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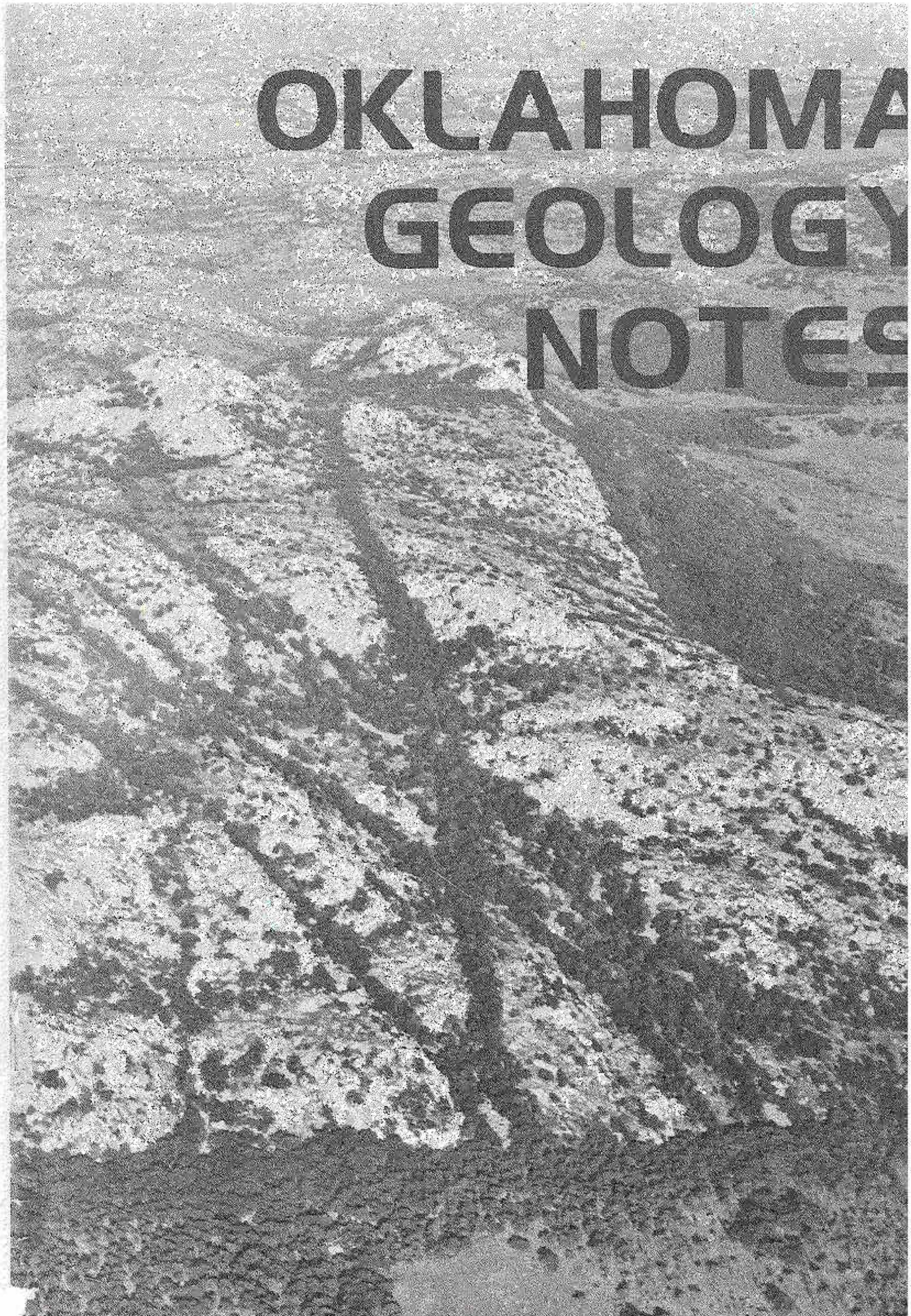

Cover Picture

HIGHEST ELEVATION IN THE WICHITA MOUNTAINS

This oblique aerial photograph, taken on the afternoon of June 9, 1978, just east of Cooperton, is a view to the east-southeast along the axis of the Wichita Mountains. In the foreground is an unnamed mountain (secs. 7 and 8, T. 4 N., R. 15 W.) on the Cooperton, Oklahoma, 7½-minute topographic-quadrangle map, parts of which are locally known as "Bear Mountain." Interestingly, the peak capping the left side of the mountain is one of the two highest elevations (at 2,479 feet) in the Wichitas. The other is nearby Mount Pinchot. Both of these peaks surpass Mount Scott by about 15 feet.

"Bear Mountain" and most of the peaks visible in the photo, including Mount Scott on the far horizon, are composed of the extensive Cambrian Mount Scott Granite sill. This sill overlies gabbros of the Cambrian(?) Raggedy Mountain Group. These gabbros floor Cutthroat Gap, which can be seen to the right of "Bear Mountain." The granite-gabbro contact is as spectacularly displayed here as it is on Mount Sheridan farther east. This area can be viewed to the east while driving along Oklahoma Highway 54.

Fracture systems, commonly resulting in prominent tree-lined ravines, are typical of all igneous exposures in the Wichitas and are well displayed in this photo. Most of these fractures formed during Pennsylvanian uplift, but some probably are Cambrian in age.

—*M. Charles Gilbert*

Editorial staff: William D. Rose, Elizabeth A. Ham, Judy A. Russell

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Short articles on aspects of Oklahoma geology are welcome from contributors. A set of guidelines will be forwarded on request.

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FAUNAL SUCCESSION AND ENVIRONMENTS OF DEPOSITION OF PLEISTOCENE LAKE BUFFALO NORTHWESTERN OKLAHOMA

Graig D. Shaak[1] and **Richard Franz**[1]

Abstract—Examination of fauna and flora recovered from Wisconsinan freshwater marl in Pleistocene Lake Buffalo in Harper County, Oklahoma, indicates the presence of four successional communities. Patterns of community succession, documented by changes in the fauna and flora through time, show advancing stages from: (1) river relict, (2) pioneering, (3) mature, to (4) residual. Data to determine the patterns were obtained by stratigraphic trench sampling of a 3.4 m section of the marl for community analysis, with taxa recovered including 14 gastropod and 2 ostracod species and the green alga *Chara* sp. Samples of recent pond faunas have been used to support interpretations of environment, and taxonomic frequencies were corrected to enable quantitative analysis of communities on a standing crop basis.

The pattern of succession, the sedimentologic data, and analogs from the modern pond communities suggest that the deposit records a transformation from a river meander loop to an oxbow lake.

Introduction

Pleistocene Lake Buffalo (fig. 1) was discovered when Arthur J. Myers was conducting field reconnaissance in northwestern Oklahoma for the geologic map of Oklahoma (Miser, 1954), work that was later expanded into detailed mapping of Harper County (Myers, 1959).

The late Claude W. Hibbard labored to decipher the late Cenozoic history of the Great Plains, realizing, fortunately, the stratigraphic and paleontologic significance of the invertebrate faunas. Dwight W. Taylor and Hibbard (1955) described the faunas and the local Pleistocene habitat of the deposits in Harper County, designating the fauna as the Bar M local fauna, locality 1. Aspects of the fauna and its climatic interpretation were developed later by Herrington and Taylor (1958) and Hibbard and Taylor (1960). Most of these early studies were concerned with faunal descriptions, climatic interpretations, chronology, and environments of deposition, making possible the recent emphasis on paleoecological interpretation of Pleistocene phenomena. Devore's Illinoian study (1975) from Kansas extracts a wealth of ecological data from the fossils and their modern counterparts. Miller (1975, 1976) traced molluscan succession and climatic variation for the Wisconsinan of southwestern Kansas and northwestern Oklahoma. Shaak (1976) traced diversity and succession of a Late Pleistocene temporary pond fauna from Major County, Oklahoma.

In reconstructing shallow benthic marine paleoenvironments, species diversity varies directly with environmental stability (Rollins and Donahue, 1972) and is predictable in a successional sequence. This predictability should apply equally to ecosystems other than marine. Pioneering stages of a freshwater lake

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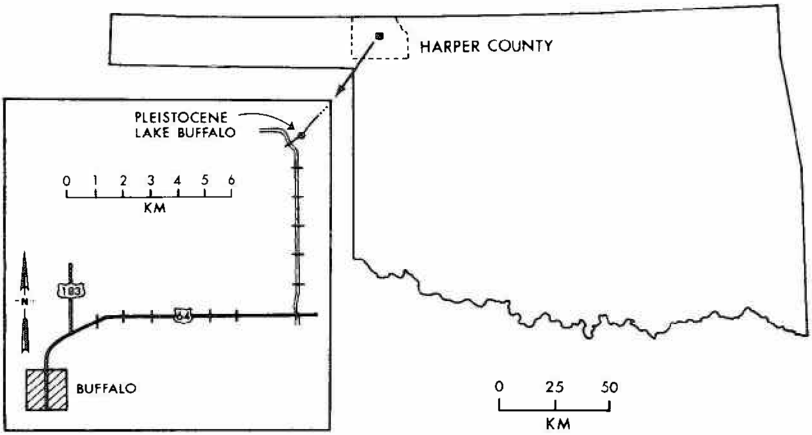

Figure 1. Pleistocene Lake Buffalo locality map, northwestern Oklahoma.

should record low diversity, high dominance, and only a few eurytopic species, indicating rigorous environmental conditions and chance colonization. As environmental conditions improve, diversity should increase, dominance should decrease, and the fauna should contain more stenotopic species. A diversity high should be directly related to environmental stability. As a lake transforms through marsh/swamp series toward a terrestrial state, conditions for lacustrine organisms deteriorate, and the lacustrine system should degrade, nearly reversing the pioneering processes.

