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Cover Picture

SAND-BARITE ROSETTE—OKLAHOMA'S STATE ROCK

Oklahoma's sand-barite rosettes, also popularly known as "barite roses" or "rose rocks," consist of reddish-brown sandy crystals of barite ($BaSO_4$) in petal-like clusters that resemble a rose in full bloom. These distinctive concretions, common in central Oklahoma, were designated the official State rock on April 8, 1968, when Governor Dewey F. Bartlett signed House Bill 1277. Most rosettes are 0.5 to 4.0 inches in diameter and have 5 to 20 radiating plates, although the largest one known is 17 inches across and 10 inches high and weighs 125 pounds.

The Oklahoma rosettes occur primarily in the Permian Garber Sandstone and are concentrated in a narrow belt that extends 80 miles through central Oklahoma between Pauls Valley and Guthrie. Barite was precipitated in interconnected voids, probably from barium-rich marine waters that covered the sand during or shortly after its deposition, and the concretions incorporated quartz sand grains, thus acquiring the red color of the host rock. Because they are more highly cemented than the host rock, the rosettes weather into positive relief on outcrops or are found scattered in a residual sandy soil.

Barite roses are also reported from California, Kansas, and Egypt, but they are probably more abundant in Oklahoma than elsewhere in the world.

This description is taken mainly from Oklahoma Geological Survey Circular 23, *Barite in Oklahoma,* by W. E. Ham and C. A. Merritt.

—Kenneth S. Johnson

(Photograph by T. W. Amsden)

Meteorologic and Hydrologic Relationships on the Great Salt Plains of Oklahoma

Johnnie L. Davis*

In an investigation of the conditions affecting the growth of "hourglass" selenite crystals on the Great Salt Plains in Alfalfa County, Oklahoma, I collected basic field data during the period June 17-30, 1968. As crystal growth is a precipitation phenomenon, the investigation included the measurement of the various factors that would enter into such a process—ground-water levels; salinity, temperature, and acidity of the ground water; and temperature and relative humidity of the atmosphere. The period of the field work was too brief to yield sufficient data for the primary objective of the investigation. Nevertheless, data collected on ground-water levels and on temperature and relative humidity of the atmosphere display interesting and apparently correlative diurnal patterns that may be significant.

The Great Salt Plains covers an area of 14,000 acres in Tps. 26, 27 N., Rs. 9, 10 W., along the south side of the Salt Fork of the Arkansas River. Average annual precipitation is approximately 26 inches, and the potential annual evaporation is 80 inches. The plains is a deltaic river deposit of varied and intertonguing layers of clay, sand, and gravel. The maximum known thickness of this deposit is 27.5 feet. The southeastern part of the original plains is inundated by by the Great Salt Plains Reservoir, which is impounded by a dam on the Salt Fork in sec. 11, T. 26 N., R. 9 W. The surface of the plains slopes downward toward the east from an elevation of 1,140 feet to 1,125 feet, with gradients of 4 to 7 feet per mile. The bedrock beneath the plains deposits appears to have an average gradient of between 1.5 and 2 feet per mile.

The ground water of the Great Salt Plains is highly mineralized, containing concentrations of chloride, sulfate, calcium, and sodium that approach or exceed saturation. Evidently much of the ground water comes from deeper formations in the Permian bedrock, where salt and gypsum beds provide the contaminants. Because of the high dissolved-solids content of the water, salt and gypsum crystals are being actively precipitated on and just below the surface of the plains. Rainfall runoff, which dissolves these crystals, and ground-water movement transmit large quantities of dissolved solids to the water of the Salt Fork and create a serious natural pollution hazard that is carried to the Arkansas River. For this reason, the hydrology and geology of the Great Salt Plains are being investigated by the U. S. Army Corps of Engineers, with the Oklahoma Geological Survey cooperating in the stratigraphic aspects of the study.

The data-collecting sites were in T. 26 N., R. 10 W., in the southwestern part of the plains where the selenite crystals seem to be most abundant (fig. 1). The area includes the selenite-collecting locality,

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the only place on the plains where excavation for crystals is permitted. The three sites pertinent to this report are listed below; observation times were on Central Daylight Savings time.

Site A. Water-level measurements; NE¼ NW¼ NW¼ sec. 27. Data recorded June 17-30, 1968 (fig. 2). A 6-foot length of 1¼-inch (ID) pipe with an 18-inch sandpoint was driven 68 inches into the ground, with 21½ inches exposed above ground. The pipe was slotted with a ⅛-inch opening to a depth of 3 feet below land surface and gravel-packed throughout this interval to allow rapid movement of water into and out of the pipe. Measurements were made with a ½-inch-diameter calibrated dowl at irregular time intervals.

Site B. Temperature-humidity measurements; SW cor. NW¼ NW¼ NW¼ sec. 23. Data recorded continuously June 24-30, 1968, on a 176-hour Friez recording hygrothermograph (fig. 3). Site was on the plains near the selenite-collecting locality, approximately 1.2 miles from the edge of the plains.

