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ELEMENTAL SULFUR IN CAVES OF THE GUADALUPE MOUNTAINS, NEW MEXICO

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Abstract—Elemental (native) sulfur occurs in at least three caves in the Guadalupe Mountains of New Mexico, including Carlsbad Cavern, Cottonwood Cave and Lechuguilla Cave. Sulfur in Carlsbad Cavern has been found at four sites. The sulfur is typically finely crystalline and occurs as sprays, rosettes or crusts that overlie late-stage speleothems or bedrock. However, the sites in Cottonwood Cave are significantly different: a ceiling-bound, multi-ton, massive deposit has a waxy luster and conchoidal fracture, whereas a nearby, smaller floor deposit is granular and admixed with massive gypsum. The three largest known deposits in Lechuguilla Cave are multi-ton accumulations. Massive to slightly vuggy deposits occur in the lower part of the cave and plate-like, vuggy deposits are found in higher parts of the cave. The well preserved relationship between the gypsum and sulfur in Lechuguilla Cave suggests that the sulfur was deposited inside preexisting gypsum masses. Lechuguilla Cave may contain more sulfur and related secondary gypsum than all other known caves in the world combined.

INTRODUCTION

Situated on the northwestern rim of the petroliferous Delaware basin (Figs. 1, 2), the carbonate formations of the Guadalupe Mountains contain more than 300 remarkable caves. They are hypogenic caves, created by the corrosive action of sulfuric acid generated where upwelling H_2S-bearing brines encountered oxygen-rich environments in reef and back-reef carbonate rocks. Widespread cave deposits of massive gypsum and rare, small occurrences of elemental sulfur suggested a link with sulfur-rich (sour) petroleum deposits (Egemeier, 1987; Davis, 1980), a notion later confirmed by comparison of VS measurements from cave gypsum and sulfur with basinal H,S gas (Hill, 1987, 1990). Although the sources, migration routes and detailed geochemistry of the H_2S-rich basinal fluid remains debatable (Jagnow, 1979, 1988; DuChene and McLean, 1989; Spirakis and Cunningham, 1992), there is a consensus that studying the distribution and morphology of cave sulfur deposits may help provide answers to many of these and other regional problems.

Recent work in Carlsbad Caverns National Park has provided additional data regarding the extent and genesis of elemental sulfur in caves of the Guadalupe Mountains. Before 1986, elemental sulfur had only been described from Carlsbad Cavern and Cottonwood Cave. Cave explorers and speleologists speculated that another cave might be found containing elemental sulfur and this prediction was fulfilled by the discovery of Lechuguilla Cave in 1986. Lechuguilla Cave has turned out to be possibly the world's best example of a remarkably well preserved hypogenic cave, having tremendous amounts of massive, secondary gypsum distributed along more than 60 mi of surveyed passages and scattered multi-ton deposits of elemental sulfur. Based on our review of the literature, Lechuguilla Cave may contain more elemental sulfur and related secondary gypsum than all other known caves in the world combined.

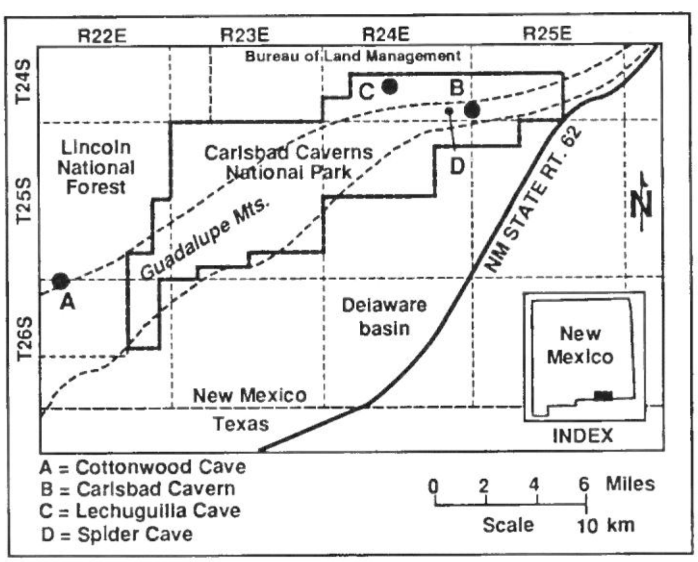

FIGURE 1. Locations of sulfur-bearing caves in the Guadalupe Mountains, NM. Dashed lines show approximate mapped outcrop extent of Capitan Limestone (Hayes, 1957; Hayes and Koogle, 1958).

PREVIOUS WORK—SULFUR IN COTTONWOOD CAVE AND CARLSBAD CAVERN

Gypsum Passage, Cottonwood Cave

Prior to 1986, the largest reported sulfur deposit in the Guadalupe Mountains was from the Gypsum Passage in Cottonwood Cave (Fig. 3). Cottonwood Cave is developed at the contact of the Seven Rivers and overlying Yates Formation. Two sulfur sites in Cottonwood Cave were originally described by Davis (1973) and later summarized by Hill (1987):

