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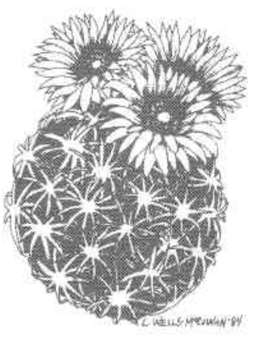
—*by Virginia T. McLemore*



The State Geological Surveys—a History

This comprehensive, 500-page volume was published in November, 1988, by the Association of American State Geologists. Edited by retired Pennsylvania State Geologist Arthur A. Socolow, the hard-covered book contains the history, organization, and functions of each of the 50 State Geological Surveys in individual chapters prepared by the respective Surveys. The chapter on New Mexico was written by Frank Kottlowski, George Austin, and Candace Merillat.

More than 30 of the State Surveys originated over 100 years ago and the accounts of the development and activities of America's State Geological Surveys shed light on a major component of geologic mapping and research that has been achieved in the United States. Geologists in government, academia, and industry, and all who are interested in geologic achievements will find this illustrated publication informative and thoroughly readable.

The State Geological Surveys—a History may be ordered from the Geological Survey of Alabama, P.O. Box O, Tuscaloosa, AL 35486. The price is $20.00 (includes shipping). Make check payable to: Association of American State Geologists.

Abstracts

New Mexico Mineral Symposium

The 9th annual Mineral Symposium was held November 12–13, 1988, at New Mexico Institute of Mining and Technology, Socorro. Following are abstracts from talks given at the meeting that concern New Mexico. The numbers in parentheses refer to locations on the map.

LOST PADRE MINE—FACT OR FICTION? by *Russell E. Clemons*, New Mexico State University, Las Cruces, NM 88003 (1)

It is said . . . that Padre La Rue came to Mexico in 1796 and was assigned a small pastorate about 10 days journey south of Paso del Norte. An old soldier told him of a gold prospect in the Sierra Organos near a Spirit Spring. Some years later, after the soldier had died, drought hit the Padre's fields. He and his followers journeyed north and succeeded in finding the gold placers and rich vein(s), but they neglected to report this to the church in Mexico City. A man named Maximo Milliano was sent north to find them. Upon learning of the approaching expedition, the miners hid the gold and the location of the mines. Milliano and his expedition eventually located the Padre and his mining camp but were refused admittance. Allegedly, the Padre and some of his followers were tortured and killed, but none revealed the location of the gold.

Most reports of lost mines are based on some facts. Typically, there are also many variations in background narratives. The Organ Mountain Mining and Smelting Association's 1881–82 prospectus suggested the Padre mine had been worked in Fillmore Canyon on the west side of the Organ Mountains, about 8 mi east of Las Cruces. Sir Kingsley Dunham indicated, in his 1935 geologic report on the Organ Mountains, that Col. A. J. Fountain may have found the mine shortly before his mysterious disappearance. Dunham also reported that a local goat herder, Tirso Aguire, was a descendant of one of the original miners. L. H. Davis had written in 1917 that Teso Aguirri (Tirso Aguire?) had shown a local prospector the cave in which the Padre lived. Henry James in his 1953 book, *The Curse of the San Andres*, wrote that he had found records in Santa Fe of Padre La Rue. James further wrote that he believed the lost Padre mine was in Hembrillo Canyon of the San Andres Mountains. Frank Kottlowski, in a 1966 paper on the lost Padre mine for *New Mexico Magazine*, quite conclusively pointed out the technical inaccuracies in James' book. Tim Kelly, in an article on the lost Padre mine and the Organ mining district published in the 1975 New Mexico Geological Society Guidebook, indicated that historic and geologic evidence support the likelihood that the mine existed—near the east slope of San Agustin Pass. Kelly also provided the Padre with two names, Philip La Rue. The search continues.

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MINERALOGY OF CARLSBAD CAVERN AND OTHER CAVES IN THE GUADALUPE MOUNTAINS, by *Carol A. Hill*, Box 5444A, Route 5, Albuquerque, NM 87123 (2)

A variety of carbonate and sulfate speleothems have formed in Guadalupe caves from dripping, flowing, seeping, pooling, and condensing water. Examples of these are stalactites, stalagmites, columns, draperies, flowstone, coral pipes, coralloids, helictites, shields, cave pearls, rimstone dams, shelfstone, baldachino canopies, rims, frostwork anthodites, moonmilk, selenite needles, cave cotton, and cave rope. Evaporation and carbon dioxide loss have been prime factors in the deposition of the magnesium-carbonate minerals, hydromagnesite, huntite, and dolomite, and in the formation of certain speleothems such as moonmilk and popcorn. Native sulfur and endellite deposits in the caves and the pronounced condensation–corrosion of speleothems are the result of the peculiar H_2S–CO_2, sulfuric-acid speleogenetic origin of Guadalupe caves.

Guadalupe speleothems are famous for their immensity, profuseness, and beauty. Size and profuseness result from: a) a sulfuric-acid mode of cave dissolution created huge chambers in which speleothems could grow large; b) the caves are very old and, therefore, there has been sufficient time for speleothems to grow; c) wet climatic episodes earlier in the Pleistocene provided the moisture necessary for speleothem growth; and d) speleothem-depositing solutions easily entered the underground through jointed limestone uncapped by impermeable strata.

THE BLANCHARD MINE—NEW DEVELOPMENTS, by *Ramon S. DeMark*, 6509 Dodd Place, NE, Albuquerque, NM 87110 (3)

Intensive mining for specimens and exploratory activity at the Blanchard mine in 1988 resulted in a number of unexpected, as well as expected, discoveries. Activity was widespread throughout the various tunnels, numerous prospects, and outcrops. In mid-June a backhoe was brought in with three specific goals in mind: 1) opening the Sunshine #6 tunnel that had been blasted/bulldozed shut; 2) exploratory trenching in the Clarence Barrett workings; 3) developing the working area in the vicinity of the ore bin in the Portales/Glory Hole area.

The Sunshine #6 tunnel was closed in 1979 by ☞

the operators (Western General Resources) because of hazardous conditions inside the tunnel. Specimens from this particular tunnel were mainly responsible for establishing the reputation of the Blanchard mine as a producer of rare and beautiful minerals. Sprays of delicate brochantite needles, druses of linarite on thin barite blades, and very fine spangolite specimens were all products of this tunnel. Additionally, superb specimens of aurichalcite, murdochite, and platternite were found in this prolific tunnel.