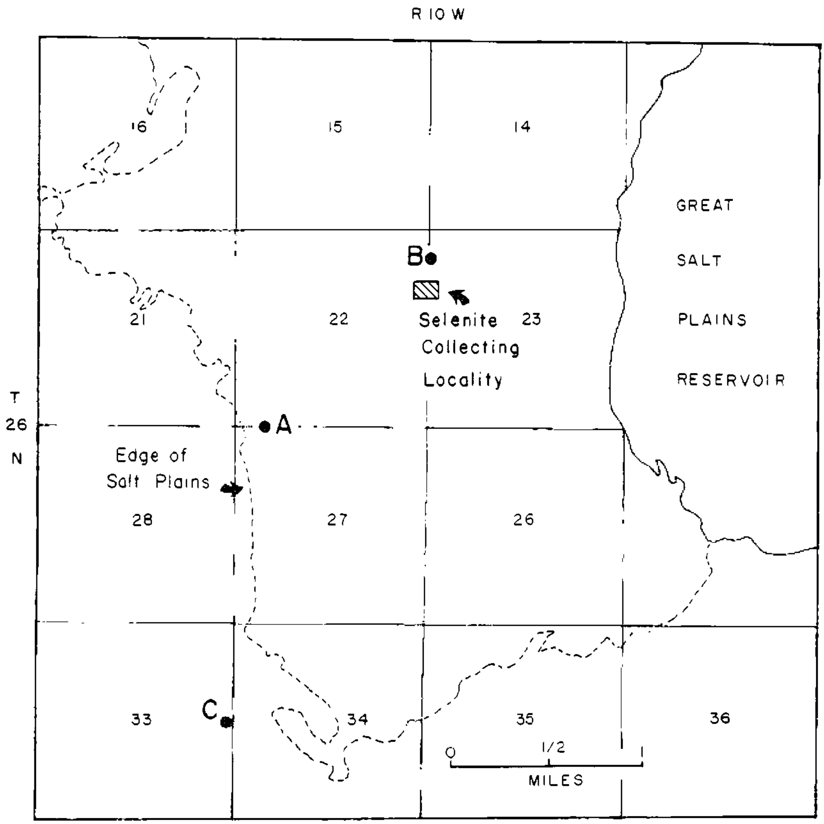


Figure 1. Map showing locations of data-collecting sites on the Great Salt Plains. Water-level measurements were made at site A. Hygrothermograph recordings were made at sites B and C.

Site C. Temperature-humidity measurements; NE cor. SE¼ sec. 33. Data recorded continuously June 24-30, on a 176-hour Friez recording hygrothermograph (fig. 3). Site was southwest of the plains, approximately 0.4 mile from its edge and 2.6 miles south-southwest of site. B.

Ground-water levels in the Great Salt Plains range from 0 to 5 feet below land surface. At site A, the maximum depth to water recorded during the period of observation was nearly 15 inches. Figure 2 is a hydrograph constructed from the water-level measurements. Except for the curves of June 19, 25, and 30, the daily curves show a typical pattern, with water-level fluctuations of 3 to 4 inches. Greatest depth of water occurred between 8 AM and 10 AM and the least between 6 PM and 8 PM or 7 PM and 9 PM. The curves for June 19 and 25 show the effect of heavy rainfall directly on the plains; that for June 30 was apparently affected by a passing thunderstorm, but other unknown factors may have contributed to its anomalous shape.

The traces of the two hygrothermographs at sites B and C are superimposed on one chart in figure 3. The black lines are for site C, in the area off the plains, and the brown lines are for site B, the area on the plains. The temperature traces closely parallel each other, with the temperatures recorded on the plains ranging from 4° to 15°F higher than those off the plains. The relative-humidity traces show a contrary pattern and cross each other perodically; brown shading between the humidity traces denotes periods when the relative humidity on the plains was lower than that off the plains.

The "crossovers" of the humidity traces show that some interesting and not fully understood conditions exist on the plains. When the air over the plains is drier than the air moving in from the surrounding area (the time periods indicated by the brown shading), moisture is being removed from the air, probably by deliquescence of the highly soluble salt on the surface of the plains. When the reverse is true, evaporation on the plains is adding moisture to the air. These alternating periods of dehumidification and evaporation show an anomalous pattern. Dehumidification occurs generally between noon and midnight, at times when the air temperature is high and the relative humidity is low; conversely evaporation occurs at low temperatures and high humidity. These relationships are directly contrary to what should be expected and are not fully understood at this time.

Reversals in water-level trends appear to correlate directly with the periods of evaporation and dehumidification, indicating that these are the principal agents that produce or are otherwise intimately related to diurnal water-level changes. However, the reversals precede the humidity crossovers by a few hours; the water level begins to rise about 2 hours before the inception of dehumidification and begins to decline about 3 hours before the inception of evaporation. This precession phenomenon is evidently a result of recharge and discharge by the lateral movement of the ground water. Toward the end of the evaporation cycle, the discharge by evaporation is lower than the recharge by lateral movement, causing the water level to begin rising before dehumidification begins. Similarly, toward the end of the dehumidifica-

