

# **MINERALS OF THE KARNES URANIUM DISTRICT-THE FRANKLIN OF TEXAS**

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## **LEAD**

Numerous important papers have been written on the geology of the Karnes Uranium District of South Texas, which has been mined for uranium resources since the late 1950's. However, there is no serious mention in the literature of the fine and unique mineral assemblage in the sediments overlying the ore zones. This may be the best mineral collecting locality in Texas, yet few are even aware of its existence. The basis for such a claim include the fine and diverse assemblage of calcite, gypsum, quartz and barite, as well as a range of fluorescent mineral colors possibly only second to those of Franklin, New Jersey. Similarly, no serious attempt has been made comparing similar concretionary zones in tuffaceous sandstone associated with uranium deposits, or the potential of using concretions as an ore indicator in exploration. Unfortunately, this possibly unique and important mineralogical location will soon be lost to a massive and long overdue open-pit mine reclamation project.

## **INTRODUCTION**

The Karnes Uranium District is named for Karnes County, which is about 45 miles south of San Antonio, Texas (Figure 1). Most of the Texas uranium mines are located in this area. Access to the main collecting area is reached by taking State Highway 181 south from San Antonio to Falls City, go right (west) on FM 791 for several miles. The former Conoco Conquista uranium mill and office will be on the left and a little further is the intersection of the former town of Deweesville. The first left past this intersection is CR 993, on to which you will turn, baring straight at one intersection where the main road appears to go to the left and the road becomes CR 999. Continue on this road until it runs very near to the steep, elongated overburden piles next to the open pits. Since reclamation work is ongoing in 1999, these may not be as noticeable, and the entire area may no longer be accessible

The entire northeast trending string of overburden mounds, from the Butler to the Wright-McGrady mines, contain concretions with crystal-lined cavities. Concretions are present north of the Butler mine, but do not appear to be as productive of quality specimens. The best specimen areas appear to be on the downdip side of the pits or in the erosional gullies in the spoils. Reclamation work in 1999 will likely make this area inaccessible.

The specimens described and shown here are mostly from the Wright-McGrady and Butler mines, however a few are also from the nearby Rosenbrock mine, which was reclaimed soon after mining operations ceased there. The specimens were collected over the course of nearly 22 years (intermittently), and all areas are entirely on private

property. The owners of the Wright-McGrady and Butler mines graciously allowed collection of many of these specimens. Attempts to gain permission to access other property and mines along the trend have only been successful through the Uranium Mill Tailings Recovery Act (UMTRA) reclamation studies, being conducted by the Abandoned Lands Division of the Texas Railroad Commission and the Bureau of Economic Geology (BEG), conducted throughout the 1990s.

I first became aware of this locality while on my first job out of college, as a mineral logger/geologist exploring for uranium in South Texas, living in Karnes City at the time. Being from New Jersey and an avid collector at Franklin since 1971, I soon organized mineral collecting trips to Mexico and Arkansas with co-workers. Our constant talk of minerals soon sparked interest in some of our co-workers who were working in the nearby Karnes County portion of the trend. They soon presented us with some septarian-looking concretions from the Rosenbrock mine they had collected in 1977. Minerals initially brought to us included calcite, quartz, and pyrite. We were mildly excited about the prospect of a collecting locality so near. When I checked the specimens under my shortwave UV light, I was even more impressed to see orange, green and pink-red fluorescence. They told us of some old abandoned open pits with extensive spoils near the Rosenbrock mine, where we might find similar concretions. We ended up going out to the former Wright-McGrady spoils several times, including a couple night outings with my battery pack and UV light. These trips resulted in expanding the suite of minerals, to include barite, gypsum, and a diversity of quartz. The range in fluorescent colors included pink, red, orange, purple, green, blue, bluish-white, white, yellow, and cream, as well as some colors more difficult to describe.