The reopening of the #6 tunnel was accomplished relatively easily. Upon entry, it was obvious that considerable deterioration of the ceiling, walls, and pillars had occurred, and safety was a paramount concern. Several large sections of the ceiling had collapsed onto the floor, and near one of the central pillars, several large boulders had dropped, splintering an 8″ × 8″ support timber. Most disappointingly, the area that had produced the exceptional spangolite specimens was covered by at least 20 ft of debris deposited when the opening had been bulldozed shut. After minor exploration, the tunnel opening was closed once again.

Exploratory trenching in the Clarence Barrett prospect area revealed extensive cave-type formations in one spot with numerous large selenite crystals as long as 45 cm and sporadic blue fluorite crystals. Farther south, large plates of fluorite-coated rocks were pulled from an outcrop. Fluorite from this location is a lustrous blue with a purple tint, and individual crystals are commonly 2.5 cm on an edge.

The final area for backhoe operations was the outcrop exposed in the trench across from the Portales-era ore bin. For several years this area produced good-quality blue fluorite cubes about 1–2 cm on an edge. Additional quantities of excellent blue fluorite were recovered from this area. More surprising was the discovery of large numbers of bipyramidal wulfenite crystals coating many of the more lustrous fluorite cubes. These wulfenite crystals are about 1 mm in length, and with their bright luster and orange color they contrast vividly with the blue fluorite.

Sphalerite, the primary sulfide mineral, has always been scarce at the Blanchard mine. The only significant occurrence of in-situ sphalerite has been the Sunshine #4 tunnel where it was found in massive gypsum often coated with a crust of pyrite crystals and, occasionally, covellite crystals. This past year, the tunnel has been the discovery site of several minerals that had not been reported previously from the Blanchard mine. A 2-m-long seam in the floor at the southern end of the tunnel has produced highly lustrous rosettes and clusters of hemimorphite crystals with an unusual reddish-brown color. The crystal groups, some of which are stalagtitic, occur in vugs and pockets as large as 0.5 m across. Close examination of these specimens revealed seams and blebs of massive cuprite intergrown with solid masses of cerussite, hemimorphite, and in one case a 2-cm linarite crystal. In many cases, the cuprite is included within the hemimorphite as very fine veils and zones (Hlava, pers. comm. April 1988) accounting for the unusual color. Native copper also has been found in a couple of instances as very minor hackly masses imbedded in the cuprite. Aurichalcite sprays and rosasite balls often accompany the hemimorphite crystal groups, and in one section, groups of 1–2-mm sea-green smithsonite crystals were recovered. Cerussite crystals, some in V-twins more than 1 cm long, were found in an area adjacent to and below the hemimorphite zone. The post-mining minerals, chalcanthite and goslarite (Hlava, pers. comm. April 1988), have also been found within and coating massive gypsum at the southern end of the tunnel.

A short west-trending drift near the #4 tunnel entrance has produced a most startling find this past year. Malachite pseudomorphs after linarite crystals more than 3 cm long have been recovered. In most crystals replacement has been complete, but in some cases a solid core of linarite remains. The crystals are found singly and in radiating groups in 5–20-cm-wide vugs in very tough silicified limestone. Unfortunately, most crystals are detached from the matrix in opening the pockets. The vugs also contain 1–3-mm-long hemimorphite crystals, usually pseudomorphed by chrysocolla, small tufts of malachite, and a white clay-like mineral coating the drusy quartz crystals that usually line the pockets. No unaltered linarite crystals have been recovered to date, but the search continues.

Perhaps the most unexpected new mineral occurrence at the Blanchard mine this past year was that of a mercury sulfide identified (Hlava, pers. comm. April 1988) from locations near the Portales tunnel (Glory Hole). X-ray diffraction has confirmed this mineral to be cinnabar (Foord, pers. comm. Sept. 1988). The cinnabar occurs as orange–red, pulverulent coatings in small cavities or in roughly square patches in what appears to be relict casts of a completely decomposed mineral. The cinnabar occurs within a very restricted horizon of altered, gypsum-bearing, punky limestone roughly 10–12 cm thick. It occurs above a zone containing cavities lined with blue fluorite crystals. The cinnabar has been found in the same horizon at two points approximately 50 m apart.

Additional exploratory work at the Blanchard mine is planned for the coming year and very possibly could reveal new and exciting discoveries. The intrigue of minerals is in large part due to our pursuit of them.

Mineral localities in the Picuris Mountains, Taos County, New Mexico, by *Herbert W. Dick*, New Mexico Mining and Milling, Inc., Los Cordovas Rt. Box 14, Taos, NM 87571 (4)

The Picuris Range in north-central New Mexico is an isolated mountain range of Precambrian rocks running 16 mi long east and west from the Sangre de Cristo Mountains to the Rio Grande rift; it averages 10 mi wide. The range consists of great masses of quartzite, mica schist, amphibolite, granite, and occasional pegmatites. The total relief is about 4,500 ft, consisting of a maze of high steep ridges and deep canyons. The highest summit is Picuris Peak, 10,700 ft above sea level.

There are two major formations: the upper, Vadito Formation with a composite thickness of 4,500 ft subdivided into a schist member and a conglomerate member; and the lower, Ortega formation of 6,650 ft with three members, Pilar Phyllite, Rinconada Schist, and lower quartzite.

The Picuris mining district includes the entire Picuris Range. Many of the minerals are found in quartz veins. Copper Hill, located 4.0 mi west of Peñasco, contains pyrite, gold, silver, chalcocite, cuprite, malachite, chrysocolla, and limonite; argentite and tetrahedrite have been reported. On Copper Mountain at the Tungsten mine, quartz veins contain brown tourmaline, tabular crystals of wolframite, malachite, and chrysocolla. This is located 1.5 mi north of Copper Hill. Near the head of Hondo Canyon (south of Taos) are prospects with quartz veins containing silver-bearing galena. These are 4.0 mi east from US–64. Spongy masses of limonite occur along the veins at the surface. The Harding pegmatite mine located 7.0 mi east of Dixon is the best known mine in the district. The major crystallization occurs some 7 miles deep and dates 1330 m.y. B.P. The important, extensively mined minerals include lepidolite, spodumene, microlite, and beryl. More than 50 minerals have been recorded from the quarry. Permits to collect can be obtained from the University of New Mexico Geology Department or from Mr. Griego in Dixon. At present the major mining is for sericite mica with extensive workings about 2.0 mi south of the crest of U.S. Hill. The mill is located near Alcalde between Velarde and San Juan. In localities around the crest are deposits of sericite–mica clay exploited by the Taos, Picuris, and Apache Indians who make pottery with a distinctly metallic appearance that is a very popular tourist item. A good deal of money is made with this craft. This cookware was made extensively in the late colonial period and was used by the Spanish and Indians alike.