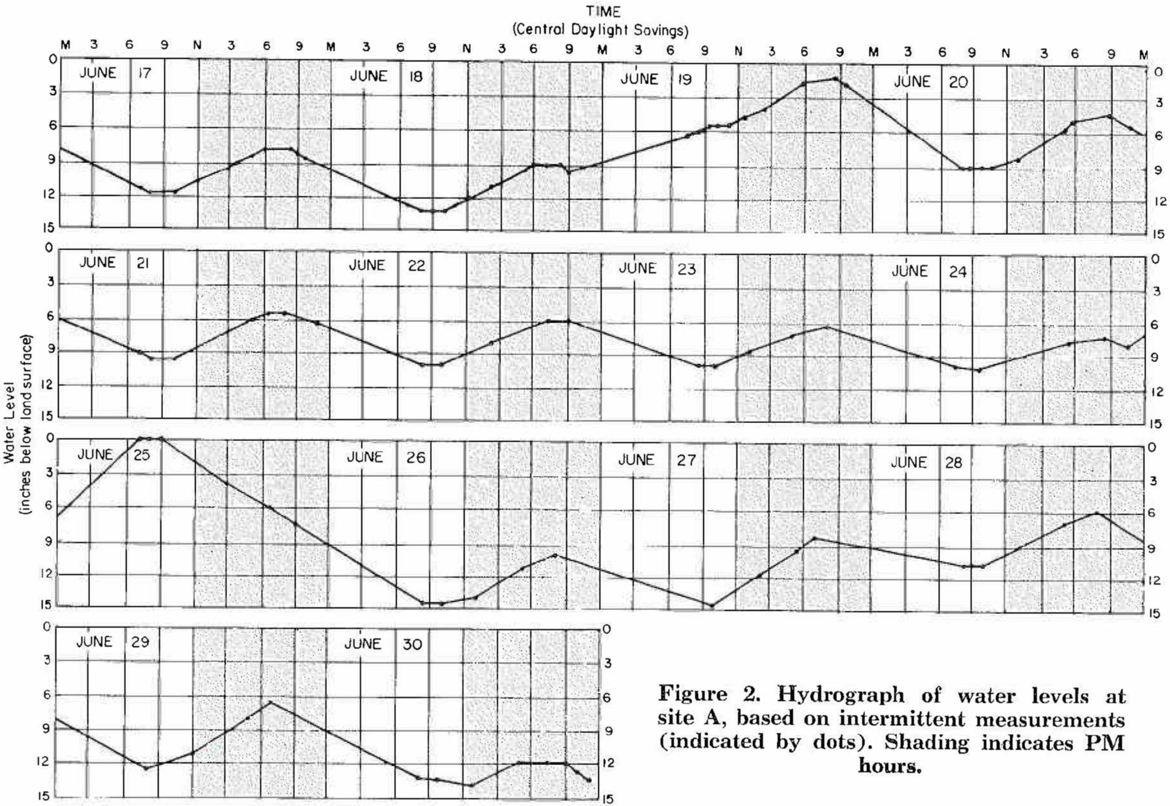


Figure 2. Hydrograph of water levels at site A, based on intermittent measurements (indicated by dots). Shading indicates PM hours.

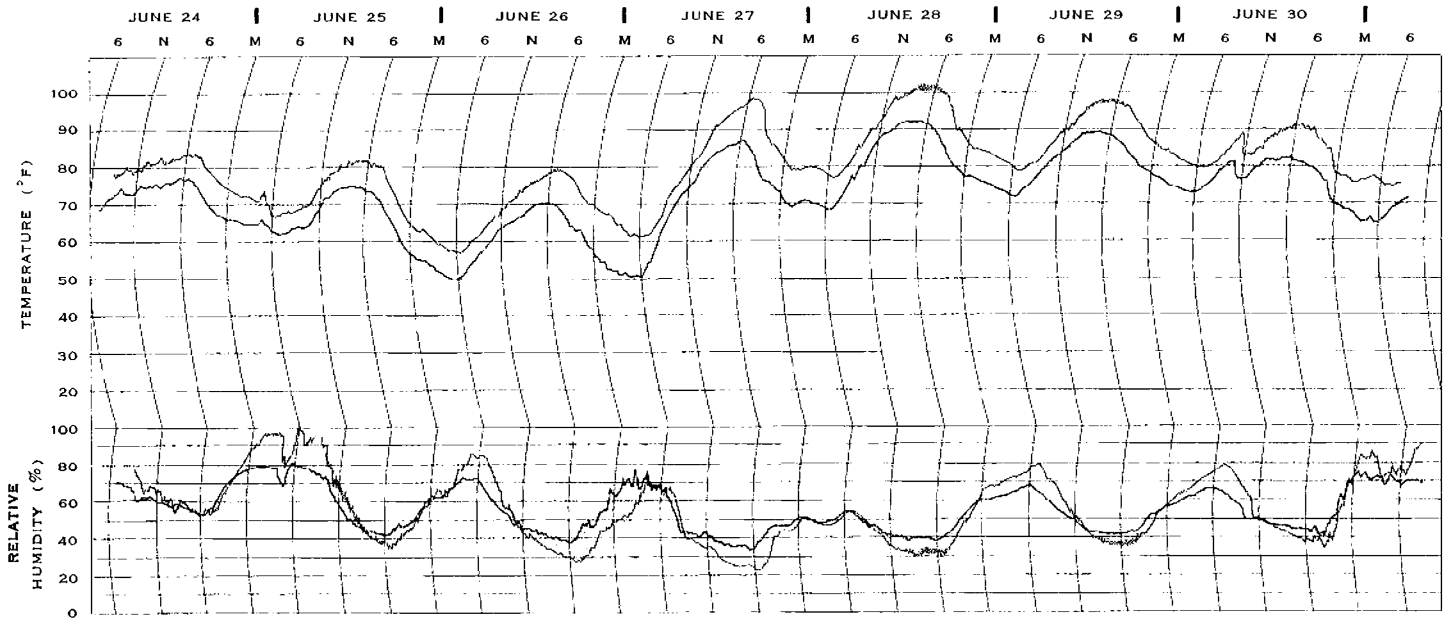


Figure 3. Hygrothermographs of sites B and C. Brown traces are for site B, black for site C. Brown shading indicates periods when humidity on the plains was lower than that on the surrounding area.

tion cycle, recharge by dehumidification is lower than discharge by lateral movement, and the water level begins to decline.

More data and a much longer period of observation are needed to verify the observations made in this report. However, it is noteworthy that such a small quantity of data can yield patterns and relationships that are so strongly evident. For this reason, a more detailed investigation will undoubtedly yield significant results.

I am indebted to W Farrin Hoover, East Texas State University, who supervised the selenite study from which this report is abstracted; to Tom Gay and Gene Gilbert, U. S. Army Corps of Engineers, Tulsa District, who provided hydrologic and geologic information used freely herein; and to Herbert R. Smith, project engineer, Great Salt Plains Dam, who provided climatological and other data. This study was done with the approval of the Oklahoma Bureau of Sport Fisheries and Wildlife.

Revision of Quarternary Nomenclature

The term Holocene has officially replaced Recent in nomenclature usage of the U. S. Geological Survey. The term was adopted following a recommendation by the Geologic Names Committee, which met in January to discuss Quaternary names. It has also been formally accepted by the Association of American State Geologists during their annual meeting in May.