Much of the fauna in this deposit has been lost due to the vagaries of preservation. We think, however, that the molluscs are sensitive enough to show the pattern of succession. The sediments reflect a cycle, although only a short episode of a gradually changing climate. Thus Wisconsinan geology and climates are secondary to our emphasis of the local sediments and the changing fauna contained within.

We use species diversity and equitability as tools in our effort to grasp the trend of faunal succession. We do not attempt to improve on theoretical aspects of freshwater ecology.

Study Area

Location

The Pleistocene Lake Buffalo (Bar M1) site is located in the NW¼NW¼, sec. 13, T. 28 N., R. 22 W. on the Buffalo NE 7½-minute topographic sheet (Johnson, 1972). The study area is in Harper County, northwestern Oklahoma, in the Great Plains physiographic province. The outcrop is about 12.9 km northeast of Buffalo and 6.5 km north of U.S. Highway 64 (fig. 1).

Stratigraphy

The deposit represents a small Late Pleistocene (Wisconsinan) lake deposit for which Taylor and Hibbard (1955) and Hibbard and Taylor (1960) suggested a valley-fill or sinkhole origin. The outcrop was exposed by headward erosion of a tributary to Willow Creek. The sediments range from light-gray to yellow-gray silt and clay, ranging from 2.4 to 3.7 m in thickness (Johnson, 1972). The sediments are friable and calcareous and are predominantly homogeneous throughout the thickness. The gray color of the lake sediments is easily distinguishable from, and unconformable above, the Permian red beds and Pleistocene unconsolidated sands. Taylor and Hibbard (1955) refer to two zones within the gray sediment, one darker than the other, but they consider them to represent a single assemblage. These lake sediments have local provenance. Permian sands and clays, Tertiary Ogallala sands and gravels, and Pleistocene volcanic ash, sands, gravels, and silts provided much of the detrital sediments. For details of the local stratigraphy and stratigraphic succession of Pleistocene local faunas see Zakrzewski (1975).

Age

A sample of shells from this deposit was carbon-14 dated (methane-proportional-counter method) in 1964. The date determined was 21,360± 1,250 B.P., or Late Wisconsinan (Myers, 1965).

Methods

Field

The outcrop thickness of 3.4 m was trench-sampled to expose fresh surfaces of in situ sediments. The trench wall was dug normal to the Permian contact, which is horizontal. The trench did not encounter the black silt zone described by Taylor and Hibbard (1955). Samples 1 (unconformable on Permian red beds) and 2 represent a stratigraphic interval of 0.15 m each. Samples 3 through 12 were taken at 0.3 m intervals. The 12 sample intervals yielded bulk samples of approximately 2 kg each. This stratified sampling plan (Griffiths, 1967) was used not only to eliminate collecting bias but also to secure a continuous sample through the entire outcrop thickness.

Laboratory

The 2-kg bulk samples were disaggregated using Lund's (1970) Amine 220 technique, and the disaggregate was wet-sieved thoroughly to remove all traces of the Amine. The washed sediment and fossils were retained on sieve numbers 10, 40, 70, 100, and 120, the 12 bulk samples thus providing 60 individual sieve fractions. Sieve fractions were split with a sample splitter to a workable quantity of approximately 1.5 gm for +70 and coarser material and 0.15 gm for the fine. Fossils at least 50 percent complete were identified and counted.

Recorded taxonomic frequencies are adjusted to a common standard in order to enable comparisons of the different samples, an adjustment made necessary by the combined fossil and sediment weight differences of the individual sieve sample splits. Initial frequencies were adjusted to a weight standard of 100 gm. For example, if the combined fossil-sediment weight is 1.25 gm, the individual taxonomic frequencies are increased by a factor of 80, approximating the total that would be found if 100 gm were initially counted.

Ostracod frequencies were reduced by a factor of nine, as they average nine ecydysis stages (Kesling, 1961). The frequencies of the ostracods are further reduced by a factor of three, as they average three generations per year. A final adjustment reduced all taxonomic frequencies to a single generation or "reflection" of standing crop (Shaak and Rollins, 1972). The gastropods have an average longevity of one year, and this one-year-average longevity value is here defined as unity. We chose to look at a series of single time episodes as opposed to a large chunk of time, because an adjustment of faunal counts to a single generation adds a level of refinement to the data subjected to diversity and equitability measures.

Information Theory and Faunal Succession

"Because modern ecology is preoccupied with developing concepts of populations and ecosystems, a holistic viewpoint about life-in-environment is increasingly prevalent, and the metaphorical language of information theory is being usefully applied to systems, such as lakes and the ocean, that transmit biochemical order from the Pleistocene to the present." (E. S. Deevey, 1965.)

Odum's (1972) second parameter of ecosystem development states that community development is an orderly process involving time changes in species structure and community processes; it is reasonably directional and, therefore, predictable. This orderly, directed, and predictable change is an important concept. Information theory is a new, powerful tool that can be used for shorthanding complex ecological systems. This formal treatment of systems ecology allows for derivation of models by means of which predictions can be made about faunal succession.

Succession follows a direction, a self-organization. Successional indicators such as increase in biomass, proportions of inert or dead matter, and entropy are virtually impossible to quantify from the fossil record. Diversity and dominance, however, are two indicators of importance that are possible to quantify.

Species diversity is either the number of species in an ecosystem or more complex measures that are sensitive to the numbers of individuals of each species in an ecosystem, or equitability. The number of species in a sample (simple species diversity) is a bias-free measure of diversity, as population sizes can be ignored. However, the interpretive value depends upon adequacy of sampling. The number of species and their relative frequencies add a dimension to species diversity that accentuates the fact that evenness or numerical equality in all species of a community is rare indeed. A maximum value is realized if each individual belongs to a different species. A minimum value would reflect total dominance; for example, all individuals belong to one species (Margalef, 1970). The Simpson Index (Simpson, 1949) is sensitive to the equitability component of diversity:

$$D_s = \frac{N\,(N-1)}{\Sigma n\,(n-1)}$$

where N = total number of individuals and n = total number of individuals per taxon. This index is not weighted with respect to population frequencies. Again, however, statistical significance depends upon adequate sampling.

To reiterate, dominance is the rule rather than the exception. This inherent quality of inequitable distribution of population frequencies in communities makes it necessary to use this kind of index for this study.

Equitability

A handy measure of equitability is the Donahue Index (Shaak, 1975):

$$\frac{\text{Simpson Index}}{\text{number of taxa}}$$

where D_s is divided by the number of taxa in that sample. These values range from 0.24 to 0.44 in this study. Any index of 1.0 denotes a perfectly equitable distribution, whereas decreasingly lower values indicate increased dominance. A value of zero represents absolute dominance.

Results

Fauna

A data matrix (table 1) displays the faunal frequencies. We identified and counted two species of ostracods and 14 species of gastropods, with the species of *Gyraulus* and *Fossaria parva* the dominant gastropods. The ostracods account for 22 percent of the total fauna, whereas *Gyraulus* comprises 47 percent of the fauna. *Pupilla* sp. is the only terrestrial fossil recorded. Six species, *Fossaria obrussa*, *Fossaria parva*, *Physa anatina*, *Pupilla* sp., *Oxyloma retusa*, and *Promenetus exacuous*, are first reported for the Bar M1 local fauna. No pelecypods were recovered, although *Pisidium* was reported from the site by Taylor and Hibbard (1955). The faunal distribution, less terrestrials, approximates Miller's (1975) group distributions (table 2).

The variance in the eastern (group III) category is based on the paucity of terrestrial species in our samples. Neither this study nor Miller's shows any eastern aquatics in the Bar M1 fauna.