For further information, two publications are:

Montgomery, A., 1953, Pre-Cambrian geology of the Picuris Range, north-central New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 30, 89 pp. (out of print but recorded on microfiche; diazo prints are available)

Schilling, J. H., 1960, Mineral resources of Taos County, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 71, 124 pp. (reprinted 1982)

Compositional variations and mineral inclusions in galena from the Organ district, Doña Ana County, New Mexico, by *Virgil W. Lueth*, Department of Physical Sciences, Tarleton State University, Stephenville, TX 76402, *Philip C. Goodell*, *Ramon Llavona*, and *Juan Sandoval*, Department of Geological Sciences, University of Texas at El Paso, El Paso, TX 79968 (5)

Galena mineral separates were collected from 21 mines in the Organ district and analyzed by directly coupled plasma-atomic emission spectrometry (DCP–AES) for the elements: antimony (Sb), bismuth (Bi), silver (Ag), tellurium (Te), and lead (Pb). The purpose of this study was to determine if trace-element substitutions of those elements (except Pb) into galena would be useful for characterizing mineralization when coupled with fluid inclusion, petrologic, and alteration studies. Galena was also analyzed by electron microprobe to determine if trace-element contents of the whole-mineral analyses of galena by DCP–AES were due to discrete mineral inclusions or solid-solution substitution. Both mineral inclusions and coupled semimetal (Sb/Bi)–silver solid solutions were found in the galenas analyzed.

Galena mineral separates that contained tellurium detectable by DCP–AES invariably contained inclusions of both altaite (PbTe) and native tellurium. Altaite replaced galena and native tellurium then replaced altaite. Hessite (Ag_2Te) was detected by electron microprobe in small grains isolated in galena from the Hilltop and Quickstrike mines in no particular paragenetic relationship with altaite or native tellurium. These samples also had high Ag concentrations as determined by DCP–AES. No tetradymite (Bi_2Te_2S) was detected in any samples from the Organ district, although it had been reported by previous workers.

Detectable silver contents in galenas were accompanied by detectable semimetal (Sb or Bi) concentrations determined by DCP–AES analysis. Very few mineral inclusions were found in these samples, suggesting a coupled solid solution between galena and $Ag–Sb(Bi)S_2$. The Ag:Sb(Bi) ratios in these samples were near 1.0 except in samples containing Te (which also contained hessite). The only sulfosalt inclusion detected by electron microprobe was tetrahedrite, from the Hornspoon mine (which had a Ag:(Bi + Sb) ratio of 0.10). No Ag–Bi sulfosalts were detected although samples with the highest silver values were accompanied by high Bi concentrations.

High bismuth and silver concentrations appear to have a weak correlation to higher temperatures determined by fluid-inclusion-homogenization methods. Bismuth-rich galenas also appear to be deposit specific, most common in skarn deposits. However, the exact mechanisms for the distribution of Bi–Sb and Ag in the galenas analyzed are unresolved. The galenas containing tellurium mineral inclusions appear to be the result of a tellurium-rich fluid overprinting of a previously formed sulfide assemblage. The progression of more tellurium-rich mineralogies (galena–altaite–native tellurium) suggests such an overprint at temperatures near 300° C (as determined by fluid-inclusion-homogenization temperatures in coexisting quartz).

MINERALOGICAL STUDIES OF SOME CAVES IN COLORADO AND NEW MEXICO, by *Peter J. Modreski*, U.S. Geological Survey, Box 25046, MS 922, Denver Federal Center, Denver, CO 80225 (2)

Mineralogical and geochemical studies of cave formations (speleothems), bedrock, and cave-filling mud can help us better understand the depositional processes and environments in caves. Samples were sparingly and carefully collected in collaboration with cave owners, members of the Cave Research Foundation (CRF), museum curators, and other USGS scientists. X-ray diffraction (XRD), scanning electron microscopy, electron microprobe analysis, bulk chemical analysis, optical microscopy and petrography, and cathodoluminescence microscopy have been used to examine samples.

Silent Splendor, a chamber within Cave of the Winds (a phreatic cave system developed in Ordovician to Mississippian limestone), Manitou Springs, Colorado, was completely sealed by mud-choked passages until it was first entered by cavers in 1984. This pristine 65-m-long room is noted for a great variety of speleothems (see Hill and Seanor, CRF 1986 Annual Report, p. 21–24; Modreski and others, 1987, GSA Abstracts with Programs, v. 19, no. 5, p. 322), particularly its exquisite clusters of beaded helictites up to 30 cm long. Minerals in Silent Splendor include calcite, aragonite, hydromagnesite, gypsum, and "limonite".

Porcupine Cave, noted for a wide variety of Pleistocene fossil vertebrate remains, is developed in the Ordovician Manitou Dolomite at the southwestern edge of South Park, Colorado. In addition to typical carbonate speleothems, mineralized areas within the cave contain barite, calcite, quartz, gypsum, carnotite, a black, botryoidal Ba–Mn oxide that XRD shows to be romanechite, and small (0.1 mm) white sphere-like crystal clusters of dolomite atop the romanechite.

Lechuguilla Cave, in Carlsbad Caverns National Park, New Mexico (Hill, CRF 1986 Annual Report, p. 16–18) has been the subject of extensive recent explorations and discoveries; it is now the deepest, 457 m (1500 feet) and the longest, 34.3 km (21.3 miles) known cave in the park and in the state. A silvery black, slippery, manganese oxide material that is a corroded limestone residue is composed of rancieite, $(Ca,Mn^{+2})Mn^{+4}_4O_9{\cdot}3H_2O$, and todorokite, $(Mn^{+2},Ca,Mg)Mn^{+4}_3O_7{\cdot}H_2O$. Associated brown-colored material contains calcite microcrystals plus nearly amorphous Fe–Mn oxides and rare grains of an apparent aluminum hydroxide mineral (gibbsite?).

An unusual cave in Precambrian gneiss was discovered in Clear Creek Canyon, west of Golden, Colorado, during blasting for road construction in May 1988 (Modreski and others, 1988, GSA Abstracts with Programs, v. 20, no. 7, p. A65). A 50-m-long × 10-m-wide × 20-m-high open void formed through collapse, settling, and dissolution of loose rock along a fault zone. The cave contains a spectacular array of carbonate speleothems, including calcite flowstone and draperies, and aragonite stalactites, stalagmites, helictites, and "frostwork" crystal druses. Other minerals identified in the cave include small amounts of hydromagnesite ("moonmilk"); minute blebs of green-luminescent opal as a coating on aragonite crystals; a black Ba–Mn oxide that contains trace Cu, Co, Mo, W, and Pb and gives an XRD pattern of poorly crystalline romanechite; and a poorly crystalline, Mg-rich, Al-poor, layer silicate mineral (a trioctahedral smectite?) with a platy to spheroidal or botryoidal morphology.