Holocene means "wholly recent" and refers to the percentage of living organisms. Originally proposed as a stage following the Pleistocene by the Portuguese committee to the Third International Congress of 1885, it has been widely used in Europe in preference to Recent. Objections to the formal term Recent have been raised by many American geologists, who have found it ambiguous when referring to Recent or recent time.

The term Recent was first used by Lyell in 1833 as a part of the Pleistocene. However, the Pleistocene was restricted to exclude the Recent by Forbes in 1846 and by Lyell in 1873.

In adopting Holocene, the Survey has given it a series rank equal to Pleistocene "because both vertebrate and invertebrate faunas reflect marked changes between Pleistocene and Holocene Epochs, and the archeological record provides means for subdividing Holocene deposits."

Petrochemical Plants in Oklahoma, 1968

Petrochemicals are the chemicals derived from petroleum, natural gas, and natural-gas liquids. They are obtained by various cracking and re-forming processes, by chemical synthesis, and by efficient methods of fractional distillation in refining. Byproducts of many refining processes provide the raw materials used to produce petrochemicals. Some of the principal petrochemicals are polyethylene,

ethylene, ethyl alcohol, benzene, toluene, and xylene. Inorganic chemicals derived from petroleum and natural gas include ammonia, carbon black, and sulphur.

Ten petrochemical plants, listed below, are currently operating in northeastern, north-central, and south-central Oklahoma; they produce benzene, ammonia, propylene tetramer, toluene, acids, sulphur, carbon black, and other products. The number of active plants in Oklahoma has more than tripled in the past nine years, and the prospects are bright for continued growth of the State's petrochemical industry.

Bareco Wax Division (Petrolite Corp.), Barnsdall
Feed: petroleum hydrocarbons and chemicals
Products: microcrystalline waxes

Cherokee Nitrogen Co., Pryor
Feed: natural gas, urea
Products: ammonia (160 t/d), nitric acid (180 t/d), ammonium nitrate (150 t/d), and urea-ammonium nitrate solutions (240 t/d)

Continental Carbon Co., Ponca City
Product: carbon black

Continental Oil Co., Ponca City
Feed: benzene, naphtha fraction, propylene
Products: benzene (350 b/d), cyclohexane (40,000,000 gal/y), propylene tetramer, and toluene-xylenes mix (1,200 b/d)

National Fuels Corp., Madill[1]
Feed: H_2S
Product: sulfur (8 lt/d)

Nipak, Inc., Pryor
Feed: natural gas
Products: ammonia and urea (feed and fertilizer grade)

Nipak, Inc., West Tulsa
Products: ammonia and di-ammonium phosphates

Sinclair Petrochemicals, Inc., Sand Springs
Feed: petroleum fractions
Products: demulsifying agents, corrosion inhibitors, acid-layer-type petroleum sulfonate (sodium salt), and oil-layer-type petroleum sulfonate (sodium salt)

Sunray DX Oil Co., Duncan
Feed: refinery gases
Product: propylene tetramer (700 b/d)

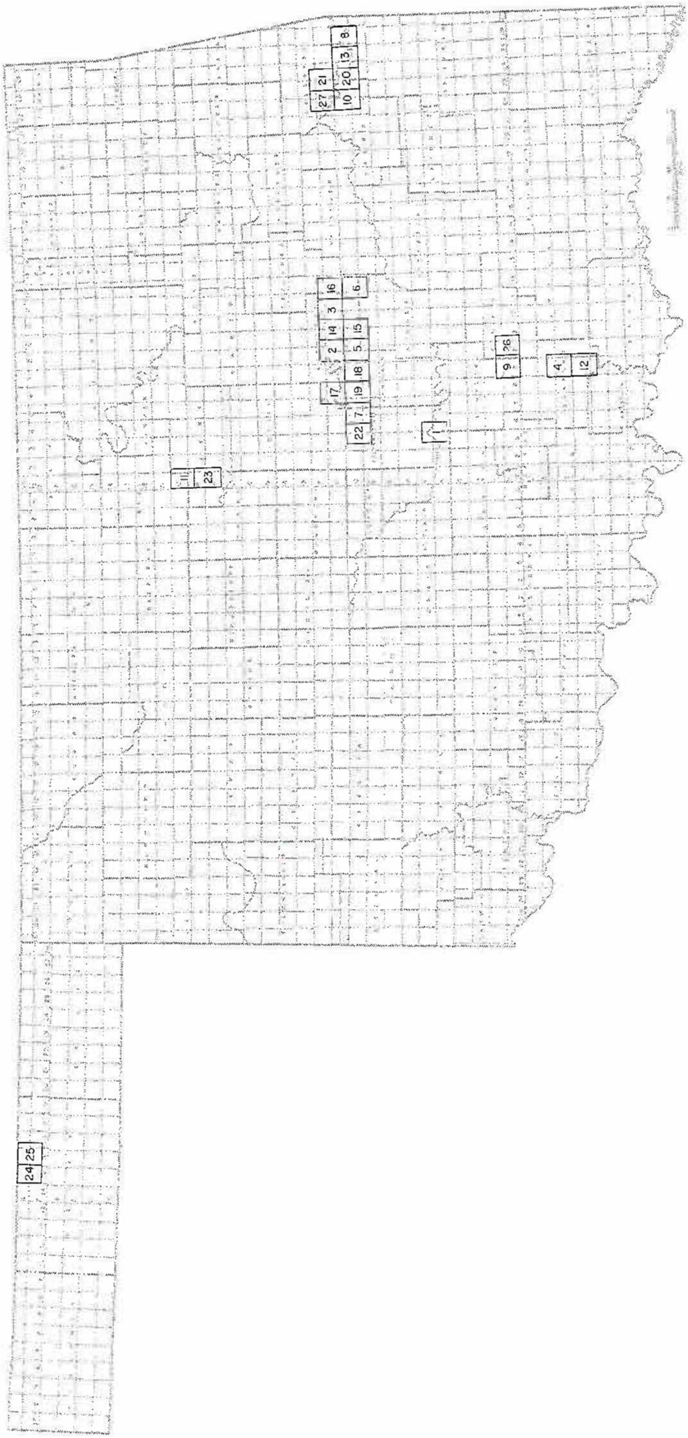
Sunray DX Oil Co., Tulsa
Feed: light Platformate
Products: benzene (1,700 b/d), and toluene (captive)

Abbreviations used:

t/d = short tons per day — b/d = barrels per day
lt/d = long tons per day — gal/y = gallons per year

[1] Plant formerly operated by National Sulphur Co.