Chara ranged from very rare to abundant in the samples (table 3). This alga provides another line of evidence for interpretation of community succession and environment of deposition. *Chara* is not known to be a food source for herbivores, but the alga serves as a substrate for the microflora on which many

TABLE 1.—DATA MATRIX OF ADJUSTED TAXONOMIC FREQUENCIES FOR PLEISTOCENE LAKE BUFFALO FOSSILS

PLEISTOCENE LAKE BUFFALO DATA MATRIX

Sample	Candona fluviatilis	Cypridopsis vidua	Armiger crista	Fossaria obrussa	Fossaria parva	Gyraulus circumstriatus	Gyraulus parvus	Gyraulus sp.	Helisoma trivolvis	Lymnaea caperata	Lymnaea palustris	Lymnaea sp.	Oxyloma retusa	Physa anatina	Promenetus exacuous	Pupilla sp.
12	1317	710	544	217	1450	136	500	3366	140	334	517	262	0	271	0	0
11	3187	1665	342	218	13764	134	735	5936	40	298	472	0	0	500	68	0
10	3114	5007	718	377	2807	367	1576	12480	60	812	1099	212	0	500	80	0
9	794	639	584	292	1082	230	574	3180	98	448	210	0	0	168	98	0
8	1570	1503	733	77	744	38	375	2740	22	137	269	0	0	27	177	0
7	2496	2052	750	213	1526	60	490	6778	335	239	620	214	22	281	327	0
6	4010	4659	1060	157	2035	270	1463	11148	34	195	884	400	0	642	348	0
5	1190	2761	500	28	2335	625	2925	13746	0	215	1426	394	0	1048	52	28
4	344	198	94	113	661	19	130	1592	94	206	414	0	0	242	57	0
3	87	139	70	134	559	192	1068	1550	52	82	243	0	0	91	45	0
2	153	93	46	16	106	113	198	910	76	115	134	46	58	131	60	46
1	108	71	21	42	205	149	382	690	120	102	62	0	21	61	20	21

TABLE 2.—COMPARISON OF MILLER'S (1975) AND PLEISTOCENE LAKE BUFFALO GROUPS I, II, III, AND IV (percentage of total species)

	Miller (1975) (in %)	This Study (in %)
northern (Group I)	43	50
southern (Group II)	8	10
eastern (Group III)	16	0
general (Group IV)	32	40

of the snails graze, and thus presence or absence of *Chara* is a determinant for many of the herbivorous gastropods.

Mollusc-Ostracod Relationship

There are co-dominant ostracods, both calcareous; the fauna totally lacks chitinous forms, a discrepancy that is probably the result of diagenesis. The significance of this loss of information is that the ostracods never approximate expected frequencies (E. S. Deevey, personal communication). This diagenetic

Table 3.—Abundance of *Chara* sp. in Pleistocene Lake Buffalo Sediments

	Abundance of Chara sp.			
Sample	Very Rare	Rare	Common	Abundant
12	X			
11				X
10			X	
9		X		
8		X		
7			X	
6				X
5				X
4	X			
3	X			
2	X			
1	X			

bias should affect diversity and equitability values, and for this reason we have calculated ostracods, molluscs, and total fauna values to determine which set of values provides the most information.

The ostracod curves are flat (fig. 2), whereas the mollusc curves depict the stages of community development more strikingly (see following section on *Community Succession*). It is interesting to compare the ranges of values for molluscs and ostracods in calculating each group's contribution to the diversity and equitability curves. Ostracod diversity ranges from 1.82 to 2.00 (table 4); mollusc diversity ranges from 2.24 to 4.99. Ostracod equitability ranges from 0.91 to 1.00, even though their sample frequencies range from 179 and 8669 individuals; the mollusc equitability ranges from 0.20 to 0.38.

Thus, because of the information loss in the ostracods, the community stages can be inferred from the molluscs alone. Actually, the molluscan curves depict community stages more graphically than does the total fauna.

Community Succession

Gyraulus *river relict community*—The basal sediments lack a simple pioneering community. Instead, samples 1–4 (fig. 2) record high diversity and high

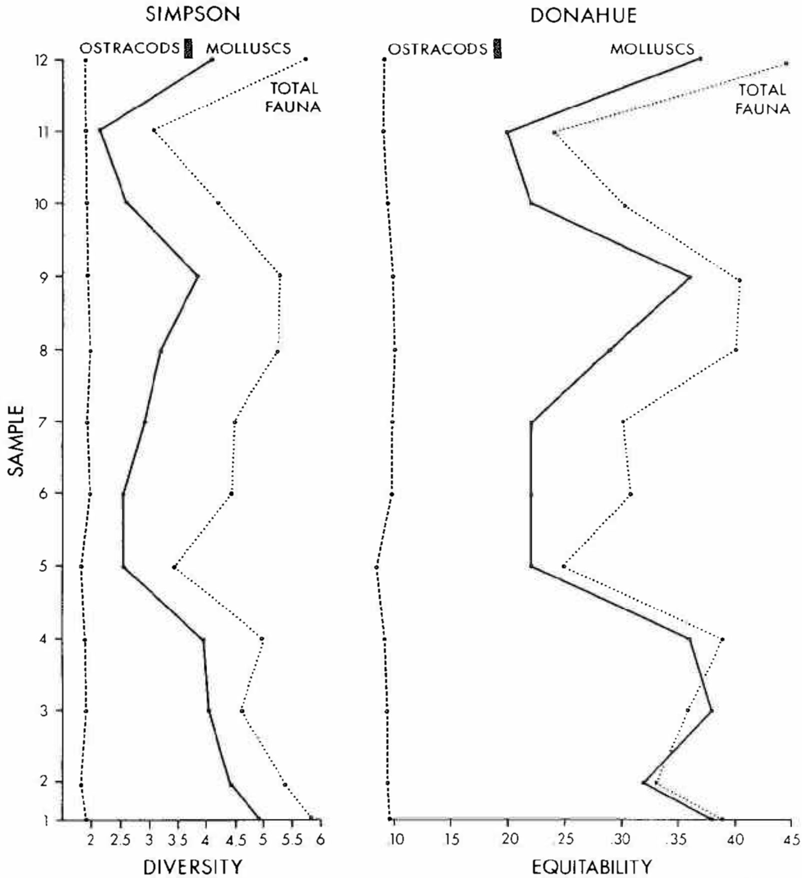

Figure 2. Summary of sample locations, diversity and equitability for Pleistocene Lake Buffalo.

equitability. *Gyraulus* is dominant, averaging 1,750 individuals per sample or 55 percent of the fauna. These high values, the low number of individuals, low frequencies of *Chara* (table 3), and the number of species (average 14) characterize a mature community, rather than a beginning as a sinkhole or valley fill deposit, evidence that is consistent with establishment of a river community. Possibly the deposition began as a meander loop of a river, into which the river introduced a full complement of organisms.

Gyraulus *pioneering community*—The meander cutoff was completed, forming an oxbow lake. The cutoff marked a faunal explosion, shown in samples 5 and 6 (fig. 3), that averaged 27,275 individuals. Diversity and equitability drop drastically in sample 5, as *Gyraulus* is strongly dominant, with over 17,000 individuals or 63 percent of the sample (fig. 2). The dominance continues

TABLE 4.—MOLLUSC-OSTRACOD RELATIONSHIP FOR PLEISTOCENE LAKE BUFFALO

	Molluscs		Ostracods	
Sample	Diversity	Equitability	Diversity	Equitability
12	4.11	.37	1.84	.92
11	2.24	.20	1.82	.91
10	2.63	.22	1.90	.95
9	3.92	.36	1.98	.99
8	3.22	.29	2.00	1.00
7	2.82	.22	1.98	.99
6	2.61	.22	1.99	.99
5	2.62	.22	1.73	.86
4	3.99	.37	1.87	.93
3	4.19	.38	1.91	.95
2	4.41	.32	1.89	.95
1	4.99	.38	1.93	.97

in sample 6; however, diversity and equitability increase as *Gyraulus* decreases to 47 percent of the fauna, roughly 13,000 individuals.

Gyraulus *mature community*—The succession continues through samples 7, 8, and 9. Faunal counts decrease but become much more equitable. Samples 8 and 9 average 5.2 Simpson with an equitability of 0.40 (fig. 2). The fauna averages 8,400 individuals, an enormous decrease (fig. 3). The ostracods show an interesting relationship to the succession, increasing in percent composition, with minor fluctuations, to a peak of 36 percent of sample 8. They contribute 33 percent of the Shannon-Weaver value (1949) of 0.28. The ostracods decrease as this community reaches maximum maturity, and with minor fluctuations they parallel the predicted asymmetric faunal succession.

Fossaria *residual community*—Samples 10 and 11 show a deterioration of the community as faunal counts jump to an average of 28,000 individuals (fig. 3). Diversity and equitability drop to the lowest values in the study (fig. 2). The Simpson value of 3.1 is complemented by an equitability low of 0.24. *Fossaria* becomes dominant, with 13,800 individuals, or 80 percent of the fauna. This marked dominance is greater than the dominance of *Gyraulus* in samples 5 and 6. Although faunal counts are high, the community deteriorates rapidly.