> Two occurrences of sulfur exist in the lower Gypsum Passage of Cottonwood Cave, one near a large gypsum stalactite known as the Chandelier [since vandalized] and one about 80 m south of the Chandelier. Respectively, these two occurrences are: (1) a vein-like deposit 45 cm wide and 15 m long, in gypsum exposed along a ceiling joint (Davis, 1973; Pl. 7A); and, (2) a crystalline deposit filling 1.2 m long and 0.3 m wide cavities within a gypsum block (Pl. 7B). In the vein-like occurrence near the Chandelier, the massive, dense, light-yellow sulfur sometimes projects out in relief from the gypsum in such a manner as to produce an almost stalactitic form. In the cavity occurrence, the gypsum block which encloses

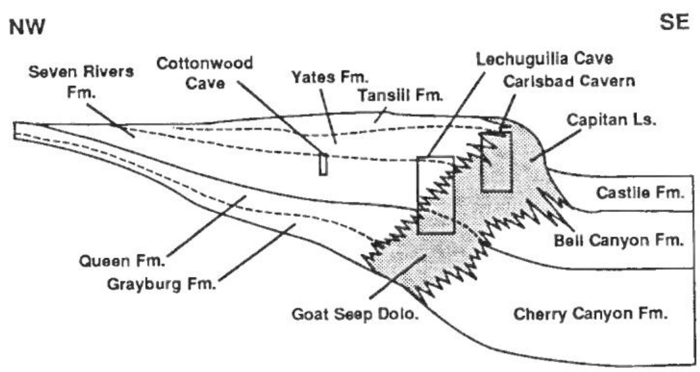

FIGURE 2. Schematic cross section through Guadalupian rocks near Carlsbad Caverns National Park, NM. Boxes denote approximate stratigraphic and vertical extent of Cottonwood Cave, Carlsbad Cavern, and Lechuguilla Cave. After Hill (1987).

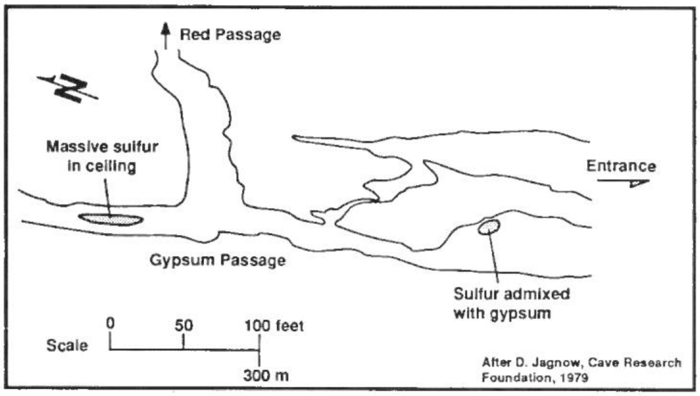

FIGURE 3. Map of part of Cottonwood Cave, Lincoln National Forest, NM, showing elemental sulfur sites.

the crystalline, canary-yellow sulfur looks like it either slumped or fell into its present position on the floor. In both of these occurrences, the gypsum looks like it has been eroded away so as to expose the sulfur within it. A sample collected from the vein occurrence of sulfur was examined for the presence of sulfur bacteria. This examination proved negative; the sulfur had neither fossilized or living sulfur bacteria associated with it (D. Caldwell, personal comm. 1980).

Davis (1973) found the deposits to consist of at least 2 distinct textures, the first being ". . . massive, breaking with a conchoidal fracture and waxy luster ... some fragments showing faint, contorted banding and elongated, fusiform cavities . . . ," and the second being "granular, somewhat porous, with well-formed rhombic crystals up to V8 in. (3 mm) or more in diameter." No new sulfur sites have been found in Cottonwood Cave since this early report was published.

Big Room, New Mexico Room and Christmas Tree Room, Carlsbad Cavern

Elemental sulfur is present in Carlsbad Cavern (Fig. 4) in the Big Room, Christmas Tree Room, New Mexico Room and a newly discovered complex of passages above the New Mexico Room known as Chocolate High. The first three of these deposits (Figs. 5-7) have been described by Hill (1987):

[...] In the Big Room [Fig. 5] the pale yellow sulfur covers an area approximately 0.6 m high and 0.3 m wide where it (I) resides on an overgrowth crust which lines a drip tube in the gypsum block, (2) occurs as a light covering on dense gypsum where the overgrowth crust has been eroded away and (3) fills cracks separating the overgrowth crust and the

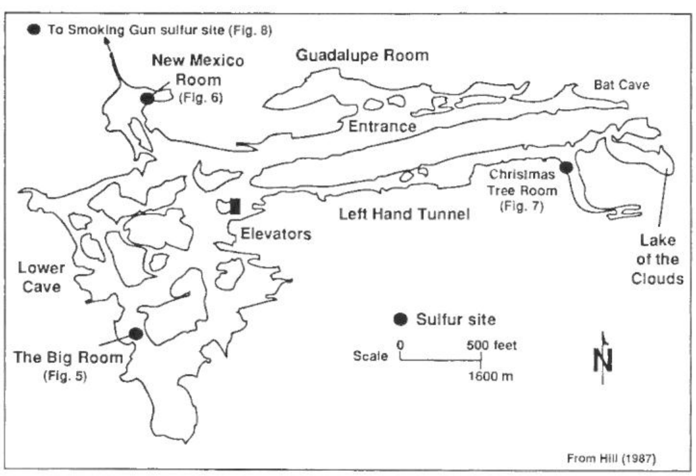

FIGURE 4. Map of Carlsbad Cavern, Carlsbad Caverns National Park, NM, showing three of the four known sulfur sites. Refer to Fig. 8 for the Smoking Gun Passage sulfur site in the newly discovered Chocolate High area north of the New Mexico Room.