Source: **Oil and Gas Journal**, vol. 66, no. 36, September 2, 1968, p. 105-135.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Recently Published Oklahoma Topographic Maps

Carl C. Branson

New Oklahoma topographic maps have recently been issued by the U. S. Geological Survey; all are 7½-minute quadrangles at a 1:24,000 scale, with 5- or 10-foot contour intervals. The maps published since February are listed below in alphabetical order, with county locations in parentheses; number refers to location on the index map, opposite page.

1. Asher (Pottawatomie, McClain, Pontotoc)
2. Boley (Okfuskee, Seminole)
3. Clearview (Okfuskee)
4. Connerville SE (Johnston)
5. Cromwell (Seminole, Okfuskee, Hughes)
6. Dustin (Okfuskee, Hughes)
7. Earlsboro (Pottawatomie, Seminole)
8. Fort Coffee (Sequoyah, Le Flore)
9. Harden City (Pontotoc, Coal)
10. Keota (Haskell, Sequoyah)
11. Lake Carl Blackwell (Payne, Noble)
12. Milburn (Johnston, Marshall)
13. Muldrow SW (Sequoyah, Le Flore)
14. Okemah (Okfuskee)
15. Okemah SE (Okfuskee, Hughes)
16. Pharoah (Okmulgee, Okfuskee)
17. Prague (Pottawatomie, Lincoln, Seminole)
18. Prague SE (Seminole)
19. Prague SW (Seminole)
20. Robert S. Kerr Dam (Le Flore, Haskell, Seminole)
21. Sallisaw (Sequoyah)
22. Shawnee (Pottawatomie)
23. Stillwater SW (Payne)
24. Straight (Texas)
25. Straight NE (Texas)
26. Tupelo (Coal)
27. Vian (Sequoyah, Haskell)

Twenty-two additional maps are at the advance-proof stage and can be expected to be published soon. An index map of topographic maps of Oklahoma dated April 1968 is available from the Oklahoma Geological Survey free of charge.

Pennsylvanian *Synbathocrinus* from Oklahoma

Harrell L. Strimple* and Melba L. Strimple

The species *Synbathocrinus melba*† Strimple has been represented by a single specimen (the montoype) found by the junior author in a crinoid zone of the Wann Formation, exposed in the northeast flank of the hill called "Bartlesville Mound" on the Osage-Washington county line at the western edge of Bartlesville, Oklahoma. The point of collection is in Osage County in an outcrop that was temporarily exposed by a pipeline excavation. The original description was published privately by the senior author in 1938 and reprinted with the addition of camera lucida drawings in 1959.

Most species of *Synbathocrinus* are found in Mississippian rocks of North America and Europe, but a few occur in the Devonian and some come from the Permian of Timor. The monotype of *S. melba* has been the only specimen of the genus described from rocks of Pennsylvanian age in North America. Because of the rarity of the form, a second specimen, recovered from a shale above the Torpedo Sandstone Member of the Wann Formation, is figured herein, even though it is incomplete.

The new specimen was found in washed residue from shale collected on the bluffs above Sand Creek in SW¼ NE¼ SW¼ sec. 7, T. 26 N., R. 12 E., Osage County, about 3 miles west of Bartlesville. The exposure was discovered by T. A. Tarr and comprises a calcareous, fossiliferous shale and an underlying thin limestone (locally no more than 3 inches thick) just above the massive bluff-forming Torpedo Sandstone.

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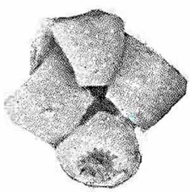
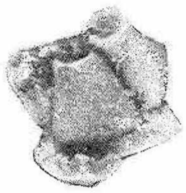
* University of Iowa, Iowa City.

† Not "melbus," as given by Kesling and Smith (1963, p. 187). The name is derived from the coauthor's first name.





A B

Figure 1. Synbathocrinus melba **Strimple, SUI 32233, approximately x10; unretouched photographs.**

A. Side view.

B. View from opposite side with distal edge of basal circlet, radial plates, and two first primibrachs exposed (two radial plates are missing).

As mapped by Oakes (1940), the stratigraphic position of the collection site is the lower part of the Barnsdall Formation, which he mapped with the Birch Creek Limestone at the base. However, we have reason to believe that the limestone at this locality is not the Birch Creek but one lower in the section within the Wann Formation, probably at the stratigraphic level assigned to the Panther Creek limestone by Beckwith (1928).

The specimen is smaller than the holotype and consists of a fused basal circlet, three radial plates, and two primibrachials (fig. 1). The radial plates are not uniform in size, one having a short proximal edge. Each primibrach is sharply tapered so that the distal edge is less than half as wide as the proximal edge. The distal end is rounded and marked on the inner side by the narrow ambulacral groove.

The specimen is in the repository at the University of Iowa, SUI 32233.

As a matter of information, a monotypic species reported from the Carboniferous of Russia (Taidon River, Kuznetsk Basin) as *Taidocrinus poljenowi* by Tolmachev (1924, 1931) may belong to *Synbathocrinus*. The specimen illustrated by Tolmachev (pl. 21, figs. 1-3), although slightly damaged on one side, looks like a typical *Synbathocrinus*.