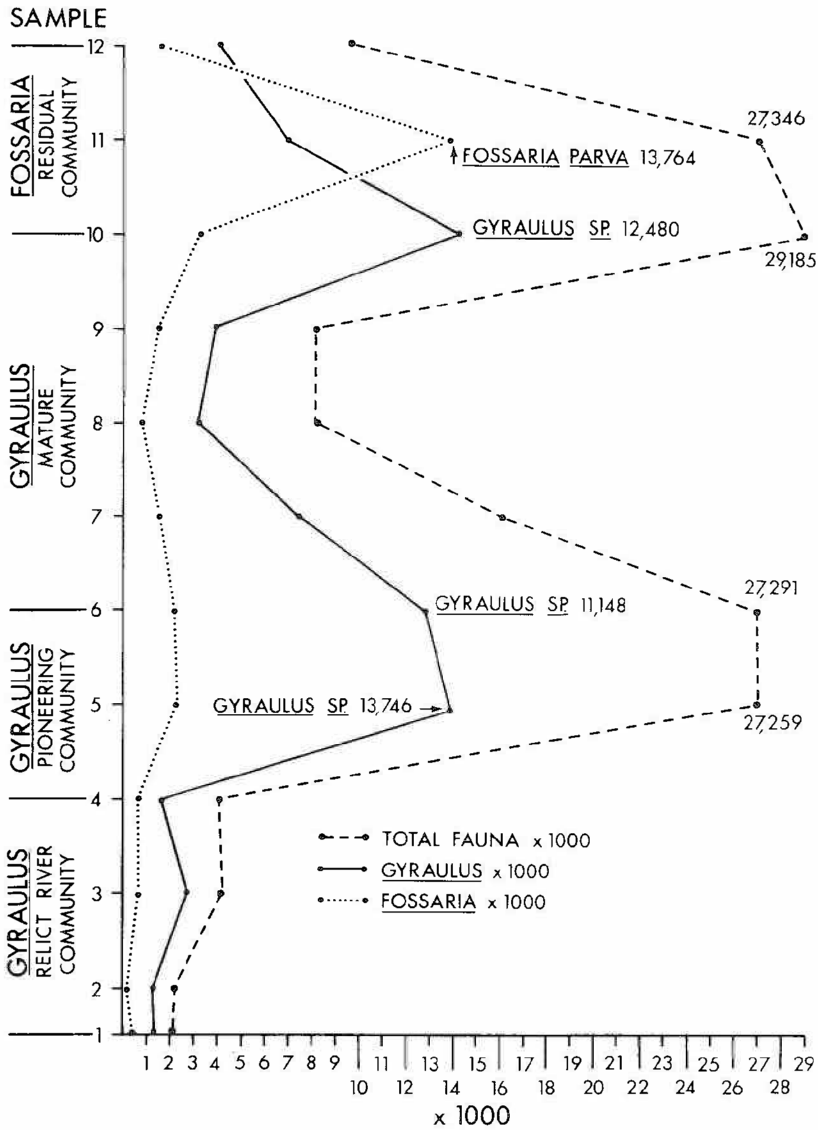

Figure 3. Summary of number of taxa and community stages for Pleistocene Lake Buffalo.

Sample 12 is anomalous at first inspection. However, the fauna drops from over 27,000 to less than 10,000 individuals (fig. 3). The number of taxa remains unchanged. The key to the interpretation is in equitability (E). An E of 0.44 is nearly twice that of sample 11. Diversity also nearly doubles (fig. 2). There is a three-fold decrease in the number of individuals. The dominant taxa are reduced in importance. *Gyraulus* is again dominant but comprises only 34 percent of the sample and contributes only 17.5 percent to the Shannon-Weaver index (1949) of 3.0. Faunal counts, percentage contribution, and diversity do not approximate the values in samples 5 and 6 (*Gyraulus* pioneering community), as is expected in a successional cycle.

The top of the section is exposed, and certainly part of the section has been removed by erosion. The fauna at the top has probably been selectively sorted and selectively weathered, and diversity values may be unreliable. Alternatively, sample 12 may mark the onset of a second cycle.

Distribution of *Chara* supports our interpretation of the community succession. *Chara* is rare in samples 1–4, the last stage of the original stream fauna. It peaks in samples 5 and 6, decreases in 7, 8, and 9, regains its prominence in samples 11 and 12, and falls off in the highest sample (table 3). This pattern parallels the successional pattern of *Gyraulus*.

Environments of Deposition

This deposit, which we interpret as either an oxbow or a flood-plain lake, was under the influence of fluctuating ground-water levels. The lake contained water at seasons when the ground-water level was high and became temporarily dry with lowered ground water. In the early stages, the lake was periodically inundated with river water into the nearly completed meander cutoff. As the cutoff was completed, the only exchange of river and lake waters was during times of flooding, then, as the river meandered away from the oxbow, the flooding became rarer. Evidence for a restricted lake is gray color (high organics), high clay content, and a snail fauna that prefers shallow, standing pools of water (Johnson, 1972).

The presence of two zones (gray and black silt zones) reported by Taylor and Hibbard (1955) was not observed by us. We suggest that the black zone was only locally exposed and may have been destroyed either through their activities or the subsequent activities of the owners in constructing two artificial ponds. Taylor and Hibbard (1955) suggested that the dark silt was laid down near the old lake shore, basing this conclusion on the dominance of land snails associated with this unit. Assuming our interpretation is correct, this had to occur after the stabilization of the lake.

Comparison with Modern Lake Communities

We sampled five modern freshwater ponds to aid in our determination of what environments of deposition are represented by the sediments of Pleistocene Lake Buffalo. The locations of the modern ponds are listed on table 5. Samples were taken with an Eckman dredge with the hope of estimating population densities, and the samples were processed similarly to the sediment samples. Larger grab samples were also taken to insure adequate recognition of the fauna.

TABLE 5.—COMPARISON OF FIVE VARIETIES OF MODERN FRESHWATER PONDS FROM THE PLEISTOCENE LAKE BUFFALO AREA

Species	Pond				
	Selenite	Harmon	Shale Beds	Oxbow	Bar Ml
Physa anatina	U	U	U	C	C
Gyraulus parvus	U	A	A	C	U
Lymnaea sp.	A	A	A	U	A
Helisoma trivolvis	A	A	A	A	U
Cypridopsis vidua	A	A	A	C	C
Candona sp.	A	U	A	C	C
Lymnocythere sp.	U	A	A	A	C
Chara sp.	C	U	A	C	C

C = common U = uncommon A = absent

Selenite Pond--6.5 km north of Sherman, off U.S. 281, Major County

Harmon Pond--Harmon Ranch, 10 km north of Sherman, off U.S. 281, Major County

Shale Beds Pond--14 km north of Sherman, off U.S. 281, Major County

Oxbow Slough--6 km south of Waynoka, off U.S. 281, Woods County

Bar M1--12.9 km northeast of Buffalo, 6.5 km north of U.S. 64, Harper County

Selenite Pond is an artificial pond formed by damming of a tributary to Main Creek in the Cimarron River drainage. The pond is in a deep, steep-walled gypsum canyon, approximately 60 m × 15 m. *Chara* forms the dominant vegetation. *Physa anatina*, *Gyraulus parvus*, and the ostracod *Limnocythere* sp. were recovered from the dredge samples; all were uncommon.

Harmon Pond is an artificial pond measuring 10 m × 90 m. This prairie pond is quite muddy and shallow. Willows, cottonwoods, and salt cedar shrubs grow at the water's edge. No submergent vegetation was evident. Only *Physa anatina*, *Candona* sp., and *Chara* were recovered from the dredge samples, and all were uncommon.

Shale Beds Pond is a 6 m diameter pond at the base of red sand and gypsum terraced hills. The red silty clay bottom supports no vegetation. A dredge sample recovered rare specimens of *Physa anatina*.

Oxbow Slough is a 60 m diameter permanent pond in a flood-plain depression approximately 275 m from the Cimarron River. The pond supports dense growth of *Chara* and cattails. The bottom is a black organic mud. Five species of snails and ostracods were dredged. All were common with the exception of *Lymnaea* sp.

The last pond we sampled was an artificial prairie pond in a small arroyo at the Lake Buffalo site. The pond had an abundance of *Chara* growing in it. Bullrushes and cattails occur in shallow water. Six species of snails and ostracods were dredged, but *Physa anatina* was the only common snail. Three species of ostracods were very common.

The Bar M1 modern and the Cimarron oxbow lake faunas most closely resemble the Bar M1 fossil fauna. *Gyraulus* is ubiquitous, and *Cypridopsis* and *Candona* are the dominant ostracods. The snail fauna lacks the northern aquatic components, with the exception of the lymnaeids. The modern faunas are interglacial, whereas the Bar M1 is glacial. Nonetheless, the faunal components and their frequencies match the oxbow lake and Bar M1 modern ponds. The only floral component preserved is *Chara*, which is common in the oxbow lake and the Bar M1 modern pond. *Chara* also is abundant in the Bar M1 samples, and its frequency pattern complements the faunal succession. Buffalo Creek is 10 km south of the fossil site. The Cimarron River is 14 km northeast of the site. Regardless of which body of water meandered across the site in the Wisconsinan, it probably can be compared with the North Platte River today. The North Platte is uncontrolled by bedrock. It is braided and meandering, readily forming oxbows and flood-plain ponds. Gradient, lack of bedrock control, and similarity of the modern and fossil faunas preclude any type of origin other than oxbow lake or flood-plain pond for Pleistocene Lake Buffalo.

Discussion

Taylor and Hibbard (1955) listed 19 mollusc species from the Bar M1 fauna. They stated that the aquatic species were found in gray silt, whereas the terrestrial species were found in black silt. We sampled a 3.4 m trench section through the gray silt. We identified two ostracod and 14 mollusc species. Six mollusc species (*Fossaria obrussa*, *Fossaria parva*, *Oxyloma retusa*, *Physa anatina*, *Promenetus exacuous*, *Pupilla* sp.) had not been reported previously from the Bar M1 fauna. In addition, one species (*Gyraulus circumstriatus*), known only from the black zone (Taylor and Hibbard, 1955), is here reported from the gray zone. The combined ostracod and molluscan faunas as tabulated in Taylor and Hibbard (1955) and by us include 26 taxa. It is difficult to reconcile the discrepancies in these two lists, but they do exist. We have used both lists in our general review of habitat, but out of necessity we have limited ourselves to the numerical data in discussing the synecology of the site.