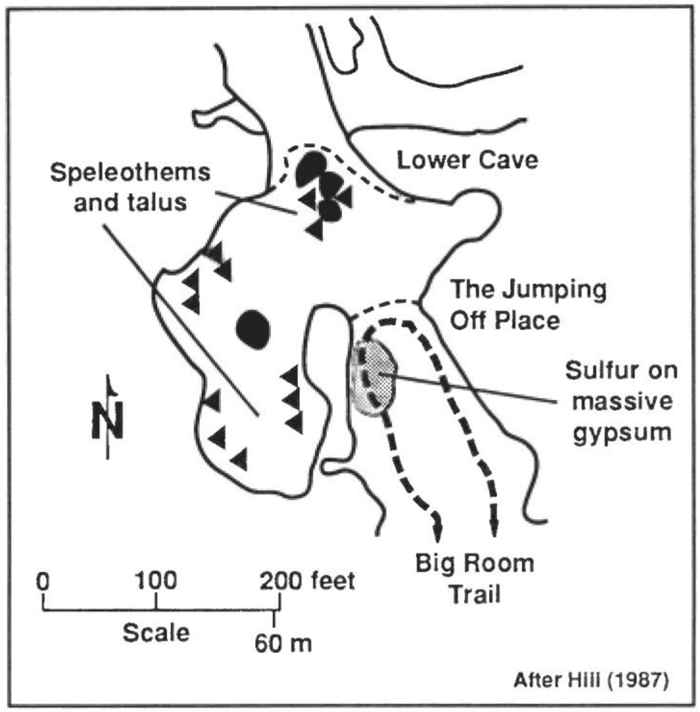

FIGURE 5. Location of the Big Room sulfur site, Carlsbad Caverns National Park, NM. The Big Room trail runs through large gypsum blocks that contain crust-like growths of native sulfur.

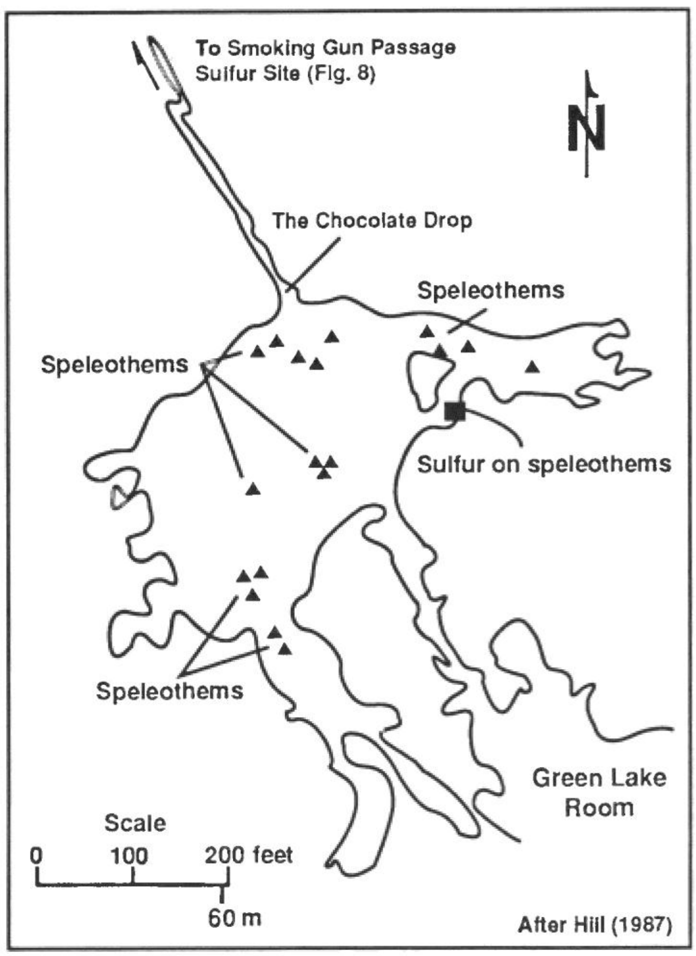

FIGURE 6. Location of the New Mexico Room sulfur site, Carlsbad Caverns National Park, NM.