The abundance of aragonite vs calcite speleothems, the relationship of speleothem type to water chemistry and evaporation rate, the correlation of luminescence to trace-element chemistry, and the nature and chemistry of Fe–Mn oxide deposits are some of the topics in mineralogy that may help shed light on the mysteries of caves.

MINERALOGY OF THE BLACK RANGE TIN DISTRICT, SIERRA AND CATRON COUNTIES, NEW MEXICO, by *Eugene E. Foord* and *Charles H. Maxwell*, U.S. Geological Survey, Box 25046, MS 905, Denver Federal Center, Denver, CO 80225, and *Paul F. Hlava*, Div. 1822, Sandia National Laboratories, Albuquerque, NM 87185 (6)

Many aspects of the mineralogy of the Black Range tin district (BRTD) have been presented previously (Foord et al., 1985, 1986, 1988; Foord and Maxwell, 1987; Maxwell et al., 1986). We have now identified and/or characterized all of the remaining unknown minerals discussed in earlier communications. Additional unreported species undoubtedly are present and may be characterized in the future.

Table 1 lists the minerals identified from three separate localities and from the rest of the BRTD. Three mineral species new to science have been discovered: squawcreekite, $(Fe,Sb,Sn,Ti)O_2$, a member of the rutile group; maxwellite, $CaFeAsO_4F$; and the Ce-analogue of chernovite-(Y), $CeAsO_4$. Species new to the state of New Mexico include: gasparite-(Ce), $CeAsO_4$, chernovite-(Y), $YAsO_4$, and tilasite, $CaMgAsO_4F$.

Three different members of the durangite group, $XY(AsO_4)F$, all having the titanite structure, have been found in the BRTD: durangite (X = Na, Y = Al) (3 localities), tilasite (X = Ca, Y = Mg) (1 locality), and maxwellite (X = Ca, Y = Fe) (2 localities). Solid solution exists between all three members. Tilasite from vapor-phase altered rhyolite at Willow Springs Draw has the following composition: $(Ca_{0.55}Na_{0.47})(Mg_{0.48}Fe^{3+}_{0.20}Al_{0.15}Ti_{0.14}Mn_{0.01})(As_{0.94}P_{0.02})O_4F$. This mineral has been found only at Willow Springs Draw.

Titanite, also found only at Willow Springs Draw, occurs in miarolitic cavities along with diopside (var. salite), pseudobrookite, and other minerals. The titanite crystals are euhedral, gem quality, red brown, and range from <0.1 to 1 mm in maximum dimension. Their composition is unusual compared to regular titanite ($CaTiSiO_5$). The content of Y + REE is about 9 wt. %, with Y being the most abundant single element (about 3% Y_2O_3). Both LREE and HREE are present. Other elements include (in wt. %): Al_2O_3 1.8, Mn_2O_3 1.0, Fe_2O_3 7.3, ZrO_2 0.1, Nb_2O_5 1.6, WO_3 0.5, ThO_2 0.17, V_2O_3 0.15, Sb_2O_3 0.15, Ta_2O_5 0.37, F 2.0. Crystallization of titanite of this unusual composition indicates the abundance of REE's and other incompatible elements in the late-stage vapor phase. This titanite composition (average of three samples) is similar to those reported from complex granitic pegmatites. Titanite in rhyolites is generally sparse because of lack of available Ca and Ti. Calcite has been found only in miarolitic cavities with the rhyolites.

The diopside occurring with the titanite is yellow orange, and the crystals are usually acicular, transparent, euhedral, and may be several millimeters in length. The composition of the diopside is $(Ca_{0.93}Na_{0.16})(Mg_{0.70}Fe_{0.28}Mn_{0.06}Ti_{0.01})(Si_{1.92}Al_{0.05})O_6$.

Crystallization of tilasite–maxwellite preceded that of titanite and diopside. Crystals of tilasite–maxwellite are etched and corroded to varying extent. The later titanite and diopside may owe their origin, at least in part, to dissolution of the earlier tilasite–maxwellite.

Minor amounts of chevkinite, $(Ce,Ca,Th)_4(Fe^{2+},Mg)_2(Ti,Fe^{3+})_3Si_4O_{22}$ or perrierite, $(Ce,Ca,Th)_4(Fe^{2+},Mg)_2(Ti,Fe^{3+})_3Si_4O_{22}$, which are dimorphous, also have been found at Willow Springs Draw. The gray–brown crystals are as much as 0.2 mm in maximum dimension. This particular chevkinite–perrierite is somewhat unusual because of its high ZrO_2 content (3.04 wt. %). The composition (average of 10 points on one grain) is: $(Ce_{1.37}Ca_{0.72}La_{0.64}Nd_{0.59}Pr_{0.15}Sm_{0.09}Th_{0.08}Gd_{0.06}Dy_{0.04}Er_{0.03}Lu_{0.02})(Fe^{2+}_{1.61}Mg_{0.17}Mn_{0.06})(Ti_{2.60}Zr_{0.30}Al_{0.19}Nb_{0.05}W_{0.01})Si_{4.24}O_{22}$.

TABLE 1—Minerals from rhyolite-hosted tin occurrences in the Black Range tin district (BRTD).*, mineral species new to science; +, mineral new to New Mexico. Quartz, sanidine, hematite, and cassiterite are ubiquitous; cristobalite, tridymite, and pseudobrookite are common.

Squaw Creek	Paramount Canyon	Willow Springs Draw	Rest of BRTD
squawcreekite*	beryl	diopside	acmite
maxwellite*	bixbyite	titanite	durangite
gasparite-(Ce)+	chernovite-(Y)+	tilasite+	hidalgoite
chernovite-(Y)+	Ce-analogue of chernovite-(Y)*	maxwellite*	beudantite
heulandite		chevkinite–perrierite	cryptomelane
calcite		calcite	vanadinite
stilbite		zircon	stolzite
chabazite			fluorite
			bixbyite
			diopside
			calcite
			todorokite
			smectite
			opal
			kaolinite
			pyrite
			alunite
			jarosite
			adularia

The REE arsenates ($REEAsO_4$) occur in the two different structural forms now known in nature: huttonite–monazite type and zircon type. Chernovite-(Y), $YAsO_4$, has the tetragonal zircon-type structure while gasparite-(Ce), $CeAsO_4$, has the monoclinic huttonite–monazite type structure (Schwartz, 1963; Graeser and Schwander, 1987). Chernovite-(Y) and its Ce-analogue have been found at Paramount Canyon. The Y-analogue of gasparite-(Ce) has not been found and has never been synthesized. The zircon-type structure of the $REEAsO_4$ is more stable at higher temperatures than the huttonite–monazite-type structure. Significantly, $YAsO_4$ and $CeAsO_4$ both occur at Paramount Canyon in the tetragonal (chernovite) form only, while tetragonal chernovite-(Y) and monoclinic gasparite-(Ce) occur at Squaw Creek. Crystallization temperatures of the arsenates at Paramount Canyon are higher than the temperatures of the arsenates at Squaw Creek. Inversion of tetragonal $CeAsO_4$ to monoclinic $CeAsO_4$ has not been achieved experimentally but must occur based on the natural existence of both forms.