Having collected minerals since high school, I felt this locality might be of relative importance. I eventually brought some back to New Jersey where I sold some to Rutgers University Geology Department (authors Alma Mater) for sale in their museum shop. I eventually donated several specimens to the South Texas Museum in Corpus Christi and also to the Barren Collection at the University of Texas at Austin. I have also sold or traded some of this material over the years, primarily at the Franklin show and to friends in Texas. As the reclamation work began on the Butler-Weddington pits, I felt it my duty to make the location known to as many people as possible, in an effort to see as many specimens recovered before the area was made inaccessible. Having led several collecting trips to the area, including the Austin Gem & Mineral Society, the Houston Gem & Mineral Club, several University of Texas Geology professors, grad students, co-workers at the Bureau of Economic Geology, and friends from the Railroad Commission, I felt I had done my duty. In addition, I prepared and presented this paper at the 1996 Tucson Gem & Mineral Show, since the show theme was fluorescent minerals and calcite.

The minerals of the overburden spoil piles and open pits of the Karnes Uranium District are not mentioned in the mineral guidebooks of Texas, with the exception of one or two sentences in one of these, entirely missing the fluorescence and larger range of minerals present. The range in fluorescent colors in these minerals may possibly be the widest range outside of Franklin, New Jersey, and possibly one or two other world-famous

localities. I believe the range of fluorescent colors in the calcite crystals is the most diverse of any locality known to date. The range of crystal forms is also noteworthy, as is/was the ease of collecting. No detailed mineralogical studies have been published on these concretions. However, several USGS papers and one BEG paper do mention some of the minerals present in the area, and present a diagenetic scenario of their formation. Additionally, the May-June 1991 Rocks & Minerals magazine indexing Texas Mineral localities did note some minor aspects of a few minerals in this area on one page. These findings in my research helped me decide to prepare a more thorough paper on this important mineral locality.

## **HISTORY**

Karnes County was occupied by the Coahuilecan Indians prior to the arrival of Spanish and Mexicans in the 1500's-1600's. The area was a trading ground, which attracted many tribes. Also, the San Patricio Trail passes near Tordilla Hill. Later, the area was settled by Poles, Czechs, Germans, Swedes, English, Scots and Irish prior to Texas independence and annexation by the United States. The nearby town of Panna Maria (Holy Mary) is the oldest exclusively Polish settlement in the U.S. The Polish influence can be seen in the names of many of the towns (Kosciusco, Chestahowa) and the mine leases (Moczygamba, Korzekwa).

Each town has their own church rising majestically above the plains, and sometimes little else. Still, you can buy some excellent and reasonably priced smoked sausage in Kosciusco, and some of the best steaks and barbecue anywhere in Karnes City and nearby towns. One of my favorites was the famous D&D Steak House in Hobson. Anyone who worked in or visited the uranium operations was usually taken there at least once. They would serve one of the most deliciously prepared large sirloins upon a turkey platter. They had to be nearly 3 pounds and would usually melt in your mouth. Unfortunately, the D&D went the way of the uranium mines when the bust period hit.

The Karnes area was initially geologically significant for oil and gas resources, and only later for uranium. When minable amounts of uranium were discovered here, this opened up Coastal Plain Deposits as a new geological environment for uranium resources. The first economic uranium mining in Texas was at the Tordilla Hill prospect in Karnes County in 1954. Explorationists were trying to link radioactivity anomalies on aerial surveys to oil and gas deposits. The link between uranium and hydrocarbons maybe due in part to a reducing environment resulting from hydrocarbon migration along faults, causing the uranium to precipitate out of the oxidized, uranium-enriched groundwater. Earlier geological surveys in the area noted yellow uranium mineralization, but did not locate economic deposits.