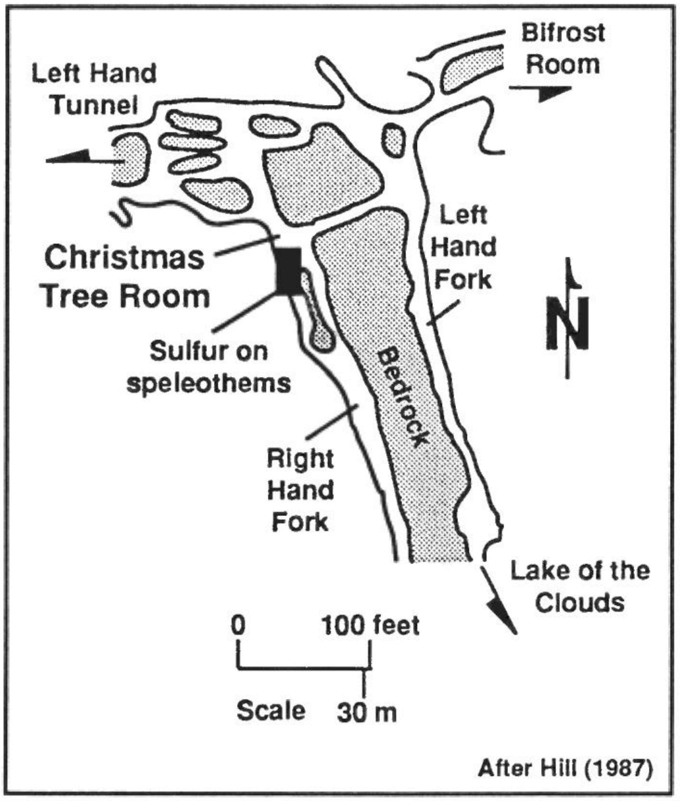

FIGURE 7. Location of the Christmas Tree Room sulfur site, Carlsbad Caverns National Park, NM.

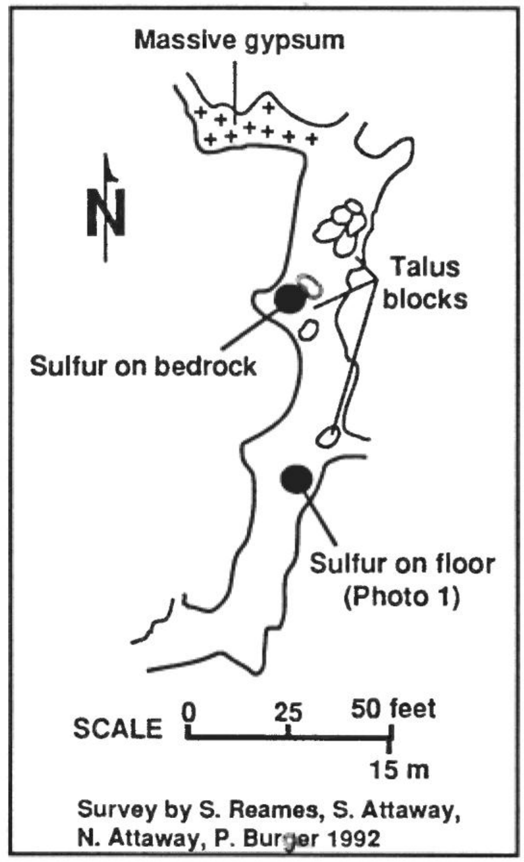

FIGURE 8. Location of the Smoking Gun Passage sulfur site, Chocolate High area, Carlsbad Caverns National Park, NM.

more compacted underlying gypsum. The sulfur occurs on the underside of the cracks and surfaces.

The New Mexico Room sulfur [Fig. 6] is not admixed with gypsum, but rather coats limestone bedrock and also subaerially formed gypsum flowers and crustal speleothems. The sulfur crystals lightly cover the undersides or vertical faces of the bedrock or speleothems, but never the top sides.

The Christmas Tree Room [Fig. 7] sulfur directly overlies bedrock, crinkle blisters and popcorn. It also coats and fills the spaces between, indurated masses of stacked cave rafts. Where the crystals overlie bedrock, they usually occur on the undersides of dipping forereef beds or on projecting fins of limestone.

The Christmas Tree Room is located at the level of the Big Room immediately above the cave's deepest point at Lake of the Clouds.

RECENT DISCOVERIES IN CARLSBAD CAVERN AND LECHUGUILLA CAVE

Chocolate High, Carlsbad Cavern

The Chocolate High complex of passages is located 160 m above the floor of the New Mexico Room in the northernmost known area of Carlsbad Cavern (Fig. 4). The area is developed in the basal part of the Yates Formation and is topographically higher than most of the passages in Carlsbad.

Sulfur is found near the northernmost part of the Chocolate High complex in the Smoking Gun Passage (Fig. 8). The sulfur occurs in a passage dissolved out of a limestone bed, located between two siltstone beds near the base of the Yates Formation. Intercalated with the siltstone and limestone is at least one lens or thin bed of pale, gray-green clay, which is exposed in the wall of the passage.

The wall rock of the Smoking Gun Passage is gray, dense limestone that has been severely corroded into irregular, cuspate, sharp-pointed, sharp-edged protrusions. In some areas, so much limestone has been removed that only paper-thin remnants are left. Many of the loose limestone fragments have crystals of sulfur and/or crusts and coatings of gypsum attached to them.

Sulfur is present in bright canary-yellow crystals ranging up to 1 mm in width, with most crystals smaller than 0.5 mm (Photo 1). It occurs as solitary crystals in some areas and in others it forms intergrown mats or crusts. Most crystals are elongate, tabular prisms, which are found individually and in rosettes. Crystals also occur as needles and acicular sprays. Prisms and needles have a vitreous luster and many of the prisms have well-formed terminations. Locally, intergrown sprays and rosettes of sulfur are sufficiently abundant to nearly cover the limestone bedrock. Sulfur is most common on downward-facing and vertical limestone surfaces, but it is also found on upward-facing surfaces.

In some areas, limestone and sulfur are covered by white, lace-like gypsum veils, which grade laterally into crusts of sucrosic gypsum ranging up to 15 mm thick. On downward-facing surfaces, pieces of gypsum crust have fallen away from the limestone, revealing crystals of sulfur on the surface of the limestone and on the inward-facing surfaces of the gypsum crust.