The gasparite-(Ce) at Squaw Creek contains about 1.3 wt. % CaO, with 4.3% ThO_2 substituting for the LREEs as well as about 6.1% P_2O_5 substituting for As. Chernovite-(Y) at Squaw Creek contains about 0.6% CaO, 0.3% SiO_2, 0.2% ZrO_2, 3.3% P_2O_5, and 2.8% ThO_2. The REE arsenates are the only minerals in the rhyolites found to contain major ☞

amounts of phosphorus. Apatite, the most common accessory mineral containing major P, is essentially absent.

The assemblages of minerals in the rhyolite-hosted tin occurrences of the BRTD indicate that deposition took place from high-temperature vapor-phase conditions down to ambient conditions with the majority of minerals being deposited from hydrothermal fluids.

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Uranium symposium

The American Association of Petroleum Geologists (AAPG), Energy Minerals Division (EMD) is sponsoring a half-day symposium, "Competitive uranium sources and outlook," at the 1989 Rocky Mountain Section, AAPG annual meeting, October 2–5, 1989 in Albuquerque, New Mexico. This symposium on the morning of October 3rd will consist of 10 papers on such topics as the domestic uranium industry and its future, the uranium industry in Canada, geology of breccia-pipe uranium deposits (Arizona), geology of the Mt. Taylor uranium mine (New Mexico), and solution mining of uranium deposits. A one-day field trip on October 5th will visit the Mt. Taylor uranium mine, Lee Ranch coal mine, and Ambrosia Lake uranium district. Registration material will be available in June. For information on the symposium and field trip, contact Virginia T. McLemore, New Mexico Bureau of Mines and Mineral Resources, Socorro, New Mexico 87801, (505) 835-5521.

Abstracts

New Mexico Geological Society

The New Mexico Geological Society annual spring meeting was held at New Mexico Institute of Mining and Technology (Socorro) on April 7, 1989. Following are abstracts from sessions given at that meeting. Abstracts from the other sessions will appear in future issues of *New Mexico Geology*.

Poster session

PALEONTOLOGY OF THE LOWER SHALE MEMBER OF THE CHINLE FORMATION (UPPER TRIASSIC), SAN MIGUEL COUNTY, NEW MEXICO, by *Paul L. Sealey, Adrian P. Hunt,* and *Spencer G. Lucas,* New Mexico Museum of Natural History, P.O. Box 7010, Albuquerque, NM 87194

We report here the first fossil vertebrates known from the lower shale member of the Chinle Formation in east-central New Mexico. These vertebrates, together with shells of *Unio* and petrified wood, were collected from 28 localities, the most prolific of which are in secs. 3 and 4, T12N, R24E, secs. 24 and 35, T13N, R24E and sec. 1, T14N, R22E, San Miguel County. All fossils are part of the New Mexico Museum of Natural History (NMMNH) collection. Phytosaurid reptiles are represented by vertebrae (NMMNH P–3678, P–3681), teeth (P–3688), scutes (P–3689) and skull and dentary fragments (P–3673). A mid-cervical lateral spike (NMMNH P–3670) and lateral spike (P–3668) are among the specimens of the aetosaur *Desmatosuchus. Typothorax* is represented by a paramedian scute (NMMNH P–3674), among other specimens. A single, incomplete paramedian scute (NMMNH P–3677) is assigned to *Paratypothorax.* Cf. *Postosuchus* sp. is represented by a caudal vertebra (NMMNH P–3672), and various teeth (P–3680) pertain to rauisuchian thecodonts. Scute fragments of small metoposaurid amphibians (NMMNH P–3667, P–3669), tooth plates of the lungfish *Arganodus* (P–3676) and coprolites with ganoid fish scales (P–3682, P–3683 and P–3684) complete the vertebrate fauna. Most of the vertebrate taxa from the lower shale member of the Chinle Formation in San Miguel County are consistent with previous lithologic correlations that identify this unit as a homotaxial equivalent of the lower part of the Petrified Forest Member (PFM) of the Chinle Formation in northeastern Arizona. The occurrence of the aetosaur *Typothorax* in the lower shale member represents an apparent extension of the chronological range of this taxon into a unit older than the upper part of the PFM of the Chinle Formation in northeastern Arizona. Also unusual is the apparent absence of large metoposaurids and presence of small metoposaurids in the lower shale member. Large metoposaurids dominate the amphibian fauna of the lower PFM in northeastern Arizona and its Texas equivalent the Tecovas Formation of the Palo Duro basin. The dominant amphibians of the upper PFM are small metoposaurids (*"Anaschisma"*). The amphibian fauna of the lower shale member of the Chinle in east-central New Mexico supports the idea that amphibian distribution in the Upper Triassic strata of the American Southwest is largely facies controlled.

CRETACEOUS STRATIGRAPHY NEAR VIRDEN, HIDALGO COUNTY, NEW MEXICO, by *Spencer G. Lucas, Thomas E. Williamson,* and *Adrian P. Hunt,* New Mexico Museum of Natural History, P.O. Box 7010, Albuquerque, NM 87194

