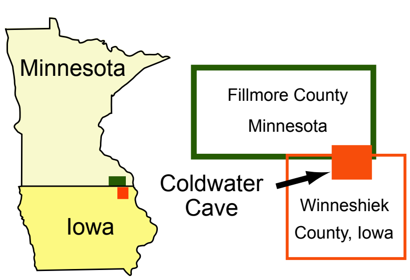

Figure 4.48: Location of Coldwater Cave.

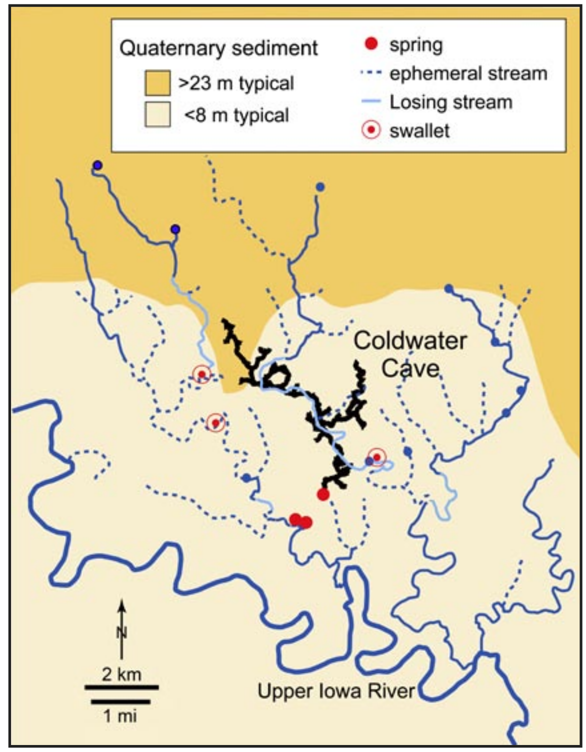

Figure 4.49: Regional setting of Coldwater Cave: groundwater basin and extent of glacial sediment cover.

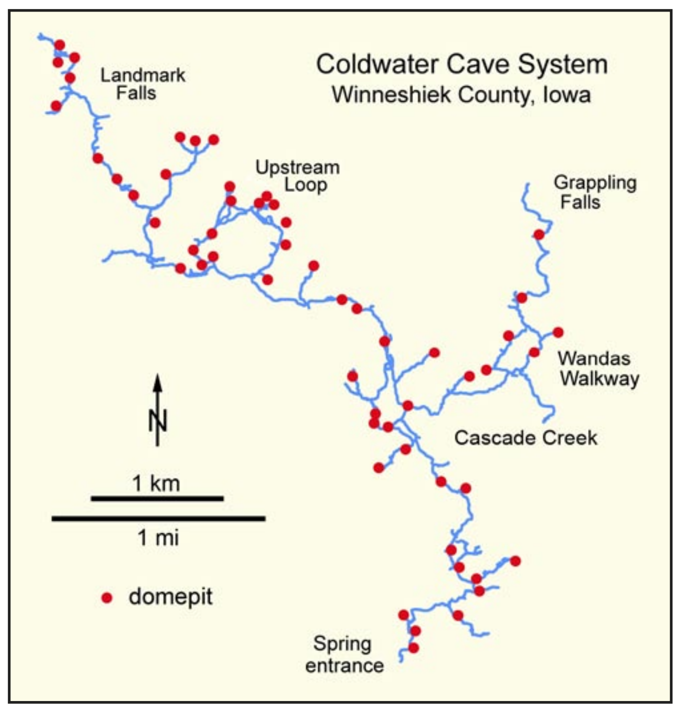

Figure 4.50: Map of Coldwater Cave, by the Coldwater Cave Project team.

Cave Description

Coldwater Cave has a branchwork pattern with many points of surface recharge. It consists of 7 km of main stream passage, nearly 2 km of parallel passages, and another 18 km of infeeders (Fig. 4.50). Passages are mainly curvilinear tubes and canyons that are controlled by bedding planes, but joint control is evident in some of the tributary passages (Figs. 4.51 and 4.52). The cave is developed in a subtle carbonate ridge capped by the shaly limestones of the Dubuque Formation and bounded

Figure 4.51: Gallery section of Coldwater Cave. Photo by Scott Dankof.

by surface drainage lines. Some of the side passages cross beneath small surface streams.