Re-examination of the species composition, including previously unrecorded taxa, does not alter the climatic interpretation of Taylor and Hibbard (1955) and Hibbard and Taylor (1960), for example, the implication of a glacial age climate. According to Baker (1928), all of the additional molluscs are wide ranging, spanning most of the central United States as far north as Canada. Comparisons of the combined fossil faunas with that of Recent faunas show that the fossil site most likely was a shallow pond or lake with fluctuating water levels. The presence of the green alga, *Chara* sp., indicates permanent water in at least some areas during a major portion of this lake's lifespan. Snails, such as *Helisoma trivolvis*, *Lymnaea caperata*, and both species of *Fossaria*, suggest quiet, shallow, more or less stagnant water with or without vegetation. As several of the species are capable of burrowing into the mud bottom, they should be able to escape the rigors of drying pools, an ideal adaptation in an arid environment. *Lymnaea caperata* and *Fossaria parva* often leave the pools and move out onto wet mud (Baker, 1928). Other species, particularly *Gyraulus* and *Promenetus*, are partial to heavily vegetated substrates. *Aplexa* and *Oxyloma* occur usually in grassy swales near the shore (Leonard, 1943; Baker, 1928). We interpret these vignettes to resemble most closely the Oxbow Slough along the Cimarron River of this report.

The age of the deposit was considered to be of either Illinoian or Wisconsinan age by Taylor and Hibbard (1955), who favored the Illinoian because of the occurrence of the extinct *Physa skinneri*. Later, Hibbard and Taylor (1960) indicate that "the matter is still uncertain for this species (*Physa skinneri*) is now known to be still living." The additional species recovered by us represent extant taxa and therefore do not add significantly to its age interpretation. However, basing the conclusion on the fauna, complemented by the carbon-14 date, we feel that a Wisconsinan age certainly is reasonable.

This study shows that modern ecologic concepts, including information theory, can be applied successfully to Wisconsinan freshwater fossils. Fixed sampling interval, due to apparent lithologic homogeneity, and unknown sedimentation rate, complicates the system. However, the fossils were judged to be in situ, representing communities instead of assemblages. Reduction of raw taxonomic frequencies to an approximation of standing crop corrects for generation overlap and defines this community more accurately.

The history of a lake offers a classic example of ecological succession. Lake sediments usually record the history of sedimentological and ecological succession. Communities are characterized by change, which is inevitable because species populations are dynamic (Reid, 1961).

We have demonstrated that the successional pattern in Wisconsinan lake sediments is predictable. We predicted and found pioneering, mature, and residual community stages. We did not anticipate that the mature community would occur at the base of the stratigraphic section and suggest now that this anomaly represents a relict stream community captured by a meander loop in the final stages of oxbow formation. The predicted community stages are stacked stratigraphically on the older relict stream fauna. The molluscan species diversity curves are more informative than the non-molluscan or total fauna curve, a result of both the taxonomic dominance of the molluscs and the diagenetic loss of data in the ostracods.

Equitability is another tool that can help decipher faunal succession. Peaks on the diversity curves generally are paralleled by peaks on the equitability curve.

The modern interglacial fauna of the region is a depauperate version of the Wisconsinan glacial fauna (Miller, 1975). The comparison of the modern and Wisconsinan faunas was most useful in recognizing environments of deposition, particularly the basal relict stream depositional environment that was so problematic at first.

Acknowledgments

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References Cited

BAKER, F. C., 1928, Gastropoda, *pt. 1 of* The freshwater Mollusca of Wisconsin: Wisconsin Geological and Natural History Survey, Bulletin no. 70, 507 p.

DEEVEY, E. S., JR., 1965, Pleistocene nonmarine environments, *in* Wright, H. E., and Frey, D. G. (editors), The Quaternary of the United States: International Association for Quaternary Research Congress, Seventh: Princeton University Press, Princeton, New Jersey, p. 643–652.

DEVORE, C. H., 1975, The molluscan fauna of the Illinoian Butler Spring sloth locality from Meade County, Kansas, *in* Smith, G. R., and Friedland, N. E. (editors), Studies on Cenozoic paleontology and stratigraphy: University of Michigan Museum of Paleontology Papers on Paleontology, no. 12 (C. W. Hibbard Memorial Volume 3), p. 19–28.

GRIFFITHS, J. C., 1967, Scientific method in analysis of sediments: McGraw-Hill, New York, 508 p.

HERRINGTON, H. B., and TAYLOR, D. W., 1958, Pliocene and Pleistocene Sphaeriidae (Pelecypoda) from the central United States: University of Michigan Museum of Zoology Occasional Papers, no. 596, p. 1–28.

HIBBARD, C. W., and TAYLOR, D. W., 1960, Two Late Pleistocene faunas from southwestern Kansas, *article 1 of* University of Michigan Museum of Paleontology Contributions, v. 16, p. 1–223.

JOHNSON, K. S., 1972, Northwest Oklahoma, *book 2 of* Guidebook for geologic field trips in Oklahoma: Oklahoma Geological Survey Educational Publication 3, 42 p.

KESLING, R. V., 1961, Ontogeny of Ostracoda, *in* Moore, R. C. (editor), Arthropoda 3, *pt. Q of* Treatise on invertebrate paleontology: Geological Society of America and University of Kansas Press, p. Q19–Q20.

LEONARD, A. E., 1943, The Mollusca of Meade and Clark Counties, Kansas: Kansas Academy of Science Transactions, v. 46, p. 226–240.

LUND, RICHARD, 1970, A new technique for chemical preparation of fossils: Journal of Paleontology, v. 44, p. 578.

MARGALEF, R., 1970, Perspectives in ecological theory: University of Chicago Press, 111 p.

MILLER, B. B., 1975, A sequence of radiocarbon-dated Wisconsinan nonmarine molluscan faunas from southwestern Kansas-northwestern Oklahoma, *in* Smith, G. R., and Friedland, N. E. (editors), Studies on Cenozoic paleontology and stratigraphy: University of Michigan Museum of Paleontology Papers on Paleontology, no. 12 (C. W. Hibbard Memorial Volume 3), p. 9–18.

———, 1976, The Late Cenozoic molluscan succession in the Meade County, Kansas area, *in* Bayne, C. K., Stratigraphy and faunal sequence—Meade County, Kansas: Kansas Geological Survey Guidebook, series 1 (Friends of the Pleistocene, Midwest Group, annual field conference guidebook), p. 73–85.

Miser, H. D., 1954, Geologic map of Oklahoma: U.S. Geological Survey and Oklahoma Geological Survey.
Myers, A. J., 1959, Geology of Harper County, Oklahoma: Oklahoma Geological Survey Bulletin 80, 108 p.
———, 1965, Late Wisconsinan date for the Bar M local fauna: Oklahoma Geology Notes, v. 25, p. 168–170.
Odum, E. P., 1971, Fundamentals of ecology: W. B. Saunders Co., Philadelphia, 574 p.
Reid, G. K., 1961, Ecology of inland waters and estuaries: Reinhold Book Corp., New York, 375 p.
Rollins, H. B., and Donahue, J., 1972, Transgression and regression: relative rates based on faunal communities: American Association of Petroleum Geologists, Eastern Section, 1st annual meeting, Columbus, Ohio, p. 67–81.
Shaak, G. D., 1975, Diversity and community structure of the Brush Creek marine interval (Conemaugh Group, Upper Pennsylvanian), in the Appalachian basin of western Pennsylvania: Florida State Museum of Biological Science Bulletin 19, p. 69–133.
———, 1976, Diversity and succession of a Late Pleistocene pond fauna, Major County, Oklahoma: Florida Scientist, v. 39, p. 81–86.
Shaak, G. D. and Rollins, H. B., 1972, Reflection of community standing crop in Pennsylvanian faunal assemblages [abstract]: Geological Society of America Abstracts with Programs, v. 4, p. 661.
Shannon, C. E., and Weaver, W., 1949, The mathematical theory of communication: University of Illinois Press, Urbana, Illinois, 117 p.
Simpson, E. H., 1949, Measurement of diversity: Nature, v. 163, p. 688.
Taylor, D. W., 1960, Late Cenozoic molluscan faunas from the High Plains: U.S. Geological Survey Professional Paper 337, 94 p.
Taylor, D. W. and Hibbard, C. W., 1955, A new Pleistocene fauna from Harper County, Oklahoma: Oklahoma Geological Survey Circular 37, 23 p.
Zakrzewski, R. J., 1975, Pleistocene stratigraphy and paleontology in western Kansas: the state of the art, 1974, *in* Smith, G. R., and Friedland, N. E. (editors), Studies on Cenozoic paleontology and stratigraphy: University of Michigan Museum of Paleontology Papers on Paleontology, no. 12 (C. W. Hibbard Memorial Volume 3), p. 121–128.

Monnett Chair Becomes a Reality

The announcement of the establishment of the Victor E. Monnett Chair in Energy Resources at The University of Oklahoma represents the fulfillment of a long-held dream for the School of Geology and Geophysics.