The Boso Lease at the north foot of Tordilla Hill was the site of the first uranium mining. Eight tons of 3%  $U_3O_8$  was sent to the mill in Grants, N.M. in 1958. Overburden stripping was begun in 1959 by the San Antonio Mining Company (Climax/Molybdenum) at the Nuhn Lease (see Figure 2). The Wright-McGrady mines

were in operation from 1972-1974 as part of the Conquista joint venture of Conoco and Pioneer Nuclear. The Butler Mine was operated Susquehanna during the 1970's. Although the trend extends from near Panna Maria at the northeast end, nearly to Campbellton at the southwest end, most of the specimens and field studies were done at the above mines and much of the detailed geology will address this area. These mines were completed prior to regulatory requirements so little in the way of public records were available, with the exception of the papers by the USGS and BEG. Perhaps communication with Conoco personnel will provide additional specific mine statistics for a more detailed follow up paper planned by the author.

Between 1958, during the first ore mining at Tordilla Hill, and the early 1990's, several companies have operated more than 30 mines and 3 mills. The small remains of the once sizable Conquista mill, and the large spoil mounds are all that remain of the once bustling uranium industry in this area. Approximately 20 million pounds of uranium were mined from the Butler-Weddington mines alone, helping to make Texas the third largest uranium producing state in the U.S. during the boom period between the 1970's and 1980's. Most of the mining was accomplished by open pit operations, and a limited amount of solution mining. Both the more recent and older pits have all been reclaimed, with the exception of a few at the southwest end of the trend (1999). While they remain open, they serve as a grim reminder of pre-mining reclamation law for Texas. However, this also allows for the study of this potentially important mineral locality.

The Conquista Project began in 1967 with a series of radiometric surveys, and eventually employed over 400 people in the late 1970's. The ore bodies ranged from over several miles in length to a few hundred feet in width. Average depth was 53 meters, but did go to depths of 100 meters. The ore zones were typically not more than 3-4 meters thick. The Conquista Project was excavating about 20 million cubic yards of earth per year during the late 1970's, exposing one million tons of ore at a grade of less than 3 pounds of uranium per ton. The mill processed about 3200 tons of material daily in the production of "yellow cake", an enriched uranium oxide powder.

The market value for uranium was truly driven by demand, which in turn drove the exploration and production. The initial phase of uranium mining in Texas occurred in the late 50's and into the early 60's as the demand for nuclear weapons and technology grew. The success in finding new uranium environments and deposits caused the drop in the demand and price and caused the closing of the Susquahana-Western mill, which carried into the early 70's. The rise of the nuclear power industry caused the longest boom period from the mid-70's into the early 80's. Following the Three-Mile Island incident and the rising costs of complying with regulations, the industry took another downturn, with only the most efficient, richest operations and/or locked price contractors surviving to the present. Ironically, One of, if not the last operational open-pit uranium mine in Texas was in McMullen County (south of the Karnes District) where I was first introduced to uranium exploration and development in 1977. Unfortunately, a visit to the mine in 1990 indicated a far less interesting mineralogy here than in Karnes County as the ore is present in sediments younger than those in the Karnes Area.

Initial research in the Karnes District was initially conducted by the Atomic Energy Commission, and more importantly, by the USGS. The most notable authors being D. Hoyt Eargle, Alice Weeks, R.M.Moxham, J.A. MacKallor, C.M. Bunker and K.A. Dickinson. These papers were the first attempt at detailed mineralogy and petrology in the area. Especially noteworthy are those papers by Alice Weeks, USGS. Detailed studies of sedimentary depositional systems were later conducted by The University of Texas Bureau of Economic Geology on the major formations located within the South Texas Uranium Belt. These papers addressed paleoenvironments, geochemistry, structure and all other important geological approaches to characterize these formations as related to energy resources. The most notable authors for this work were William Galloway for the Catahoula and Oakville formations and W.L. Fisher for the Jackson Group. The only other research were individual M.S. and PhD. theses and the Department of Energy's National Uranium Resource Evaluation (NURE) program. The NURE program was unique in that it was the first and possibly the only program of its kind in which the entire nation was assessed for uranium potential. The scope was nothing less than gargantuan. I was fortunate to have worked on this program in Texas from the late 70's until the contract ended in 1981. This was truly regional work that coalesced aerial radiometric and magnetic surveys, stream sediment and well samples, log data and existing literature into as comprehensive a report as possible. The initial report for the South Texas trend by Bendix Field Engineering (John Quick, et al, 1977), was perhaps the first detailed assessment of the entire trend and was widely used at the time as a starting point for research in this area.