Coldwater Spring is the only known natural entrance to the system. It issues from the base of a 30-m bluff in the Cold Water Creek Conservation Area. Access by this entrance requires scuba diving, but the opening is currently gated. The other active springs and two relict springs are not humanly enterable. The primary entrance is now a 29-m shaft (Flatland Entrance) drilled by the State of Iowa in the early 1970s to allow access for researchers. A second privately owned shaft entrance was drilled in 2003 about 2 km downstream from the Flatland Entrance.

More than 100 epikarst shafts have been documented in the cave system (Fig. 4.50). They drain the epikarst zone above into the conduit system below. Their diameters at floor level are 1-10 m, and some reach heights of 20 m or more. Some contain limited upper-level passage development. They all display solutional wall features such as flutes and rills. Some also contain calcite speleothems. Three epikarst domes have perennial waterfalls. Some domepits have active waterfalls while more become active during high flow.

Figure 4.52: Speleothems in Coldwater Cave. Photo by Scott Dankof.

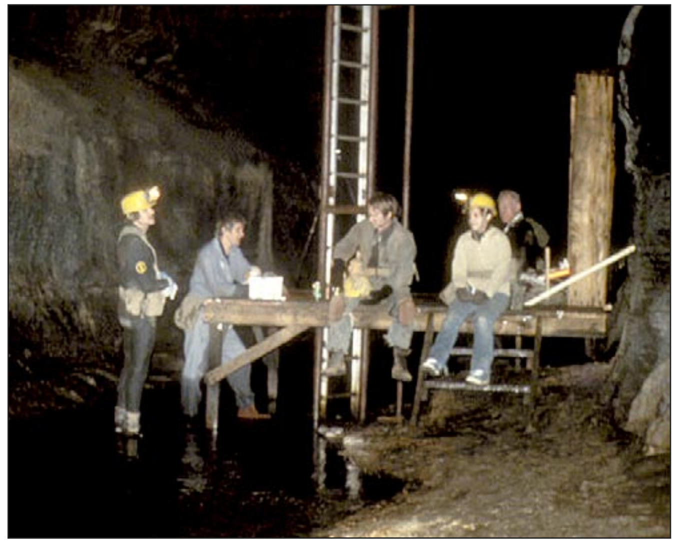

Figure 4.53: Platform and man-made shaft with ladder. Photo by Dr. Warren Lewis.

History of Exploration

Coldwater Cave was discovered in 1967 by cave divers who were investigating the cave potential of the many springs in the area. Their success at Coldwater Spring was one of the most significant cave discoveries of the upper Midwest. They explored and ran a compass-and-pace survey of more than 5 km of sizeable stream passage. The cavers then brought their discovery to the State officials in hopes that the state would preserve the cave.

The State conducted a two-year study to determine if development was feasible for tourism. To facilitate the study they drilled the 29-m shaft that now serves as the main entrance and constructed a metal building over the top that now serves as a field house and research station (Fig. 4.53). They concluded that it was not cost-effective to develop the cave because of its remote location. In 1974 the state lease expired, and the landowners took over the responsibility of overseeing the cave. Their willingness to open the cave for exploration, survey and study instigated the establishment of the Coldwater Cave Project. Exploration and mapping have continued to the present.

In the early 1980s, Coldwater Project cavers were able to breach a drainage divide in Cascade Creek Passage to discover Wanda's Walkway, a stream passage that parallels the main passage. A major infeeder, Grappling Falls, was climbed and passage explored and mapped to a breakdown terminus. Dives have attempted to pass the upstream sumps. During very dry years some of these turn into low-air passages, and teams have been able to survey many kilometers of stream canyons. With surveys still continuing, the length of the Coldwater Cave System currently stands at 28 km (17.5 mi).

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