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Oakes, M. C., 1940, Geology and mineral resources of Washington County, Oklahoma: Okla. Geol. Survey, Bull. 62, 208 p.

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Tolmachev, I. P., 1924, 1931, Nizhnekamennougol'naya fauna Kuznetskogo uglenosnogo basseyna: Leningrad, Geologichekiy Komitet, Materialy, Vypusk 25; pt. 1, p. 1-320, pls. 1-5, 8-11, 18-20 (1924); pt. 2, p. 321-633, pls. 6, 7, 12-17, 21-23 (1931).

OKLAHOMA ABSTRACTS

THE UNIVERSITY OF OKLAHOMA

Petrology of the Upper Permian Cloud Chief Formation of Western Oklahoma

NALEWAIK, GERALD GUY, The University of Oklahoma, Ph.D. dissertation, 1968.

The Cloud Chief Formation in the Anadarko basin is primarily composed of redbeds with gypsum and dolomite. Interbedding with nonpersistent lateral facies produces many repetitious and irregular sequences which are not correlative over wide areas. There is an upward decrease of the quantity of evaporites in the stratigraphic section and a lateral increase of coarser detrital constituents to the north-northwest. More than three-fourths of the clastic rocks are feldspathic subgraywackes and orthoquartzites. Shales and mudstones are common. Subarkoses are present, and the most abundant feldspar species are orthoclase and plagioclase (oligoclase-andesine).

The terrigenous grains have undergone multicyclic development, with contributions from granitic, metamorphic, and sedimentary terranes being most important. Volcanic materials may also have provided detritus to these rocks. Some of the reworked grains were derived from preexisting redbeds. Postulated source areas include the ancestral Rocky Mountains of Colorado and New Mexico and the Ouachita structural belt to the south and southeast of the Anadarko basin. Because the formation contains some reworked sediments, the Wichita Mountains may have indirectly provided material to these rocks.

The clay-mineral assemblage is compositionally uniform and consists of trioctahedral montmorillonite, illite, chlorite, and interstratified mixtures of these minerals. Kaolinite is absent. An arid to semiarid climate with poor ground-water circulation and concomitant retention of the soluble ions is indicated by the immature weathering of the clay minerals. The trioctahedral montmorillonite may be the weathering product of 10-angstrom mica-type minerals. Minor modifications due to recent weathering are observable in the interstratified clay minerals. Significant authigenic effects have not developed in the clay minerals.

The site of deposition involved quiet-water conditions, but sporadic turbulent conditions produced anomalous, bimodal size distributions and irregular influxes of sand-bar, aeolian, and flood-plain material. Isolated basins of evaporation must have existed for development of the many lenses of gypsum present. A marine, tidal-flat environment is postulated. This would have been principally a quiet-water, low-energy environment, susceptible to marginal marine fluctuations and

OKLAHOMA ABSTRACTS is intended to present abstracts of recent unpublished papers on Oklahoma geology. The editors are therefore interested in obtaining abstracts of formally presented or approved documents, such as dissertations, theses, and papers presented at professional meetings, that have not yet been published.

tidal influences with attendant turbulent conditions. Restricted shallow estuaries developed the supersaline basins which produced the thick evaporite deposits present in the Cloud Chief Formation.

(Reprinted from Dissertation Abstracts, Pt. B., vol. 28, no. 11, p. 4626-B)

UNIVERSITY OF ILLINOIS

Boron Sorption and Fixation by Illites

COUCH, ELTON LEROY, University of Illinois, Ph.D. dissertation, 1967.

Samples of Beavers Bend, Fithian, and Marblehead illites were treated in solutions containing boric acid (H_3BO_3) in concentrations ranging from 10^{-4} to 1 molar along with a chloride salt in concentrations ranging from 10^{-2} to 3 molar at temperatures ranging from 25° to 215° C and for periods ranging from 12 hours to 210 days.

The data indicate that, for the illites studied, sorption of boron is enhanced by increasing boron concentration, salt concentration, temperature, and time of treatment. The amount of boron which is sorbed is also dependent on the type of illite treated—being controlled primarily by the specific surface area and secondarily by the crystallinity and/or polymorphic composition of the illite, and being largely independent of the original boron content of the clay.

A two-step mechanism is proposed for boron sorption by illite, consisting of rapid chemical adsorption of the tetrahedral $B(OH)_4^-$ anion at the "frayed edge" of the illite, followed by much slower diffusion of boron into the tetrahedral part of the structure. Crystal defects probably provide the routes for this diffusion.

The dependence of boron sorption on boron concentration and on salt concentration is demonstrated and supports the contention that, with certain reservations and restrictions, the boron content of illites may be used as a paleosalinity index.

(Reprinted from Dissertation Abstracts, Pt. B, vol. 28, no. 8, p. 3336-B)

Stratigraphy of the Permian Blaine Formation and Associated Strata in Southwestern Oklahoma

JOHNSON, KENNETH SUTHERLAND, University of Illinois, Ph.D. dissertation, 1967.

Surface and shallow subsurface investigation of 700 feet of lower Guadalupean Permian redbeds and evaporites have permitted regional analysis of the lithostratigraphy of the Blaine Formation and associated strata in 5,000 square miles of southwestern Oklahoma. The writer has been able to correlate beds in this area with those in the type area of the Blaine Formation in northwestern Oklahoma.

Formations studied include the Duncan Sandstone, Flowerpot Shale, Blaine Formation, and Dog Creek Shale, each commonly 100 to 250 feet thick; they constitute the El Reno Group, which is underlain by the Hennessey Shale and is overlain by the Whitehorse Group.

These strata were deposited in the eastern part of a broad, slowly subsiding epicontinental sea which in Oklahoma covered portions of three tectonic provinces: the Anadarko basin, the Hollis basin, and the more slowly subsiding Wichita uplift between them.