## **GEOLOGY**

The Karnes Uranium District is located on the northern end of the South Texas Gulf Coastal Plain Physiographic Province. The area is underlain by sedimentary deposits containing Tertiary fluvial, coastal, and redeposited and windblown volcanoclastic (tuffaceous) materials. The strata dip (generally <1 degree) and thicken southward toward the Gulf Coast geosynclinal basin. Oscillation of the shoreline resulted in interfingering of marine and nonmarine sediments. Major growth fault zones, approximately parallel to the coastline, have localized oil and gas and uranium deposits. Uranium and concretion mineralization occur at the fault hinge line, but are primarily a result of diagenesis and groundwater movement tuffaceous sandstone.

## **Stratigraphy**

Approximately 100 meters of strata were exposed in the deepest pits. The mineralized concretion-bearing overburden zones, unoxidized roll-front uranium ore bodies and source occur in three stratigraphic units: The Jackson Group of Eocene age and the unconformably overlying Frio Clays or Catahoula Formation of Oligocene age. Table 1 describes the stratigraphic sequence of a portion of the units for this mining area. A detailed description of the Wright-McGrady and Butler mines will follow, as the majority of work and specimens are from these mines.

The surface geologic maps (Crystal City Sheet-BEG, and USGS maps) indicate the southern/downdip portion of the mining district is overlain by Catahoula tuffaceous sandstone on the eastern side and Jackson Group Whittsett Formation sediments to the north and west. The lithology of the Whittsett Formation's Tordilla and Stone Switch Members are beach and fluvial host rocks composed of quartzose to feldspathic arenites. The beach sands are fine- to coarse-grained, moderate- to well-sorted, strike-oriented blanket sands. These are overlain by Fashing Clay member lagoonal and paludal mudstones rich in organics. The northern half of the district contains fluvial feeder channels containing fine to coarse channel lenses, trending to the southeast. These are in turn overlain with wind- and river-borne, tuffaceous Catahoula Sandstone.

The Catahoula Tuff is a trachytic-andesitic ash deposited in near-shore, fluvial and interfluvial environments, and later weathered and diagenetically altered over time to form not only the underlying uranium ore deposits, but also the various concretion-bearing zones. The Catahoula is believed to be the major source of mineral-forming elements. These sediments likely covered the entire mining area, has reached thickness' of several hundred meters, and can be compared to the thick, recent ash-falls of Mt. St. Helens. The source for the ash was western Texas and Mexico.

One controlling factor for mineralization in the Whittsett Formation is whether the Frio Clay, a downdip marine clay facies, is present to separate the Catahoula and Whittsett units. Where present, the Jackson is typically not mineralized. The Frio is mostly absent in the Karnes area, with the exception of the Rosenbrock Mine, the furthest downdip mine in the main area. Here, the Frio is not more than 15m thick, but the uranium was transported by way of the Fashing Channel, a paleochannel facies.