Approximately 625 m of Cretaceous strata are exposed NE of Virden in secs. 7–9, 16–18 and 20–21, T18S, R20W, Hidalgo County. The oldest Cretaceous strata here pertain to the Sarten Formation (= Beartooth Quartzite) and rest nonconformably on coarse microcline granite of Precambrian age. Sarten strata are 18–45 m thick and are dominated by medium gray and reddish brown, coarse-grained, poorly sorted, trough-crossbedded quartzarenite. The Sarten is disconformably overlain by 70–96 m of Mancos Formation which are mostly olive-gray and yellowish brown, calcareous siltstone. About 10 m above the base of the Mancos are 5.5 m of gray limestone and yellowish brown calcarenite we assign to the Bridge Creek Member. These Bridge Creek strata contain abundant *Pycnodonte newberryi* and fossil-shark teeth and rare inoceramids and ammonites. The Atarque Sandstone overlies the Mancos Formation near Virden; it is 24–39 m of greenish gray and pale yellowish brown calcarenite and calcareous siltstone dominated by biostromal layers of *Crassostrea.* We assign the 103 m of yellowish brown and pale orange beds of sandy siltstone and trough-crossbedded quartzarenite above the Atarque Sandstone to the Moreno Hill Formation. Above them are 340 m of strata dominated by beds of gray siltstone and pale olive lithic and subarkosic sandstone. The upper 80 m of these strata include volcanic boulder conglomerates and volcaniclastic sandstones. Approximately 64 m below the top of this interval, a volcaniclastic sandstone in the SE¼SW¼SE¼ sec. 8, T18S, R20W produces fossil leaves (*"Araucarites, Ficus, Juglans"*, etc.) previously considered to be of Maastrichtian age. We believe the upper 340 m of the Cretaceous section near Virden may be equivalent to the Ringbone Formation and/or Hidalgo Volcanics of the northern Little Hatchet Mountains, 100 km to the southeast. For now, we restrict use of Elston's (NMBMMR Geologic Map 15) name Virden Formation to these 340 m of strata; Elston originally used the name Virden Formation to refer to all the post-Mancos Cretaceous strata exposed NE of Virden. The Virden Formation sensu stricto is disconformably overlain by andesite and latite flows and tuffs of the lower Datil Group (Eocene–Oligocene).

FLUID INCLUSIONS IN FOSSIL RESIN: RECENT RESULTS, by *D. Bellis,* Department of Chemistry, New Mexico Institute of Mining and Technology, *D. L. Wolberg,* New Mexico Bureau of Mines and Mineral Resources, and *D. Norman,* Department of Geology, New Mexico Institute of Mining and Technology, Socorro, NM 87801

Fluid inclusions in fossil resin (amber) occur in a variety of sizes and shapes with a diversity of contents and appear to be ubiquitous in amber of all genetic types. Of all types of inclusions, gaseous inclusions are the most common; two-phase inclusions are abundant, however. We characterize genetic types of fossil resin by the following four end members: 1) primary, those fossilized in situ which have been neither transported nor metamorphosed, 2) secondary, those squeezed out of coals and lignites during coalification processes, 3) tertiary fossil resin is primary and secondary resin that has been transported and/or metamorphosed, and 4) quaternary, resin products found in petroleum. Studies of diffusion rates and re-equilibration of included fluids may allow us to reinterpret the results of the mass spectrometric analysis of the contents of fluid inclusions in resin of various ages, botanical affinity, and genetic origin. Diffusion coefficients and solubility vary widely as a result of the number of variables associated with each sample of fossil resin. Therefore, it is imperative to characterize both the diffusion and solubility of atmospheric gases in a sample before conclusions can be drawn as to the composition of paleoatmospheres.

FOSSIL RESIN BIOGEOCHEMISTRY; STRATIGRAPHY AND SEQUENCE, by *D. L. Wolberg, D. Bellis, G. S. Austin*, and *P. Domski*, New Mexico Bureau of Mines and Mineral Resources, Socorro, NM 87801

Variation of several paleoenvironmental and geochemical parameters have been determined on samples from a 303.4 ft continuous core and correlated outcrops from the Late Cretaceous Fruitland Formation in the Fossil Forest study area, San Juan Basin, New Mexico. Fossil resin occurs throughout the sequence in association with coal, sandstone, shale and petrified wood. The infrared spectra and trace element concentration in fossil resin has been related to those parameters. In addition to palynological studies, mineralogy of the whole rock and <2 micron fraction were determined by X-ray diffraction. Trace element concentrations were determined by atomic absorption. Trace element content of the resin is thought to be independent of allocthonous affects. Concentration of these elements in the resin, therefore, depends on the biogeochemical environment at the time of deposition. Some elements are concentrated in the resin relative to the associated coals; some are depleted. Infrared spectra of resins from throughout the sequence reveal differences attributable to oxidation and botanical origin.

CATENARY SOIL DEVELOPMENT AND SLOPE DEGRADATION ON THREE LATE QUATERNARY FAULT SCARPS IN NEW MEXICO, by *P. Drake, P. Eberly, C. Renault, T. Royek*, and *T. Skirvin*, Department of Geology, University of New Mexico, Albuquerque, NM 87131

Single-rupture fault scarps reflect erosional, depositional and pedogenic processes that have acted through time to modify slopes produced in a single, nearly instantaneous event. These features offer the opportunity to study catenary soil development in the absence of the complex sequence of events that comprise the genesis of other slopes. This study uses soil morphologic and stratigraphic data to assess catena development and slope degradation on three late Quaternary fault scarps in New Mexico. The study areas include the Hubbell Springs Bench east of Los Lunas and piedmonts of the Sacramento and San Andres Mountains (east of Alamogordo and near the Very Large Array, respectively). Diffusion modeling and trends in relative soil development indicate that the Hubbell Springs scarp is the youngest feature examined (mid to late Holocene). The Sacramento scarp and San Andres scarps are of late to latest Pleistocene age. Diffusion results are complicated, however, by winnowing of fine material down slope and mantling of slopes by coarser clasts. These phenomena produce erroneously low diffusion age values. Soil pits (n = 13) were hand-excavated and described along profiled transects. Profile development indices, carbonate morphology, profile thickness, and thickness and development of Bt horizons indicate that mid-slope positions on fault scarps are most weakly developed. The weak development of these soils can be explained by fluvial and colluvial processes acting on scarp surfaces. Truncation or thinning of pedons near crests and production of thick cummulic soils near toes of the scarps were recognized and are related to soil development prior to faulting, increased scarp age, and slow rates of erosion and deposition relative to pedogenesis.