The Rift, Lechuguilla Cave

Sulfur has been found at four locations in Lechuguilla Cave (Fig. 9). The Rift sulfur site is the smallest and closest to the cave entrance. Sulfur occurs as scattered 1 to 2-mm-thick translucent to clear crystals on gypsum, similar to the deposits in Carlsbad Cavern. The overall amount of sulfur is probably no more than 20-30 g.

North Ghost Town, Lechuguilla Cave

Elsewhere in Lechuguilla Cave, sulfur has been found in a low, wide passage (about 1 m high and averaging 4-6 m wide) on the north side of Ghost Town (Fig. 10), a large room in the central section of the cave, approximately 220 m below the entrance. The sulfur-bearing passage appears to be 3-4 m high, but 60-75% of it has been filled with massive gypsum. The sulfur rests on the surface of the massive gypsum in some areas and is partly to completely encased by gypsum

PHOTO 1. Elemental sulfur in the Smoking Gun Passage, Carlsbad Cavern, Carlsbad Caverns National Park, NM. Scale is approximately 25 cm across the scene. The sulfur occurs as discrete crystals coating the surfaces of bedrock amd speleothems. Photo by K. Sisson, 1992.

PHOTO 2. Elemental sulfur in the North Ghost Town area, Lechuguilla Cave, Carlsbad Caverns National Park, NM. Scale is approximately 3.5 m across the scene. The vuggy, platy texture of the sulfur is evident in both large blocks in the foreground. Note massive crystalline gypsum lying unconformably on sulfur on the upper right corner of the largest block and around a sulfur projection at far right of scene. The calcite stalactites hang from limestone bedrock that has been discolored and deeply weathered by corrosive air. Photo by L. D. McLaughlin, 1991.

PHOTO 3. Elemental sulfur in the South Ghost Town area, Lechuguilla Cave, Carlsbad Caverns National Park, NM. The sulfur projects downward approximately 20 cm below the gypsum solution plane dissolved during a higher stand of the pool visible in lower part of scene. Note the massive, low-porosity texture of this sulfur compared to the platy, high-porosity (15–25%) texture of the North Ghost Town site located 150 m to the north. Photo by L. D. McLaughlin, 1991.

PHOTO 4. Elemental sulfur in the Void area, Lechuguilla Cave, Carlsbad Caverns National Park, NM. The sulfur block occurs on a balcony above larger, more extensive deposits located 20–30 m below. Photo by D. LaForge, 1993.

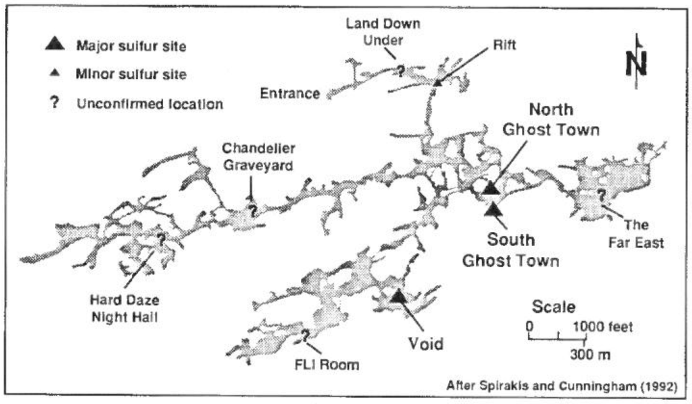

FIGURE 9. Locations of known and reported sulfur sites in Lechuguilla Cave, Carlsbad Caverns National Park, NM.

in others. Where fully exposed, the sulfur deposits do not extend from wall to wall; rather, they form masses along the approximate center of the passage and the long axes of the masses are oriented parallel with the long axis of the passage. As much as 10 metric tons of sulfur have been estimated at this location (Spirakis and Cunningham, 1992) and there may be more encased in gypsum. Calcite speleothems (predominantly stalactites) have grown through the gypsum in several places near the sulfur deposits. These inactive speleothems are chalk white and have corroded textures.

The passage containing the sulfur exposes a bed of clastic material estimated to be 50-100 cm thick and probably part of the basal Seven Rivers Formation. Outcrops of this bed are found in both walls of the passage. Where underlying solution and collapse have cut completely through the clastic bed, the passage has intersected the base of a layer of beige to tan, fossiliferous limestone exposed in the ceiling. A thin layer of unconsolidated silt coats most upward-facing surfaces. The clastic bed is composed of unconsolidated to poorly consolidated, friable, pink siltstone or very fine-grained sandstone that is pinkish-red on exposed surfaces. The surface is commonly mottled light and dark reddish-pink and is partly coated with chestnut-brown corrosion residue.

Sulfur occurs in masses with convex, upward-facing surfaces. Vertical and downward-facing surfaces are bright canary yellow; upward-facing surfaces are coated with beige or light-tan dust, which imparts a dull yellow color to the sulfur.

Where visible, masses of sulfur range in thickness from a feather edge to as much as 40 cm. Some of the deposits are well exposed and apparently rest on top of massive gypsum; other sulfur masses are partly encased in granular, sucrosic gypsum. Exposed masses range up to 2 m in width and 3-4 m in length (Photo 2).