The Duncan consists of interbedded sandstone and shale deposited as a delta bordering the sea on the west; the delta receded and remained in the southeast as younger marine beds of the El Reno were deposited in the study area. The Flowerpot and Dog Creek Formations are mostly reddish-brown shale and contain persistent thin beds of dolomite and gypsum as well as 200-foot-thick sequences of salt and shale in the subsurface. They are separated by the Blaine Formation, which comprises 200 feet of interbedded gypsum, shale, dolomite, and salt (locally); nine principal beds of gypsum, each with dolomite below and shale above, are grouped into the newly designated Elm Fork and Van Vacter Members. Beds of gypsum or anhydrite, mostly 97 to 99 percent pure, are 5 to 25 feet thick; dolomite beds are 1 to 4 feet thick; and shale units are 1 to 50 feet thick. Salt units just above gypsum beds are 15 to 40 feet thick and are limited to the subsurface.

As sea water transgressed from the southwest it was partly evaporated and was successively concentrated with respect to carbonates, sulfates, and chlorides, thereby producing contemporaneous deposits of these types of rocks; toward the shore, fresh water draining the land diluted the concentrated brine and carried in fine clastic material which was deposited as shale. With regression of environments to the west, a succession of dolomite, gypsum, salt, and shale was deposited at each place. This vertical succession of strata is repeated cyclically and is characteristic of the Blaine and associated formations in southwestern Oklahoma.

(Reprinted from Dissertation Abstracts,
Pt. B., vol. 28, no. 12, p. 5081-B)

The University of Wisconsin

Conodont Biostratigraphy of the Mississippian-Pennsylvanian Boundary and Morrowan Series in Western United States

DUNN, DAVID LAWRENCE, The University of Wisconsin, Ph.D. dissertation, 1967.

Conodont samples from thirteen sections in Texas, Oklahoma, Utah, and Nevada were processed and their conodonts studied in conjunction with a biostratigraphic study of the Mississippian-Pennsylvanian boundary and the Morrowan Series (Lower Pennsylvanian) in western United States. Formations sampled include the Upper Mississippian (Chesterian) Barnett Shale and Lower Pennsylvanian (Morrowan) Marble Falls Limestone from two locations in the Llano area of central Texas; the Pitkin Limestone (Chesterian) and Hale and Bloyd Formations (Morrowan) from Muskogee County, Oklahoma; the Kessler Member of the Bloyd Formation (Morrowan), Sequoyah County, Oklahoma; the Soapstone (Chesterian) and Round Valley (Morrowan) Formations, Wasatch County, Utah; the Chainman Formation (Chesterian) and Ely Limestone (Morrowan) from several localities in Millard County, Utah, and White Pine County, Nevada; the Indian Springs (Chesterian) and Bird Spring Formation (Morrowan) from the Spring Mountains near Lee Canyon, Clark County, Nevada; and the Moleen Formation (Morrowan), Elko County, Nevada.

All conodont zones previously established in the Upper Mississippian Chester Series of the Mississippi Valley can be recognized in the western United States material. Also, two of three Morrowan zones established by Lane (1966, ms.) are recognized. In addition, four new Morrowan zones—the *Rhachistognathus primus-Adetognathus muricatus* zone, the *Streptognathodus expansus-S. suberectus* zone, the *Idiognathodus humerus-I. sinuosis* zone, and the *Streptognathodus parvus-Adetognathus spathus* zone—have been determined to be persistent over a widespread area. Modification of the definition and name of one previously proposed zone is in order. The continual geosynclinal sections in Nevada contain conodonts which apparently span a post-Chesterian — pre-Morrowan time interval, but this is not a major break. These observations suggest that the "Springer Series" of the Midcontinent region represents a relatively insignificant geologic time span, and it is recommended that "Springeran" be dropped as a series term.

Although conodonts are not abundant in most Great Basin material studied, Mississippian and Pennsylvanian strata could always be differentiated. Most Great Basin samples studied yielded between 5.5 and 63.2 conodonts per kilogram.

Phylogenetic studies based primarily on a well-displayed evolutionary sequence of conodonts in the Indian Springs and lower part of the Bird Spring Formations suggest that all Pennsylvanian platform conodonts evolved from two main Late Mississippian stocks: (1) The *Gnathodus girtyi* stock, which gave rise to the genera *Declinognathodus, Idiognathodus, Idiognathoides, Neognathodus,* and *Streptognathodus* and (2) the *Adetognathus unicornis* stock, which gave rise to several species of that genus as well as the genus *Rhachistognathus.*

Phylogenetic studies, moreover, indicate that the genus *Gnathodus* does not range much above the Mississippian-Pennsylvanian boundary; Pennsylvanian species heretofore assigned to *Gnathodus* are now referred to the new genus *Neognathodus.* Sixty-eight species are recognized which include eight of the genus *Adetognathus,* six of *Cavusgnathus,* three of *Declinognathodus,* one of *Geniculatus,* eight of *Gnathodus,* two of *Hibbardella,* one of *Hindeodella,* four of *Idiognathodus,* four of *Idiognathoides,* one of *Lambdagnathus*?, one of *Ligonodina,* one of *Lonchodina,* one of *Lonchodus,* one of *Metalonchodina,* two of *Neognathodus,* n. gen., six of *Neoprioniodus,* six of *Ozarkodina,* one of *Rhachistognathus,* three of *Spathognathodus,* six of *Streptognathodus,* and two of *Synprioniodina.* Four new species—*Adetognathus inflexus, Declinognathodus implexus, Idiognathoides scrobus,* and *Ozarkodina spatula*—have been recognized.