### **Summary of Concretionary Zone Geology**

The diagenesis of the tuffs resulted in alteration to smectitic and montmorillonitic clays, while a mineral enriched, alkaline groundwater migrated through the sediments. When these oxidized waters migrated and pressure was released, carbon dioxide escaped, precipitating calcite. Concretions were formed by precipitation of calcite, micrite and silica layers around a nucleus, or as wave fronts without nuclei. Most of the concretions are flat ellipsoid, rounded, or botryoidal clusters of dense, and occasionally siliceous micrite. Change in pH from organics caused the uranium and other minerals to precipitate out of groundwater, and later groundwater migration redissolved the uranium and redeposited it lower or downgradient of the more stable mineralized concretion zones. The combined effects of changes in rainfall, temperature, sea level, volcanic activity, and erosional processes contributed significantly to the mineralization process. When mining operations reshuffled and exposed sediments to near-surface conditions, additional diagenesis and mineralization occurred. This process is indicated by the crust of gypsum crystals seen on some concretions, on the surface of the spoils, and as sheets throughout desiccation cracks and fractures in the spoils. The gypsum appears to be the last mineral to form, always appearing as overgrowths inside the concretions. There are also overgrowths of various calcite, barite and quartz.

The concretions are present in what most of the literature refers to as the upper Jackson clay and sandstone members and up into the younger Frio or Catahoula clays. The Conquista Clay is the lowest unit that contains the concretions. Here they are reportedly found in sand stringers within the upper zone. They are up to 3' diameter and also have petrified wood within the same member. The concretions were reportedly composed of a dense core and outer zone of radially oriented aragonite prisms or wedges. I have found a couple of these in the Wright-McGrady area. They are slightly flattened along bedding, as are many of the concretions (Photo \_\_). The overlying Tordilla and Deweesville Sandstone members also contain petrified wood and nodules with a hard bluish-gray silicified core of chalcedony, one of which I found in the Butler area. The silicification of the wood occurred shortly after burial, as there is little distortion of the grain.

The more exotically mineralized concretions are primarily found within the overlying clays that are typically classified as either the Fashing Clay member of the Whittsett Formation, Jackson Group or the Frio/Catahoula clays. There is still some question as to what formation these are actually part of, but the fossil shells are a clear indication of a near shore, probable bay environment. Some of the concretions reach many feet in length, the largest I've seen being some 4'. The concretions within these clays are typically either flattened, elongated, and chambered looking (Photo \_\_), rounded, botrioidal-looking masses, or singular round spheres in shape. Most appear to have mudcrack-like raised patterns (sometimes referred to as basket-weave pattern) on the outer surface, and a radiating structure within. The insides also have differing geometry, many having concentric outer and inner cavities, or central cavities without any apparent pattern, and still others that are very nearly solid. Crystal growths are typically plain calcite or quartz and calcite with either gypsum, quartz, barite or minor occurrences of pyrite or uranium minerals growing on top of the calcite crystals. Often there are two or more episodes of calcite crystallization, typically with larger and different forms and/or colors on smaller crystals. Many of the concretions also contain manganese dendrites on fracture surfaces within the concretions. Some of the quartz concretions are septarian or very nearly so (Photo \_\_). There are also some solid sandstone and micrite concretions that have no cavities or crystals, and may comprise up to 20% of all concretions. Not all concretions have readily apparent attributes, such as large, well formed or colored crystals present, but they may have impurities that cause them to fluoresce a different color or shade than the others, or quartz coatings over calcite may create some interesting fluorescence also.

Crystal-bearing concretion zones are primarily limited to the downdip, southern portion of the Karnes District, overlying the strike-elongate, barrier bar beach facies and unoxidized ore zones. The beach facies is about 1 to 2 miles wide, but stretches the entire length of the Texas Coastal Plain. The concretions occur in 2 to 6 zones, with the Weddington Mine area having the greatest number of these zones and concentration of concretions. These zones are between 3 and 30 meters below surface and are entirely in the paludal-lagoonal facies of the Fashing Clay Member of the Whittsett Formation. The major exception is the downdip Rosenbrock Mine, where the Fashing fluvial channel is the likely conduit to transport mineralizing waters away from the main trend, thus providing a slightly different mineralogy. Here, silicified logs, concretions and septarian

nodules containing calcite, quartz and pyrite are present in the overlying Catahoula Formation and Frio Clay. These units contain concretions in the upper 45 to 60 meters below surface, and are reportedly often fluid-filled (Weinzapfel, A., 1981). There are additional reports of mineralized concretions in the Felder Mine in Live Oak County, near Three Rivers, which is even further down dip and higher in the stratigraphic section. The author did not notice any during visits to that mine in the early 1980's, but one colleague has specimens he says are from this deposit. One interesting study would test the areas in between the Felder Mine and the Karnes District to determine whether the mineralized concretions are limited to the areas directly over the mines, or are prevalent throughout these formations.