Although requests for contributions to fund the Monnett chair were initiated only 2 years ago this past summer, the possibility of offering such a position in the School had been under discussion for years. Efforts of the OU Alumni Advisory Council of the School of Geology and Geophysics, under the leadership of Frank Schultz of Dallas, Robert Klabzuba of Fort Worth, Hugh Thralls of Tulsa, and Denny Bartell of Houston, were so successful in the recent drive that the $750,000 endowment was oversubscribed. Alumni, wealthy or otherwise, friends of the School, and energy-based corporations were so generous, in fact, that it has become possible for the endowment to remain intact as capital, with interest from its investment providing the salary for the professorship. A careful search is under way for a highly qualified geologist and educator to fill the position.

Victor E. Monnett was a man who was in the right place at the right time and who had the ability to use that advantage to the fullest. A former student at OU, he returned to join the faculty in 1916. This was at a time when petroleum was entering its heyday. This was also at a time when explorationists, who had been drilling mostly by guess and by God, by the seat of their pants, by experience, were beginning to acknowledge that maybe the geologists had something to offer them. Dr. Monnett became chairman of the Department of Geology in 1924, and this was at a time when, by virtue of large yields from Glenn Pool and the Cushing, Healdton, and Garber Fields, Oklahoma had attained first place in production.

The oil was here, and natural gas; there was a need for these resources, a market; there was a need for geologists trained in methods that would help in locating reservoirs; and Monnett saw to it that the need was filled by OU-trained geologists. In the years of his administration, from 1924 through 1955, the university turned out so many petroleum-oriented geology majors that it was not possible to find a place in the free world where OU geology alumni were not active in the petroleum industry.

Certainly it is fitting that a chair in energy resources at The University of Oklahoma be designated in honor of the man who was the "mentor of probably more geologists than any teacher in history." We congratulate the Alumni Advisory Council in achieving their objective so successfully and so quickly.

Klabzuba Professorship

A second endowed distinguished faculty position for the School of Geology and Geophysics has been established through a gift of $300,000 that was presented to the OU Foundation Inc. by Robert and Doris Klabzuba. Investment earnings from this endowment will be used to support the Joe and Robert Klabzuba Professorship of Geology and Geophysics.

Bob and Joe Klabzuba, who are brothers, are both OU geology alumni, Joe having graduated in 1936, Bob in 1940. Bob, chairman of the Alumni Advisory Council last year, is a consultant in Fort Worth. Joe is an independent oil operator in Prague, Oklahoma.

Markle Nominated Bureau of Mines Director

Roger A. Markle, president of the Western Division of the Valley Camp Coal Co. in Salt Lake City since 1974, has been nominated by President Carter to be director of the U.S. Bureau of Mines. His executive career, which includes broad experience in management, tax, legal, accounting, and financial aspects of the minerals industry, makes him an excellent candidate for the job. Markle holds a B.S. degree in mining engineering from the University of Alaska, an M.S. degree in mine management from Stanford, and an M.B.A. degree from the University of Chicago.

GSA Schedules Annual Meeting in Toronto

For the first time in 25 years, The Geological Society of America will hold its annual meeting in Canada. Scheduled for October 23–26, this year's meeting will be held on the north shore of Lake Ontario in Toronto, with GSA, the Geological Society of Canada (GSC), and the Mineralogical Society of Canada (MSC) serving as co-sponsors. It will be the 91st annual convention for GSA, the 31st for GSC, and the 23rd for MSC.

With 26 scheduled field trips and 29 symposia, in addition to numerous oral and poster sessions, the program will be extremely full. Also, eight associated societies will hold concurrent meetings: The Cushman Foundation, Geochemical Society, Geoscience Information Society, Mineralogical Society, Society of Economic Geologists, and Society of Vertebrate Paleontologists. The American Underground Space Society will hold a partially overlapping meeting.

The Oklahoma Geological Survey will be represented by Charles J. Mankin, director, Kenneth S. Johnson, economic and environmental geologist, and S. A. Friedman, coal geologist.

In addition to attending technical sessions, Mankin will be involved in four meetings while at the convention, the first being a project meeting for COSUNA (Correlation of Stratigraphic Units of North America). Mankin is a regional coordinator and editor for this committee. He will participate in a meeting, as an incoming member, of the management board of the South-Central Section of GSA, and he will participate in a breakfast meeting of the Association of American State Geologists of which he was a past-president. Mankin is current president of the American Geological Institute, and on the final day of the convention he will be chairman of a meeting of the governing board of that body.

Johnson will present a paper on "Regional Geologic Characteristics Important for Storage of Radioactive Waste in Salt Deposits of the United States" at a technical session on Engineering and Environmental Geology. Friedman, as chairman of the division, will preside over the annual business meeting of the Coal Geology Division. He has been instrumental in developing this year's program, which will be the most extensive ever offered by the GSA in coal and will include technical sessions, a symposium, and a poster session. Friedman will also participate in a pre-meeting field trip to the coal fields of Nova Scotia.

Two professors from the OU School of Geology and Geophysics have prepared papers for presentation at the GSA meeting. Patrick K. Sutherland will talk on "Redefinition of the Morrowan Series (Lower Pennsylvanian) in its Type Area in Northwestern Arkansas" at a technical session on stratigraphy. This paper was co-authored with Robert C. Grayson, Jr., recent Ph.D. graduate of OU now on the faculty at Baylor University. John S. Wickham is co-author with R. J. Stein, OU graduate student, of a paper on "Computer Models of Drape Folding and Related Faulting" to be delivered by Stein at a symposium on structural geology. Prior to the meeting Wickham will accompany a group on a field trip to the Grenville Front Tectonic Zone, one of the major structures of the Canadian Precambrian shield.

Linda Tway, OU graduate student, will present a paper at the meeting of the Society of Vertebrate Paleontology on the metamorphism of ichthyoliths.

Claren Kidd, geology librarian, will attend sessions and will meet with the Guidebook and Ephemeral Publications Committee of the Geoscience Information Society to work on a supplement to the *Union List of Geologic Field Trip Guidebooks of North America*. She will also join a post-meeting field trip to the Canadian Shield and the Paleozoic lowlands of south-central Ontario.

Kenneth F. Wantland, who assumed the directorship of the School of Geology and Geophysics in June, and Harvey Blatt, professor in the School, will also attend the annual meeting.

Coal-Geology Course Offered at OU

The fifth annual short course in Coal Geology Fundamentals will be given October 30–November 1 at the Oklahoma Center for Continuing Education on The University of Oklahoma campus in Norman. Sponsored by the Oklahoma Geological Survey and OU's Management Development Programs, the 3-day course will focus on applied coal geology and will offer an optional 1-day field trip (November 2) to the eastern Oklahoma coal field.

This introductory noncredit course was organized by S. A. Friedman, the Survey's coal geologist, and will stress origin, distribution, classification, petrology, methane content and extraction, sulfur content, resources and recoverable reserves, exploration, and economic aspects. A syllabus is also included. Friedman's lectures contain illustrations from Oklahoma and Indiana coal fields and are supplemented by lectures from five of North America's outstanding geological authorities on coal: P. A. Hacquebard, geologist with the Geological Survey of Canada; C. G. Groat, new director of the Louisiana Geological Survey; Maurice Deul, geologist with the U.S. Bureau of Mines; E. C. Beaumont, consultant from Albuquerque, New Mexico; and R. L. Fuchs, president of Geosystems, Inc., Westport, Connecticut.

This comprehensive course is not offered anywhere else and has been attended, since its beginning in 1974, by people from major and independent oil producers, coal producers, state and federal agencies, and universities.

Tuition for the course is $175.00, plus an additional $50.00 for the field trip, which will include guidebook, lunch, and refreshments. For further details, contact John Boardman, Director, Management Development Programs, The University of Oklahoma, 1700 Asp Avenue, Norman, Oklahoma 73019 (phone, 405–325-1931).

GSA Research Grants Awarded to OU Students

Two graduate students from The University of Oklahoma's School of Geology and Geophysics were among 20 chosen as recipients of grants donated by industries to The Geological Society of America. Elisabeth Krause Goodwin, working on fracture densities in a drape fold from the Wyoming Province, and James Bryan Tapp, working on relationships of rock-cleavage fabrics to incremental strain paths, are to be congratulated.

OU Energy Resources Center Receives Grant

The award of a U.S. Department of Energy (DOE) grant in the amount of $1.8 million to The University of Oklahoma Energy Resources Center (ERC) (see *Oklahoma Geology Notes*, v. 37, p. 45) will enable the center to proceed with plans to establish a comprehensive data file on oil and gas production and reserves. The file will be unique in that it will contain information on all oil and gas fields in the United States and, where possible, data on all known reservoirs in the fields. Current DOE funding is for the first year of this proposed 3-year, $6.4-million project.

Charles J. Mankin, OGS director, has been named interim director of the center, and the Oklahoma Geological Survey will participate in building the information system by developing a basic data file on oil and gas fields in Oklahoma. This work is expected to be carried on under a subcontract from ERC.

The project of compiling data on Oklahoma will involve listing all fields, assembling information gathered on reservoirs of all new fields, assigning information acquired to the proper fields and reservoirs, and developing reports on production by each company and also on production from individual fields. The aggregate information will make it possible to offer production and reserve estimates on each field and reservoir.

Dr. Mankin has stated that the large petroleum-data files maintained at OU by the Petroleum Data System was the key to acquiring the project and that information made available will be invaluable to industry, government, and all interested in the development of energy resources.