Some of the upward-facing sulfur surfaces are partly covered with beads of water condensed from the saturated atmosphere in the cave. Some beads are beige to light-tan and match the color of the dust that coats the surface. Other beads are reddish-brown and the two colors exist in close proximity. In a few cases, tan and reddish-brown beads have coalesced and the colors form swirled bands with sharply defined boundaries.

Downward-facing sulfur surfaces have many points and edges where drops of clear water are suspended, some containing clear to translucent crystals identified as gypsum (R. Pollastro, U.S. Geological Survey, oral comm. 1992). This water has a slightly sour taste and a field pH of approximately 6.0. Where the water drips, drill pits have been dissolved through the underlying gypsum. In other places, solution has made large openings in the underlying gypsum, revealing more sulfur underneath. Some of the dissolved gypsum has recrystallized nearby in poorly developed crystals. Where solution of the underlying gypsum is greatest, gravity has caused the sulfur masses to crack and slump, exposing the internal morphology of the deposits.

Naturally broken pieces of sulfur contain irregular, fusiform plates 2-4 mm thick. The sulfur appears to have accumulated in a pile of subparallel plates, much like a pile of large cornflakes. Elongate, ir regularly shaped vugs are abundant within the sulfur masses. These vugs occur where plates of sulfur have bridged gaps between underlying plates. The plates are aligned in subparallel layers that are not horizontal, but rather have a slight hummocky appearance reminiscent of miniature anticlines, synclines and teepee structures. We have visually estimated the porosity at 15-25%.

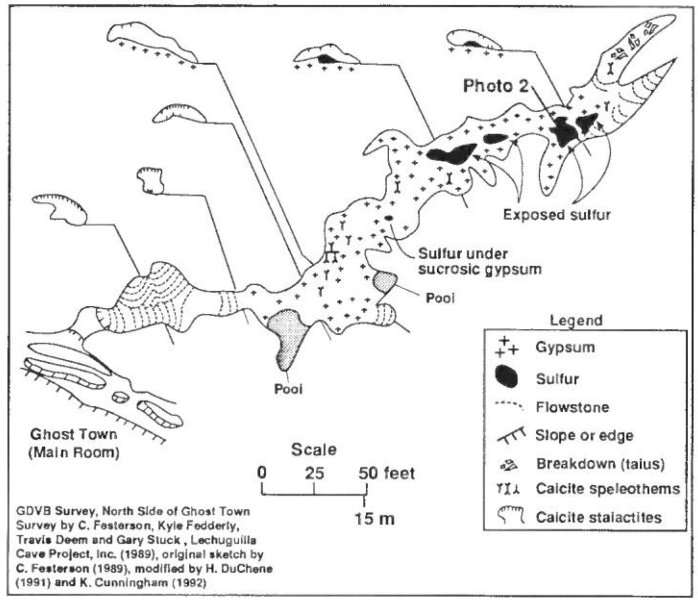

FIGURE 10. Location of sulfur deposits in the North Ghost Town area, Lechuguilla Cave, Carlsbad Caverns National Park, NM.

Locally, fresh surfaces of sulfur have blades of colorless, transparent, well-crystallized selenite attached. The other ends of the selenite blades are attached to a crust of granular gypsum. The selenite blades appear to be pushing the two minerals apart.

South Ghost Town (Ghost Busters Pit), Lechuguilla Cave

A large deposit of elemental sulfur is on a balcony above Ghost Busters Pit on the south side of Ghost Town, approximately 100 m south of the previously described sulfur deposit and in a similar setting (Fig. 11). The deposits are not as well exposed as those at the north Ghost Town site, but the total amount of sulfur is probably greater.

The two outcrops of sulfur near Ghost Busters Pit are at opposite ends of a 10-m-long passage. This passage is entered through a side passage with outcrop I located to the left of the entrance and outcrop 2 located to the right (Fig. 11). Both of these outcrops have smooth external surfaces coated with beige to tan dust, which gives the sulfur a pale yellow color. Downward-facing surfaces are a more typical canary yellow.

The passages near Ghost Busters Pit appear to be at least 50% filled with massive gypsum deposits. The traversible passage is 1.5-2 m high and averages 4 m in width. The passage above the top of the sulfur and gypsum deposits is entirely within a clastic bed, which is probably part of the basal Seven Rivers Formation. This bed is composed of poorly cemented to uncemented, friable, pinkish-red siltstone to very fine-grained sandstone. The surface of this clastic bed is mostly covered with chestnut-brown and occasional yellow to red, well-developed corrosion residues. Disaggregated silt or sand covers most upward-facing surfaces and ranges up to 10 cm or more in depth throughout most of the area. Calcite speleothems are common, predominantly near passage walls. Some are moist and actively growing, but most are desiccated and chalk white.