(Reprinted from Dissertation Abstracts, Pt. B., vol. 28, no. 11, p. 4621-B, 4622-B)

Arthur Curtis Shead
1891-1968

Dr. Arthur Curtis Shead, associate professor emeritus of chemistry at The University of Oklahoma, died June 17, 1968, at his home in Norman. Shead, who had been ill for several months, was a member of the faculty from 1924 until his retirement in 1957.

Born February 14, 1891, in New Madrid, Missouri, he was graduated from high school in Oklahoma City in 1909. He received a Bachelor of Science degree in 1919 and a Master of Science degree in 1923 from The University of Oklahoma, and in 1931 he was awarded the Doctor of Philosophy degree from the University of Illinois.

While working toward his degrees at The University of Oklahoma, Shead was chemist for the Oklahoma Geological Survey from 1918 to 1923. During this period, he investigated the chemical compositions of numerous mineral substances and published his findings in the Proceedings of the Oklahoma Academy of Science. He also assembled all the available information on the chemical composition of Oklahoma mineral raw materials. The result of this compilation is Oklahoma Geological Survey Bulletin 14, *Chemical Analyses of Oklahoma Raw Materials,* first published in 1928 as University of Oklahoma Bulletin 423 (new series). The bulletin contains 1,465 chemical analyses taken from 75 published and unpublished sources, including his own work. The analyses cover samples from all areas of the State and from a wide range of geologic materials—igneous and sedimentary rocks, minerals and ores, hydrocarbons, ground and surface waters, and even meteorites. Many of these analyses are still the only ones available for a particular Oklahoma locality or substance.

Shead's subsequent work was devoted primarily to investigations into high-precision analytical chemistry and the development of useful chemical products from noneconomic vegetation, such as blackjack oak and Johnson grass.

Despite his retirement, he remained active and even published a paper on phosphate nodules as recently as 1964. He is survived by his wife, the former Elizabeth Blanche Belt, sons Arthur A. and Carleton G., and daughter Mrs. Robert L. Holt.

Water for Oklahoma

Water is the lifeblood of Oklahoma, and its development and conservation is of the utmost importance to every Oklahoman. In *Water for Oklahoma,* published by the U. S. Geological Survey as Water-Supply Paper 1890, the facts about State water resources and uses are clearly described.

The State as a whole and each of the State's geographic sections —the High Plains, the central and eastern plains, the Ozark Plateaus, and western and southeastern Oklahoma—are discussed in depth, with their present water supplies and future potentials thoroughly outlined. Such a look at the State shows that the average annual rainfall increases from a scanty 16 inches in the western Panhandle to approximately 30 inches in the central area and to 58 inches in parts of southeastern Oklahoma, making a State average of 33 inches annually.

The authors of this report, T. B. Dover, A. R. Leonard, and L. L. Laine, point out that the average annual rainfall provides approximately 40 thousand billion gallons of water, 34 thousand billion gallons of which is lost by evaporation. This leaves an annual average of 6 thousand billion gallons (approximately 17 billion gallons per day) of potentially manageable water. Of this remaining precipitation, half falls on 17 percent of the State where only 12 percent of the people live.

Seasonal uses of water create a fluctuating strain on the available water resources, but the biggest danger comes from the threat of drought, with its accompanying water rationing and loss of plant and animal life. In each dry period to date, the State has been caught with its "water buckets empty." To prevent a recurrence of such problems, the authors emphasize a "be prepared" policy for Oklahoma.

The trend toward urbanization and industrialization has further affected the State's water requirements, causing considerable strain on some water supplys. In assessing this problem, the paper studies the principal urban centers in Oklahoma. In Oklahoma City, for example, water has been taken primarily from the North Canadian River and stored in two reservoirs, Lakes Overholser and Hefner. Because flows from the North Canadian River cannot fill the lakes sufficiently, the city has had to develop additional resources, drawing water from as far as 100 miles away. Growing population and industrial development will cause additional depletion of the city's supply, and careful planning for the future is a necessity.

Water resources for the population centers of Ada, Altus, Ardmore, Bartlesville, Chickasha, Duncan, Enid, Lawton, McAlester, Muskogee, Norman, Okmulgee, Ponca City, Shawnee, Stillwater, and Tulsa are also discussed.

The report describes, in terms understandable to both layman and expert, the development, conservation, and future prospects of Oklahoma's water supply. Included is a fold-out map, scale 1:1,000,000, that shows the water and physiographic features of the State. This timely information on our most important and necessary natural resource should be of great interest to everyone in Oklahoma. The 107-page bulletin is available from the Superintendent of Documents, U. S.

Government Printing Office, Washington, D. C. 20402, and the Oklahoma Geological Survey, 830 South Oval, Room 163, Norman, Oklahoma 73069, at a cost of $1.25.

—*Carol R. Patrick*

U. S. Board on Geographic Names Decisions

Canadian Sandy Creek (not Big Sandy, Sandy, or Spring Brook Creek) has been adopted as the name for a stream approximately 35 miles long that heads 2 miles north of Roff in Pontotoc County and flows northeast to the Canadian River 6 miles north of Ada in secs. 31 and 32, T. 5 N., R. 6 E.

Douthat (not Century or Deuthat) has been adopted as the name for a village 1.5 miles south of Picher in Ottawa County.

Little Canadian Sandy Creek (not Big Sandy, Little Sandy, or Sandy Creek) has been adopted as the name for a stream approximately 7 miles long in Garvin and Pontotoc Counties. The stream heads in sec. 11, T. 2 N., R. 3 E., and flows northeast to Canadian Sandy Creek, 13 miles west-southwest of Ada, at sec. 17, T. 3 N., R. 4 E.

Spring Brook Creek (not Spring Creek) has been adopted as the name for a stream approximately 21 miles long in Pontotoc and Garvin Counties. The stream heads at 34°50′00″ N., 96°59′08″ W., and flows east-southeast to Canadian Sandy Creek, 2 miles west of Ada, in sec. 36, T. 4 N., R. 5 E.

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