A similar sequence of calcite and barite-containing concretions occurs in the Black Hills of South Dakota and several other uranium-bearing areas associated with tuffaceous sandstone in the Western United States, where uranium occurs in carbonate-poor sandstone adjacent to carbonate-rich sandstone. An article in the March-April 1987 Mineralogical Record addressed barite and calcite enriched concretions in Elk Creek, South Dakota. The author has also seen honey-colored calcite rhombs from the formerly-Exxon Highland uranium mine in Wyoming. A summary of units and areas in the Western United States where concretions are associated with uranium include:

- ◆ Elk Creek, South Dakota
- ◆ Pumpkin Buttes, Powder River Basin, Wyoming
- ◆ The Highland Mine, Wyoming
- ◆ The Inyan Kara Group, South Dakota
- ◆ The Pierre Shale, Kansas, Colorado, South Dakota and Wyoming
- ◆ The Phosphoria Formation, Idaho
- ◆ The Lakota Sandstone, South Dakota
- ◆ The Edgemont District, Colorado
- ◆ And possibly the Chadron Area, NW Nebraska

Perhaps more research and comparison will prove this as a new class of mineralization process occurring worldwide. It would be interesting to see if some of the overseas uranium deposits in Australia, Russia, Antarctica, and other locations have similar mineralized concretions associated with them.

## MINERALS

Table 1 lists all the minerals identified to date for this report, and includes those noted in the literature (\* indicates those found by author), fluorescent and phosphorescent colors, and crystal forms.

**TABLE 1**

<u>Mineral</u>	<u>Fl color</u>	<u>Pfl color</u>	<u>Crystal forms</u>
Calcite*	Yellow Red-pink		Rhombohedron Dogtooth(simple truncated)

	Purple	scalenohedron)
	Orange	complex,twinned scaleno)
	Green-yellow	Complex rhombohedron
		Rhombohedral, stalactic,
	White-blue	Drusy, radiating prisms
<b>Quartz*</b>		
Amethyst	NF	Hexagonal, simple
Clear	Green,Cream/white	Hexagonal, simple
Chalcedony	Green	Drusy
Opal-Agate/Petrified	Green	Wood structure
<b>Gypsum *</b>	NF to Cream(rare)	Monoclinic-numerous simple and complex shapes
<b>Barite *</b>	Yellowish green(odd shade)	Orthorhombic,thin tabular single, divergent groups
<b>Pyrite*</b>	NF	Cubic, some twins
<b>Marcasite*</b>	NF	Cubic, some twins
<b>Uranium*</b>		
Autunite, Meta-autunite,uraninite, coffinite, others	NF to green	Cubic to grainy and filmy
<b>Heulandite/clinoptilolite ?</b>		Radiating
<b>Pyrolusite*</b>	NF	Dendritic coatings on fracture faces

Molybdenite, Mourite, Phillipsite, powellite, psilomelane, selenium, carnotite, coffenite, jarosite, ilsemannite, schoepite, tyuyamunite, uranophane (Smith, A. E., 1991)

### **Calcite, CaCO<sub>3</sub>**

Calcite is by far the most abundant and diverse mineral in the concretions. Most every mineralized concretion contains calcite crystals. The crystal habits range from numerous simple and twinned forms of rhombohedrons, scalenohedrons, pinacoids and druses of finer crystals, the largest and most abundant of which are the rhombohedrons. Most crystals are moderately to highly lustrous but many that are exposed to the intense Texas sun become dull. Some rhomb intergrowths and twins form fishtails or appear elongated due to the corners growing together. One concretion has stalactic masses of rhombic crystals hanging down into the inner cavity. Some crystals have striations or curved faces. Individual crystals range from microscopic to about 1 inch across.