At outcrop 1, a mass of sulfur about 1 m wide and 30 cm thick is exposed except where covered by granular gypsum. A second, smaller mass adjacent to the large mass is mostly covered with a rind of granular gypsum about 15 cm thick. The sulfur rests on an irregular layer of sucrosic gypsum, which in turn rests on dense, massive gypsum. A

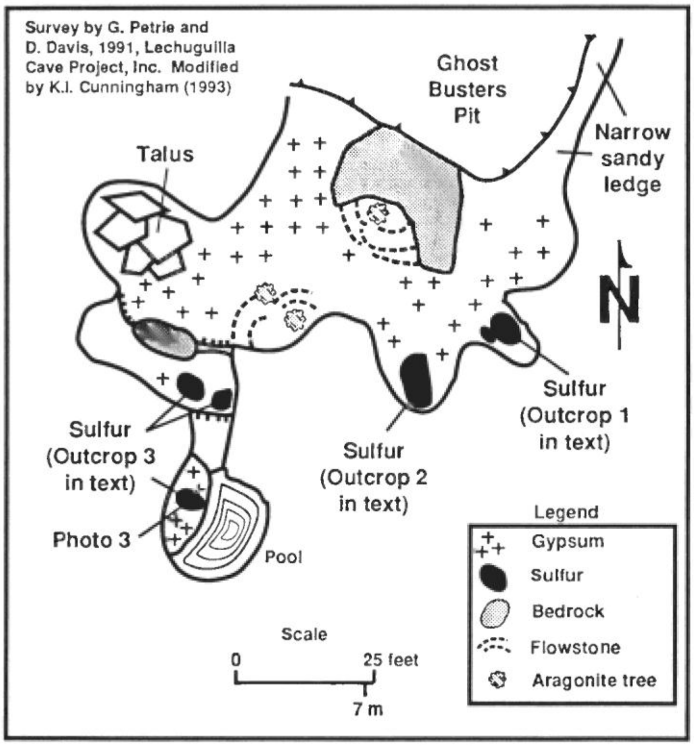

FIGURE 11. Location of sulfur deposits in the South Ghost Town area, Lechuguilla Cave, Carlsbad Caverns National Park, NM.

nearly horizontal, sharply defined line, similar to an unconformity, separates the coarsely crystalline layer from the massive gypsum below.

Outcrop 2 is a tongue of sulfur about 30 cm thick at the end of the passage. The tongue is about 2 m long, tapering down in width and thickness to a blunt, rounded end. Beneath this tongue of sulfur and attached to the downward-facing surface, a 1 to 2-cm-thick sucrosic gypsum crust develops downward to terminate in large, clear selenite crystals.

The upward-facing surfaces of this and all other sulfur outcrops in the area are coated with beige to tan dust, which gives the sulfur a dull yellow color. These passages are part of a maze and the sulfur at outcrop 2 is believed to be exposed again at outcrop 3 (Fig. 11).

At outcrop 3, a pool of water partly fills a passage underneath some sulfur that is encased in granular gypsum. The pool level was higher in the past and water dissolved the granular gypsum, leaving a downward-facing plane. The sulfur, which is highly insoluble in water, protrudes downward as much as 20 cm from the planar surface of the gypsum, providing a spectacular pseudo-stalactitic exposure (Photo 3).

Sulfur is abundant near outcrop 3, but it is mostly covered with granular gypsum, which in turn is partly coated with pinkish-red silt and chestnut-brown corrosion residues. The combination of sulfur and gypsum almost completely fills parts of the passages in this area. Spirakis and Cunningham (1992) estimate that more than 10 metric tons of sulfur occur in the Ghost Busters deposit.

The Void, Lechuguilla Cave

The Void is in the Southwestern Branch of Lechuguilla Cave (Fig. 9) immediately above a vertically extensive passage system that leads 130 m downward to the water table in the Capitan aquifer. The Void itself is a series of large, steeply sloping talus-filled rooms generally devoid of speleothems. Several distinct water lines appear on the walls in this area. Just above the best defined water line, massive gypsum blocks have cuspate protrusions. Below the line gypsum is generally absent. The distribution and surface texture of the gypsum and the presence of the water lines indicate reflooding, or an event of fresh water replacing brine, sometime after the formation and initial drainage of the cave.

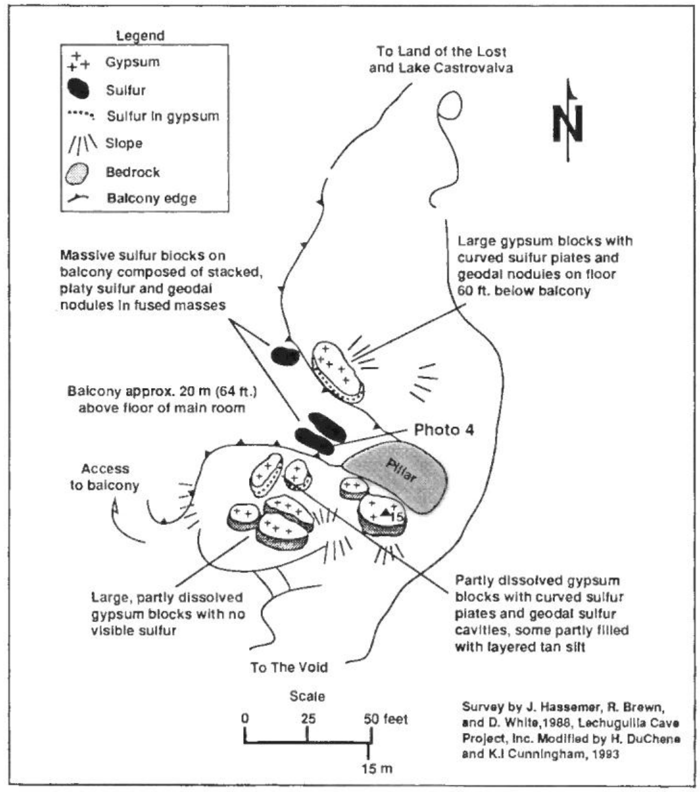

FIGURE 12. Location of sulfur deposits in the Void, Lechuguilla Cave, Carlsbad Caverns National Park, NM.