DOE Issues Reports on Uranium

The Grand Junction office of the U.S. Department of Energy recently released three open-file reports on uranium. The first, entitled *Evaluation of Uranium Potential in Selected Pennsylvanian and Permian Units and Igneous Rocks in Southwestern and Southern Oklahoma*, was prepared by John W. Shelton and Zuhair Al-Shaieb as part of the National Uranium Resource Evaluation (NURE) program. Areas studied include parts of the Wichita, Arbuckle, and Hunton–Pauls Valley Uplifts; the Central Oklahoma Platform; and the Anadarko Basin.

The second report, *Regional Geochemical Model for Groundwater Associated with Uranium Mineralization in Northwest Texas*, was prepared by C. E. Nichols, V. E. Kane, and G. W. Cagle, also as part of the NURE program. Based on the model of trace elements and ground water, five areas of potential uranium mineralization were identified in the study area: one each in the Quartermaster Formation and Dockum Group and three in the Ogallala Formation.

A Preliminary Classification of Uranium Deposits is designed to facilitate systematic collection, analysis, and storage of uranium-occurrence data for the

NURE program. The report was edited by David G. Mickle of Bendix Field Engineering Corp. and consists of four papers by geologists from Bendix.

The first report, 261 pages, GJBX-35(78), dated June 1977, the second report, 26 pages, GJBX-93(77), dated November 1977, and the third report, 78 pages, GJBX-63(78), dated May 1978, are on open file at the Oklahoma Geological Survey, 830 Van Vleet Oval, Norman, and can be purchased on microfiche from Bendix Field Engineering Corp., Technical Library, P.O. Box 1569, Grand Junction, Colorado 81501; the cost is $3.00 each.

In addition to the open-file reports, DOE issued a report, *Statistical Data of the Uranium Industry*. The report is issued annually and contains historical facts and figures of the uranium industry in the United States and covers subjects such as production, resources, exploration, land holdings, and employment. Copies of the 101-page report, GJO-100(78), are available from the Technical Library of Bendix at the address given above; the cost is $3.00 each.

New Theses Added to OU Geology Library

The following M.S. theses have been added to The University of Oklahoma Geology and Geophysics Library:

A Study of Local Earthquakes in Oklahoma Recorded on 1-3 Hertz Seismographs, by Keven Lowell Woller.

Breccias and Megabreccias of the Arbuckle Mountains, Southern Oklahoma Aulacogen, Oklahoma, by James Bryan Tapp.

Surface and Subsurface Study of the Southwest Davis Oil Field, Sections 11 and 14, T. 1 S., R. 1 E., Murray County, Oklahoma, by Elliott W. Wiltse.

The Areal Geology and Cretaceous Stratigraphy of Northwest Marshall County, Oklahoma, by Alan M. Holtzman, Jr.

The Geology of the Hartshorne Coals (Desmoinesian) in Parts of the Heavener 15′ Quadrangle, Le Flore County, Oklahoma, by David R. Donica.

The Lithostratigraphy of the Morrowan Bloyd and McCully Formations (Lower Pennsylvanian) in Southern Adair and Parts of Cherokee and Sequoyah Counties, Oklahoma, by Grant David Zimbrick.

U.S. Board on Geographic Names Decision

The U.S. Board on Geographic Names has approved one Oklahoma place name. The name was listed in the April through June 1978 issue of *Decisions on Geographic Names in the United States* (Decision List 7802).

Still Creek has been adopted for a stream, 4.8 kilometers (3 miles) long, that heads at 35°10′06″ N., 97°24′09″ W., and flows south to the Canadian River at Noble. The creek was named for a distillery that was located along this creek in about 1900. Cleveland County; sec. 27, T. 8 N., R. 2 W., Indian Meridian (35°08′03″ N., 97°24′12″ W.).

Fossil-Resource Report Completed

A Survey of Paleontological Resources of Southeastern Oklahoma, a report prepared by Coleman R. Robison as visiting geologist with the Oklahoma Geological Survey, presents results of a combined paleontological and environmental survey conducted this year in the coal fields of the Arkoma basin. The program of evaluating paleontological material in the region was established by the U.S. Department of the Interior's Bureau of Land Management (BLM) to fulfill requirements of a national public law that requires assessment of the impact of mining on paleontological and archeological materials in Federal coal lands. Robison's investigations were carried through under a grant of $32,000 from BLM, and the report has been issued in open file by that agency.

The 146-page report presents descriptions of more than 200 localities in seven southeastern counties, with listings of fossils recovered from each; a location map is included. There is an extensive bibliography of pertinent literature with brief abstracts of each entry. Ten fossil plates are included in the report.

Robison has assembled an outstanding fossil collection of plant and invertebrate material to accompany the report. This collection has been deposited in the OU Stovall Museum of Science and History.

This open-file report is available for inspection at the Survey offices; at BLM offices at 200 Northwest 5th Street, Oklahoma City; and at BLM offices in Albuquerque, New Mexico. Copies can be made at the requestor's expense upon order to BLM.

Colorado Geological Survey Releases New Publications

The Colorado Geological Survey has just released Resource Series 4, *1977 Symposium on the Geology of Rocky Mountain Coal*, edited by Helen E. Hodgson. The symposium was held in May 1977 at the Colorado School of Mines and was sponsored by the Colorado Survey and the U.S. Geological Survey. The 219-page source book contains 14 papers on such diverse subjects as depositional models of coal deposits, mine planning and development, the role of geologists in mining, computer applications, and geophysical techniques.

Also just released by the Colorado Survey is Map Series 10, *Mining Activity Map of Colorado with Directory*, by A. L. Hornbaker. This map shows metal-mining activity, exclusive of uranium and vanadium. The locations of all mines are numerically keyed to a county alphabetical list with the names of the operators, addresses, and, if available, telephone numbers. The mines are coded as to size ranges based on value of production.

A third publication issued recently by the Colorado Geological Survey is Resource Series 3, *Colorado Coal Directory and Source Book*, a 235-page looseleaf computerized guide offering information on production, reserves, mines and producers, and economics.

Resource Series 3, at a cost of $6.00, Resource Series 4, at a cost of $5.00, and Map Series 10, at a cost of $3.00, are available from the Colorado Geological Survey, 1313 Sherman Street, Room 715, Denver, Colorado 80203.

Industrial-Waste-Disposal Report on Open File

A study on *Surface Disposal of Controlled Industrial Wastes in Oklahoma* has been completed, and a report on the project has been prepared in preliminary form in partial fulfillment of a grant contract with the Oklahoma Department of Economic and Community Affairs (DECA). The report, prepared by the Oklahoma Geological Survey and DECA in cooperation with the Oklahoma State Board of Health, represents the result of extensive geologic, hydrologic, and engineering investigations by the authors, Kenneth S. Johnson, OGS economic and environmental geologist, and Kenneth V. Luza, OGS engineering and environmental geologist. Funding for the project in the amount of $14,698 was made available through DECA under a grant from the Economic Development Administration of the U.S. Department of Commerce.

The 97-page report incorporates a reconnaissance of bedrock geologic materials that can be utilized for safe containment of such waste products of industrial operations as spent acids, caustic solutions, poisons, explosives, flammable liquids, and liquids containing heavy-metal ions. Geologic units are categorized into three zones on the basis of their suitability as safe repositories. Social, economic, climatic, and political considerations are evaluated as well. The report contains numerous maps and tables and includes a large, folded map of the State, at a scale of 1:750,000, delineating and describing the zones.

Another report, also in fulfillment of the DECA contract, will be submitted when the second stage of the project is completed. This will give results of a companion study to evaluate subsurface rock units in Oklahoma. The two reports will be combined and revised at a later date and will be published as an OGS circular.

Copies of *Surface Disposal of Controlled Industrial Wastes in Oklahoma* are available for inspection at the Survey offices, 830 Van Vleet Oval, Norman, and at DECA offices, 5500 North Western Avenue, Oklahoma City. Twenty-five additional copies have been put on deposit with the Oklahoma Department of Libraries and are available on interlibrary loan through the Allen Wright Memorial Library, 200 Northeast 18th Street, Oklahoma City.

Results of these geologic environmental assessments will be presented in a paper by Luza and Johnson to be delivered at the annual meeting of the Association of Engineering Geologists in Hershey, Pennsylvania, October 16–21.

Oklahoma's Geological Societies Announce New Officers

New Officers and executive committees for the 1978–79 year have been announced by the following geological and geophysical societies in Oklahoma:

Ardmore Geological Society

President, **B. W. (Bronc) James**, independent
Vice-President, **Jim R. Hallett**, Quinton Little Co.
Secretary-Treasurer, **Edward W. Wakeland**, Dauber Exploration Co.
Past President, **Harry A. Spring**, independent

Geophysical Society of Oklahoma City

President, **Harry Goebel**, Nova Energy Corp.
First Vice-President, **B. B. Ferrell**, Data Finders
Second Vice-President, **Clint Hutter**, Texas Pacific Oil Co.
Secretary, **Bill Haselwood**, Forest Oil Corp.
Treasurer, **Marc Pottorf**, Terra Resources, Inc.
Past President, **R. R. Foster**, Dawson Geophysical Co.