Most concretions are limey or siliceous micrite, aragonite or sandstone/tuff in composition, and have an internal appearance of an outer cavity typically extending most of the circumference, and a rounded or flat inner core connecting to the outer cavity by numerous and often radiating cavities. The outer structure of the concretions is typically rounded or ellipsoid and can be either individual or clustered. Many show a mud crack type of pattern of ridges surrounding flat areas (sometimes referred to as a basket-weave pattern). Black dendrites (probably pyrolusite) are sometime present along fractured faces of the concretions. Color is typically various intensities of clear to cloudy honey yellow, although some whitish, clear and canary yellow crystals are present. Occasionally internal crystal zonations and inclusions of an untested mineral are present, with the inclusions likely being an iron mineral, giving the crystal a rusted appearance. An interesting link appears present in the area between crystal forms and fluorescence. The rhombic forms always fluoresce various shades of yellow, cream and white, with the drusey masses or coatings fluorescing a whitish-blue, while the scalenohedrons fluoresce red/pink or purplish, and the more complex forms fluoresce orange. Some of the cream to white fluorescing rhombs and druses also phosphoresces the same. When clear quartz crystals form on top of the calcite, this results in bright yellowish to white bands on the exposed edges and odd colored shades of yellow to cream showing through the quartz.

Usually there appear to have been at least two growth periods, as evidenced by larger crystals situated on small ones and overgrowths of either quartz, gypsum, barite or pyrite. The calcite appears to have formed first and sometimes has undergone several growth sequences, but I have yet to see differing crystal habits as overgrowths. Chemical and crystallographic analyses have not been conducted as of yet and will be included in a more intensive study of the specimens.

## **Quartz, SiO<sub>2</sub>**

Quartz is the next most abundant and definitely most diverse of the minerals. It occurs as petrified wood and also in the concretions as clear crystals, drusy quartz, chalcedony and even pale amethyst crystals. Most of these occurrences are overgrowths on calcite, which provides for some odd fluorescent effects. The drusy variety also fluoresces and phosphoresces. A few rare occurrences of light blue transparent crystals in septarian nodule form were found in the now reclaimed Rosenbrock mine, while the pale amethystine variety has been found in both the Wright-McGrady and Butler mines.

Crystal size ranges from opalized wood up to individual crystals about ¼ inch. The crystalline varieties have the typical vitreous luster, the druses tend to have a sparkle effect, and the chalcedony is a dull gray. Much of the wood has either a dull, waxy or vitreous luster. Crystal habits are all the common quartz hexagonal basal pinicoid form. No twinning has been observed to date. The amethysts and septarian nodules are the most exotic and attractive forms, while the chalcedony makes a nice contrast of green against red/pink calcite under ultraviolet light. Both the septarian crystals and petrified wood fluoresce green under short wave UV. I have also seen one concretion of clear quartz crystals having a dusting of fine pyrite crystals, but the person who collected this

from the Rosenbrock mine refused to part with it and I have long forgotten his name.

### **Gypsum $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$**

Gypsum is nearly as abundant as quartz and occurs in more forms than I have ever seen. At times I wonder whether each occurrence has its own specific crystal form. The crystals within the concretions form as overgrowths on the calcites and are sometimes encrusted with chalcedony. There is also a crust of gypsum that commonly evaporates at the surface in flat, mat-like masses, and along spoil and sediment fracture surfaces.