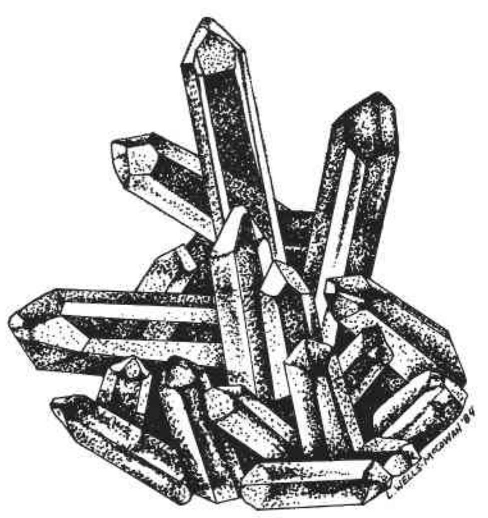
Hydrology, environmental, and general geology session

TRACE ELEMENT VARIATION IN A LATE CRETACEOUS SEQUENCE FROM THE FRUITLAND FORMATION, FOSSIL FOREST STUDY AREA, SAN JUAN BASIN, NEW MEXICO, by *Diane Bellis*, Dept. of Chemistry, New Mexico Institute of Mining and Technology, Socorro, NM 87801

Trace element concentrations have been determined in samples from a 303.4 ft continuous core and correlated outcrops from the Fruitland Formation, Fossil Forest study area, San Juan Basin, New Mexico. Be, Co, Cr, Cu, K, Li, Mg, Mn, Pb, Sb, Sr, V, and Zn concentrations have been determined using atomic absorption spectroscopy on more than 100 samples from throughout the Fruitland Formation. The Fruitland Formation is approximately 430 ft thick in the sampling area and analyses from the underlying Pictured Cliffs Sandstone through the overlying Kirtland Shale are included. The samples are from a variety of lithologies including the principle lithologic components of the regressive Fruitland Formation: mudstone, siltstone, sandstone, and coal. In addition, included resins, unusual carbonates and frequently occurring ash partings from the coals were analyzed. Trace element concentrations vary with lithology and inferred depositional environments.

TECTONIC AND CLIMATIC INFLUENCES ON MOUNTAIN-FRONT LANDFORM EVOLUTION ALONG A SEGMENTED RANGE-FRONT FAULT, SANGRE DE CRISTO MOUNTAINS, NORTH-CENTRAL NEW MEXICO, by *Frank J. Pazzaglia*, Department of Geology, University of New Mexico, Albuquerque, NM 87131

Morphologic characteristics of drainage basins, alluvial fans and stream terraces along a tectonically active mountain front may be influenced by both the tectonic history of the segmented range-front fault as well as by Quaternary climatic fluctuations. The soils and sedimentologic characteristics of alluvial fan units are consistent along tectonically dissimilar mountain-front segments. However, morphometric analyses suggest that the geometry and linear spacing of fans and their drainage basins change systematically with the segmentation pattern. Larger and more elongate fans and drainage basins tend to be located at segment boundaries while smaller fans and basins with steeper slopes tend to be located between boundaries and in areas characterized by higher uplift rates. A soil chronosequence has been developed for fluvial terraces of the Red River. Relative soil development coupled with several ^{14}C dates indicates that at least two depositional terraces are temporally correlative with Bull Lake and Pinedale age glacial outwash deposits and spatially correlative with major alluvial fan depositional units. Carbon-14 dates obtained from younger debris-flow type deposits throughout the study reveal that they are mid-Holocene in age, suggesting a possible relationship to neoglaciation. These data suggest that the segmentation pattern of the tectonically active range-front fault strongly influences the geometry of mountain-front landforms. However, climate is the driving force that governs their production and stratigraphy. These results will help define the relative contribution of Quaternary climatic fluctuations and neotectonic activity on landform evolution in the northern rift. Understanding the sensitivities of landform morphology to neotectonic activity may also have strong implications for assessing the possible seismic hazards of tectonically active areas.



A LABORATORY AND FIELD EVALUATION OF SEVERAL FLUORINATED BENZOIC ACIDS FOR USE AS SOIL AND GROUNDWATER TRACERS, by *Joseph Gibbens*, and *Robert Bowman*, New Mexico Institute of Mining and Technology, Socorro, NM 87801

In groundwater investigations involving multiple sources of water, or in cases where measurements are repeated over time, several unique tracers which can be used simultaneously are required. A group of fluorinated benzoic acid derivatives has previously been shown to be effective as soil and groundwater tracers. In this study, four related fluorobenzoates were examined in an attempt to enlarge the suite of proven tracers. The organic anions being studied are 2,3-difluorobenzoic acid (2,3-DFBA), 2,5-difluorobenzoic acid (2,5-DFBA), 3,4-difluorobenzoic acid (3,4-DFBA) and 3,5-difluorobenzoic acid (3,5-DFBA). A high pressure liquid chromatography (HPLC) separation was developed for simultaneous detection of the four anions being evaluated, as well as bromide anion which was used as a standard against which the others were measured. The laboratory phase of this evaluation consisted of batch studies to measure the resistance of these compounds to degradation and affinity for sorption on soil surfaces, as well as column studies to measure the mobility and stability of the compounds. The batch study using a low organic content sand showed no loss of concentration of any of the fluoro-organics over a 90-day period, while the study using a high organic matter silty clay loam is still underway. Both ponded and trickle irrigation column flow conditions indicated no loss of mass as well as similar mobility of the fluoro-organics compared to bromide. The field portion of this evaluation will consist of a single-well tracer test to measure their stability under saturated conditions, and a trickle irrigation tracer test to evaluate their behavior under unsaturated natural conditions. These two experiments are now underway, with results expected by May.

USING REGIONAL HEAT-FLOW DATA TO DELINEATE VERTICAL GROUND-WATER FLOW PATTERNS IN SOUTHEASTERN NEW MEXICO, by *David L. Jordan*, and *Marshall Reiter*, New Mexico Bureau of Mines and Mineral Resources, Socorro, NM 87801

In this study, we examine the variation of heat flow with depth along several profiles in southeast New Mexico. We divide heat-flow data into two

(continued on page 43)

Basin, Rio Grande rift, New Mexico: Geology, v. 17, no. 3, pp. 230–233.
Warshaw, C. M., and Smith, R. L., 1988, Pyroxenes and fayalites in the Bandelier Tuff, New Mexico—temperatures and comparison with other rhyolites: American Mineralogist, v. 73, no. 9–10, pp. 1025–1037.
Zody, S. P., 1988, Seismic refraction investigation of the shallow subsurface of the lower Rio Salado, northwest of San Acacia, New Mexico: M.S. thesis, New Mexico Institute of Technology, 119 pp.

Open-file reports

USGS

*87–258—Aspects of the petrology, mineralogy, and geochemistry of the granitic rocks associated with Questa caldera, New Mexico, by B. Dillet and G. K. Czamanske, 1987, 246 pp. $49.20

87–638—Analytical results and sample locality map of heavy-mineral-concentrate and rock samples from the Organ Mountains Wilderness Study Area (NM–030–074), Doña Ana County, New Mexico, by T. A. Delaney, G. W. Day, R. L. Turner, and J. L. Jones, 1988, 13 pp., 1 sheet, scale 1:24,000.