The passage containing sulfur (Fig. 12) is one of a dozen that crisscross the Void area and define a three-dimensional maze. In this area, sulfur occurs as free blocks and as plates or masses admixed with massive gypsum. Deposits are generally massive and composed of cryptocrystalline sulfur that commonly breaks with conchoidal fracture. Some large blocks of gypsum contain imbedded, irregularly shaped, curved plates of sulfur, which range up to about 2 cm in width and stand out in relief from the gypsum. Open cracks in the gypsum expose sulfur in the interior of the blocks. On parts of the large gypsum-covered slope, fragile, hollow sulfur hemispheres, as much as 30 cm in diameter and 1-1.5 cm in thickness, are partly to completely enclosed in gypsum. As is true for sulfur deposits elsewhere in the cave, upward-facing sulfur surfaces are covered with beige to tan fine-grained dust that dulls the color to pale yellow. Downward-facing surfaces are bright canary yellow. Upward-facing surfaces also are partly covered with beige to tan water beads that match the color of the dust coating.

A balcony above the sulfur deposits on the floor of the room contains blocks of limestone, gypsum and sulfur, with a coating of loose silt. These materials rest on a surface of irregular limestone fragments that slopes downward toward the edge of the balcony.

The amount of gypsum on the balcony and floor area in this part of the Void is less than the amount in the deposits at North and South Ghost Town. The gypsum here appears to be more dense, granular gypsum is sparse (some occurs on the balcony) and the remaining blocks are small and cuspate and have many points and sharp edges. The gypsum blocks on the floor of the room are 1-2 m high, 2-3 m wide and 3-5 m long, whereas most blocks on the balcony are less than I in' in volume.

The floor of the balcony contains abundant nested, curved siltstone plates lying on the talus. Unconsolidated silt is common and is probably derived from corrosion of the siltstone present in the ceiling. The ceiling is irregular, typical of most of the cave and has shallow domes and other phreatic forms that contain remnant silt. Sulfur on this balcony occurs in crystalline masses ranging up to I m x 0.5 m x 0.5 m, with many smaller masses. Many blocks are composed of stacked, platy sulfur and geodal nodules in fused masses (Photo 4). Some of the blocks are partly disaggregated, and fragments of sulfur have sifted downward between fragments of limestone and siltstone talus. Upward-facing surfaces are coated with beige to tan dust and are pale yellow and vertical or downward-facing surfaces are bright canary yellow. Upward-facing surfaces are partly covered with water beads, some of which are beige to tan and others of which are pinkish-tan. Blocks of sulfur are distributed across the balcony, but many of the larger pieces are close to the lip of the balcony above the even larger deposits 15-20 m below.

UNCONFIRMED SULFUR SITES

Sulfur has been reported, but not confirmed, from several other areas in Lechuguilla Cave and from the back area of nearby Spider Cave (Dale Pate, National Park Service, oral comm. 1993; Fig. 1). In Lechuguilla Cave (Fig. 9), sulfur may be present at sites in the Western Borehole (as yellowish crusts beneath breakdown blocks in Hard Daze Night Hall and in an unknown form in the Chandelier Graveyard complex), the Southwest Branch (as light crystal coatings on speleothems in the FLI Room) and the Far East section of the cave.

CONCLUSIONS

The oxidation of H_2S was probably the precipitation mechanism for all of the sulfur found to date in the caves. Nevertheless, the various sulfur deposits found in Guadalupe Mountain caves possess dissimilar characteristics and appear to fall into three broad textural categories that may indicate somewhat different depositional environments.

Discrete sprays, rosettes and crusts of sulfur overlie calcitic speleothems or occur as discrete crystals on gypsum crusts in Carlsbad Cavern and Lechuguilla Cave. These deposits may result from late-stage sublimation of sulfur from pulses of H_2S-rich gas that entered the cave during or after drainage (Hill, 1987).

Massive, conchoidal-fracturing, microcrystalline sulfur is found in the middle and lower parts of Lechuguilla Cave and in the Gypsum Passage of Cottonwood Cave. The generally microcrystalline texture of the Void deposits, the high saline content of fluid inclusions (Spirakis and Cunningham, 1992) and the presence in these inclusions of light chain aliphatic hydrocarbons (G. Landis, U.S. Geological Survey, written comm. 1992) suggest deposition in a dominantly phreatic regime in which ascending H_2S-bearing brines mixed with oxygenated ground water (Davis, 1980; Spirakis and Cunningham, 1992).

In Lechuguilla Cave, platy, fusiform, vuggy sulfur occurs in large deposits at cave levels 100-150 m higher than the massive deposits. Egemeier (1981, 1987) suggested this type of deposit formed by reaction of free H_2S gas with subaerially exposed, moist limestone walls. Under lowering base-level conditions late in the cave's history, sulfur may have formed as irregular wall plates, which spalled off and accumulated in piles beneath the water surface. Alternatively, these deposits were formed early in the cave's history and were originally massive (similar to those in the Void). The apparent plate-like texture results from dissolution and removal of syndepositional or earlier gypsum from inside the deposit.

ACKNOWLEDGMENTS

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