The gypsum inside the concretions are mostly water clear to the point they can be difficult to see on the buff colored micrite groundmass that comprises the concretions. This is truly a shame, as the various crystals are outstanding. Some concretions also contain gypsum that encrusts limonitic stained material and has a rust color. I truly do not know where to begin with the various crystal habits, but many are blocky to elongated prisms, typically twinned into incredible forms and even curved and striated faces are very common. A few specimens of "ramshorn" and rose gypsum have been found, and are typically small in size. Some crystals can be cut with a knife and have the resultant "peeling" effect occur as the crystal bends away from the cut. Individual crystals range in size from microscopic to  $\frac{1}{2}$  inch, while elongated twinned clusters can reach nearly 1 inch. The crystals have a vitreous luster, while only one of the gypsum has been observed to fluoresce to date, a pale cream color.

### **Barite $\text{BaSO}_4$**

Barite is the least abundant of the minerals that can readily be found. It occurs solely within the concretions as an overgrowth on calcite. Crystals range in size from  $\frac{1}{10}$  inch to 1 inch. The barites have a vitreous luster and are typically honey color to clear, and less commonly gray, white, or blue. Crystals are either clusters or individual platy forms, and often form in fan shaped clusters against each other or in sheaf-like clusters. Most of the honey colored plates are cloudy while the clear crystals are transparent. Some of the barites fluoresce an odd, washed out yellowish-green color under short wave UV. Few twinned habits have been observed in barites from this area, and at least one occurrence of barite overgrowing a rectangular mineral (possibly uranium). The barite usually makes a nice color contrast against the calcite.

### **Other Minerals**

The uranium minerals and the zeolite hulendite/clinoptilolite are often referenced in the literature and are likely very abundant, however I have not made an effort to include these minerals that typically occur within the ore mineralization zone. Pyrite and marcasite are also found as a fine dusting of crystals in the area, but I have only seen three such specimens. Other minerals are also likely present and will be included within the scope of a more technically oriented study I am hoping to undertake should funds become available.

## **DISCUSSION**

The formation of the minerals in the overburden as well as the ore have been detailed by other authors and were briefly addressed in this paper. However, one issue that has not been adequately addressed by earlier authors is how this mineralization environment should be classified, and there has been no comparison with other similar deposits. Therefore I am proposing a new sub-category within sedimentary mineral environments – “volcanoclastic diagenesis”, in which the climate is as important as the sediment composition. In this environment, alternating wet and dry periods in a relatively warm temperature zone is required to cause optimal mineralization. The sediments must also have sufficient depositional structure, sediment and groundwater chemistry to provide the right near-surface diagenetic environment. A sort of intensified, or hyper-calichification process, if you please. I hope this hypothesis will cause others with knowledge of similar deposits to come forward and provide additional information or support for such a classification.

Another issue that has not actually been addressed prior to this paper, and which I am indebted to Tim Jackson for, is the presence of Frio sediments considerably further updip, and well into the mining area, more so than is previously indicated on geologic maps and cross-sections. I believe these sediments account for some of the diversity and mineral zonations in the area. This can readily be seen by comparing the sediments in the Wright-McGrady verses the Butler-Weddington pit areas. Additionally, the Rosenbrock mineral assemblage and crystal forms were considerably different than the other pits, and was the farthest downdip pit in the area, being well into the Catahoula-Frio sediments. These sediments are more clayey and contain thicker sequences of tuffs. It is also important to note a thicker and more extensive updip section of the Catahoula-Frio sediments have been eroded, thus providing considerable mineralized waters to migrate and diagenetically alter in the deeper sediments during alternating periods of deposition and erosion in near-shore, regressive/transgressive phases of the gulf waters.

Whether this locality is the second best fluorescent mineral locality, and possibly the best fluorescent calcite locality known, is also up for discussion. In my travels, research and experience, I am not aware of a more diverse color range outside of Franklin, New Jersey. I should greatly appreciate it if someone would inform me on specific localities that are superior, as I have not seen them addressed in the literature and would very much like to visit them or perhaps arrange a trade to further my collection of fluorescent minerals. At any rate, I feel comfortable in saying that any updated versions or new authoritative works on fluorescent minerals will have to address the minerals of the Karnes Uranium District to be complete.

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