Upcoming geologic meetings

Conference title	Dates	Location	Contact for more information
International Association of Volcanology and Chemistry of the Earth's Interior General Assembly	June 25–July 1	Sweeney Convention Center	IAVCEI/1989 Protocol Office, LANL Mail Stop P-366 Los Alamos, NM 87545 (505) 667–6574
Ute Mountain Gem and Mineral Society Show	July 8–9	Annex Bldg. Cortez, CO	Patrick E. Haynes P.O. Box 1531 Cortez, CO 81321 (303) 565–1029
San Juan Gem and Mineral Society Show	July 21–23	The Inn E. Broadway at Scott Ave. Farmington, NM	Frank M. Clark 4501 Hannon Drive Farmington, NM 87401 (505) 325–5292
Colorado Springs Mineralogical Society Show	July 22–23	City Auditorium Kiowa and Weber Sts. Colorado Springs, CO	Bob Sloan 1224 Hartford St. Colorado Springs, CO 80906

(continued from page 41)

groups: shallow heat flows and deep heat flows. The shallow heat flows show areas of surface ground-water recharge and discharge. Shallow heat flows are also affected by deep vertical ground-water movement. This effect is especially pronounced in the area of the Pecos River, where there is a significant component of recharge to the San Andres Formation from deeper formations, and thus deep vertical ground-water movement. Deep heat flows generally mirror shallow heat flows and indicate areas of deep upward ground-water movement. We found that upward ground-water flow from deep depths generally raised the shallow temperatures, therefore increasing the shallow temperature gradients and consequently shallow heat flows. Because of the elevated shallow temperatures, the deep gradients, and hence deep heat flows, were lowered. We also found that, east of the Pecos River, downward ground-water flow from shallow depths decreased the shallow temperatures, therefore decreasing shallow temperature gradients and shallow heat flows. Because the shallow temperatures were lowered and the deep temperatures remained the same, the deep gradients were increased, as well as the deep heat flows. Preliminary numerical modeling results fit well with our conclusions concerning upward and downward vertical ground-water flow.

HYDROGEOTHERMAL PHENOMENA IN THE SOCORRO KNOWN GEOTHERMAL RESOURCE AREA, by *M. W. Barroll*, and *M. Reiter*, New Mexico Bureau of Mines and Mineral Resources, and Geoscience Department, New Mexico Institute of Mining and Technology, Socorro, NM 87801

Heat flows in the Socorro area vary widely within relatively short distances, suggesting that uppermost crustal phenomena are responsible. Heat flows as high as 490 mW/m**2 are measured in the Socorro mountain block, while in La Jencia Basin (less than 10 km west) heat flows below 30 mW/m**2 are observed (regional heat flows average 75–100 mW/m**2). Low heat flows in La Jencia Basin are probably caused by downward ground-water flow. We suggest that ground water flowing eastward in the basin subsurface is constrained to move downward into deeper aquifers by low permeability clays and claystones in the eastern part of the basin. Percolation of hydrologic recharge down from the surface may also influence heat flows, but we believe this is a relatively minor effect. High heat flow in the Socorro mountain block may be caused by either an upper crustal heat source (such as magma), and/or upward ground-water flow. We suggest that upward ground-water flow is a major influence, if not the entire cause of the high heat flows. High heat flows coincide with upfaulted blocks of permeable fractured volcanic rocks, which are located 'downstream' from thick, relatively impermeable, claystone units. These upfaulted blocks act as hydrologic windows allowing confined ground water to flow upward, elevating near-surface heat flows. Finite difference modeling demonstrates that the hydrologic phenomena we postulate are, in fact, consistent with the hydrogeology of the Socorro area. In addition, modeling also demonstrates that such hydrologic phenomena can produce anomalous heat flows of the magnitudes and relative locations observed in the Socorro area.

HYDROTHERMAL MODELING, STEEPLE ROCK DISTRICT, NEW MEXICO, by *Paul I. Eimon*, and *Khosrow Bazrafshan*, Geoscience Department, New Mexico Institute of Mining and Technology, Socorro, NM 87801

The Steeple Rock silver/gold mining district lies in southwestern New Mexico 15 miles east of the town of Duncan, Arizona. During the last decade, exploration activity and drilling has been carried out by several companies including Inspiration, Pioneer, Nova Gold, FMC, Mount Royal, Sutel and Queenstake. Also Steeple Rock has been the object of prospecting by individuals, satellite imagery interpretation by the Imperial College in London, and fluid inclusion/gas geochemistry analysis at New Mexico Tech. Compilation of all this work indicates that the alteration and mineral zoning in the Steeple Rock district, the depositional temperatures and the structural features are similar to other "bonanza" vein, volcanic-hosted epithermal systems in which new discoveries are being made throughout the world. Current small-scale mining occurs at the Center Mine on the Carlyle vein system which is producing flux ores for smelters in Arizona and New Mexico. Further potential in the district includes the Summit mine area: 1) underground mining for silver/gold ores (smelter flux) delineated by Inspiration and Nova Gold drilling and underground workings and 2) possible open pit mining of lower grade vein surface ores. The East Camp vein system and others offer similar possibilities. Clay data, geochemical sampling results, mineral zoning patterns, volcanic features and fluid inclusion values indicate a possible fossil heat and volcanic center immediately north of the intersection of the Summit vein/East Camp structural system, the Carlyle structural trend and the north–south structural trend shown by the Imperial and Jim Crow veins. These features indicate a possible boiling-upwelling zone that is an exploration target for bonanza gold ores. Additional work is necessary in the Steeple Rock district to detail 1) the volcanic history of the area, 2) alteration zoning and its relationship to the structural features, 3) hydrothermal model and epithermal fluid flow patterns and 4) targets for further exploration.

MONITORING ROCK MASS BEHAVIOR DURING LANGBEINITE PILLAR RECOVERY, by *Kevin M. O'Connor*, Assistant Professor of Geological Engineering, New Mexico Institute of Mining and Technology, Socorro, NM 87801

A mining company in southeastern New Mexico has just completed a prototype pillar recovery operation in the 4th ore zone of the McNutt potash member where langbeinite is being mined. The uniqueness of this operation is due to the langbeinite which is too hard and brittle to be extracted using conventional continuous miners, so undercut and blast techniques must be used. Although there is a wealth of experience with pillar recovery of sylvite using continuous miners, it is not directly applicable to this operation, and a program was established to monitor rock mass behavior during pillar recovery as well as laboratory testing to characterize the engineering properties of langbeinite. A presentation will be made of the monitoring program which incorporated pressure cells, convergence measurements, TDR cables to monitor roof strata movements, air pressure measurements, and a surface survey network. Summary plots of the monitoring data will be presented as well as slides of typical observations made during pillar recovery. At this stage, it has only been possible to make a preliminary assessment of the data so there will not be any attempt to present conclusions and recommendations.