Geophysical Society of Tulsa

President, **M. E. (Mo) Arnold**, Amoco Production Co.
First Vice-President, **R. A. Wyckoff**, Continental Oil Co.
Second Vice-President, **Stanley S. Wedel, Jr.**, Seismograph Service Corp.
Secretary, **W. O. Heap**, Seismograph Service Corp.
Treasurer, **Donald D. Ott**, Geodata Corp.
Editor, **O. (Lawayne) Eberhart**, Texaco, Inc.
Editor-Elect, **Janet L. Borgerding**, Cities Service Co.
Past President, **M. R. (Marv) Hewitt**, Amoco Production Co.
District Representatives: **M. E. (Mo) Arnold**, Amoco Production Co.; **M. R. (Marv) Hewitt**, Amoco Production Co.; **R. W. Mossman**, Seismograph Service Corp.

Oklahoma City Geological Society

President, **Don F. Weber**, independent
First Vice-President, **Gary W. Hart**, independent

Geophysical Society of Tulsa executive committee for 1978–79. Seated, left to right: W. O. Heap, secretary; Stanley S. Wedel, Jr., second vice-president; M. E. Arnold, president; R. A. Wyckoff, first vice-president; Janet L. Borgerding, editor-elect. Standing, left to right: O. L. Eberhart, editor; M. R. Hewitt, past president; R. W. Mossman, district representative; Donald D. Ott, treasurer.

Second Vice-President, **W. P. Anderson, Jr.**, consultant
Secretary, **Jerry E. Upp**, Tenneco Oil Co.
Treasurer, **M. Stuart Kirk**, AN-SON Corp.
Shale Shaker Editor, **William T. (Tom) Gans**, Continental Oil Co.
Library Director, **J. W. (Jim) McHugh**, consultant
Social Chairman, **John G. Borger II**, Walter Duncan Oil Properties, Inc.
Public Relations Chairman, **John C. Shenk**, Cheyenne Petroleum Co.
Past President, **Sherrill D. Howery**, Southport Exploration Co.
Representative-at-Large, Midcontinent Section of the AAPG, **Douglas J. Seyler**, Union Oil Co.; Chairman of Representatives to AAPG House of Delegates, **Guy B. Kiker**, Gadsco, Inc.

Tulsa Geological Society

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Oklahoma City Geological Society executive committee for 1978–79. Seated, left to right: Sherrill D. Howery, past president; William T. Gans, **Shale Shaker** editor; Don F. Weber, president; J. W. McHugh, library director; John C. Shenk, public relations chairman. Standing, left to right: Douglas J. Seyler, representative-at-large to AAPG Midcontinent Section; Gary W. Hart, first vice-president; John G. Borger II, social chairman; Jerry E. Upp, secretary; M. Stuart Kirk, treasurer; W. P. Anderson, Jr., second vice-president.

Oklahoma State University

Geochemistry of the Wichita Granite Group in the Wichita Mountains, Oklahoma

SCOTT RANDALL ADAMS, Oklahoma State University, M.S. thesis, 1977

Scope and Method of Study: The granites, granophyres, and hybrid rock (formed by the assimilation of basic rocks by granite), probably Middle Cambrian in age, of the Wichita Granite Group were studied using samples collected from quarries, prospecting pits, outcrops, and drill cores. The samples were analyzed for major and minor elements using various geochemical techniques such as atomic absorption spectrophotometry, X-ray fluorescence spectrometry, and fluorometry. Gamma ray spectrometry was used in radiometric analysis. Fission track analysis was conducted on some of the samples to determine sources of uranium in the granites. Comparisons of major and minor elements were made. Maps and histograms showing the trace element distribution in the Wichita Mountain granites were also analyzed.

Findings and Conclusions: The granites of the Wichita Mountains show a differentiation trend based on increasing alkalinity and decreasing iron content with progressively younger rocks. The Quanah granite is exceptionally peralkaline. Differentiation from a parent magma may have produced the non-peralkaline granites; the Quanah granite may have been generated from the partial fusion of upper crustal basement rocks of the Arbuckle Mountains by a mafic magma. Copper, lead, zinc, manganese, lithium, uranium, and thorium average 10 ppm, 22 ppm, 108 ppm, 372 ppm, 29 ppm, 3 ppm, and 25 ppm, respectively. Uranium is present in aegirine, riebeckite, and allanite in Quanah granite pegmatites. Uranium has been remobilized after emplacement of the granites by hydrothermal, deuteric, and (or) weathering processes. The enrichment of uranium in aegirine-riebeckite pegmatite dikes is due to the remobilizing of uranium from the granites during late-stage, hydrothermal activities.

Surficial Geology of the Cimarron Valley from Interstate 35 to Perkins, North-Central Oklahoma

JOHN ANTHONY BLAIR, Oklahoma State University, M.S. thesis, 1975

Scope and Method of Study: This study summarizes the stratigraphy, geomorphology, structural geology, geologic history, and environmental geology of the Cimarron River Valley from Interstate 35 to Perkins, north-central Oklahoma. Field work and interpretations of aerial photographs and topographic maps were used to produce geologic and geomorphic maps, cross sections, and longitudinal profiles of stream terraces. Environmental interpretations of all stratigraphic units were made.

Findings and Conclusions: By means of two plates and eight figures, this report presents a three dimensional picture of the geology of the study area. Three tables provide a means of evaluating the environmental impact of man's activities in the area. The report is intended to be a useful guide to both geologists and nongeologists interested in the project area.

Four terraces, a flood plain along the Cimarron River and its tributaries, and sand dunes were distinguished. Four bedrock units of Permian age were delineated. Eleven Quaternary stratigraphic units were delineated including eolian, fluvial, gravity, and anthropic deposits. Geologic history includes deposition of Permian marine units, uplift and erosion, and during the Quaternary Period, a complex sequence of alluvial episodes often accompanied by eolian episodes, interspersed with colluvial episodes.

Environmental geology problems considered within the area include shrinking and swelling soils, erodibility, quantity and quality of ground and surface water, earthquake susceptibility, seepage, rippability, slope instability, flooding, and depth to bedrock.

Subsurface Stratigraphic Analysis of the Prue, Skinner and Red Fork Sandstones, Southern Noble County, Oklahoma

CHARLOTTE EVANS CANDLER, Oklahoma State University, M.S. thesis, 1976

Scope and Method of Study: The depositional environments of the Red Fork, Skinner and Prue sandstone intervals were determined from net-sandstone thickness maps, correlation sections and log maps. An isopach map from the base of the Pink limestone to the top of the Mississippian System was used to estimate the paleotopography of the Mississippian limestone and its influence on deposition of Cherokee sediments. Likewise, the possible effects of structural movement on sediments of the Cherokee group were estimated from a "paleo-structure" isopach map of the interval between the base of the Oswego limestone and the base of the Pink limestone.

Findings and Conclusions: The Cherokee rocks were deposited during a series of transgressions and less extensive regressions. The Red Fork, Skinner and Prue sandstones are thought to have been deposited in a deltaic environment including interdistributary, channel and possibly delta-fringe facies. The Cherokee sea advanced from a southerly direction and the source area for the Cherokee rocks is believed to have been to the east and northeast of the study area. Locally, deposition of the Cherokee sandstones was influenced by the paleotopography of the Mississippian limestone and also by paleostructure, including differential compaction and structural movement.

Surficial Geology Along the Arkansas Valley from Ponca City Northward to Kirk's Hill Top, North-Central Oklahoma

VICHOL CHINSOMBOON, Oklahoma State University, M.S. thesis, 1976

Scope and Method of Study: The surficial geology of the study area was mapped by airphoto interpretation and field work supplemented by existing published and unpublished geological works pertaining to the area. The engineering soils of the area were mapped by making engineering interpretations of existing pedological mapping supplemented by field work. To aid in the correlation of alluvial deposits, longitudinal profiles of the terraces and flood plain along the Arkansas River were constructed. Cross sections were constructed to show the vertical relationships of surface and near surface units. Data on the economic geology and engineering geology of the area were derived from existing publications and field work.

Findings and Conclusions: The Pliocene Ogallala Formation may have overlain the study area but has been eroded away. It is probable that the huge intrenched meanders of the present-day Arkansas were superimposed on the bedrock from a high-discharge stream (the ancestral Arkansas) in the Ogallala. Five alluvial deposits are present. In order of decreasing topographic position and decreasing age, they are: The McCord Terrace Alluvium, the Ponca City Terrace Alluvium, the Uncas Terrace Alluvium, the Kaw City Terrace Alluvium, and the flood plain alluvium of the Arkansas River. Deposits of Lake Blackwell I and Lake Blackwell II, which were produced when successive valley trains from the Rocky Mountains down the Arkansas Valley dammed the mouth of the valley of the Salt Fork of the Arkansas River, occur in the southwest part of the study area. Eolian deposits are not common in the area because the deep, narrow Arkansas Valley generally restricted the sweep of wind across the various alluvial deposits. Colluvium is present on almost all hillslopes.

There is local evidence that the climate of the study area changed repeatedly from humid to arid and back again during the Pleistocene Epoch.

Geochemical Studies of Uranium in South-Central Oklahoma

RICHARD WARREN OLMSTED, Oklahoma State University, M.S. thesis, 1975

Scope and Method of Study: Hydrogeochemical methods were used to outline areas having potential for radioactive mineralization. Ground-water samples were collected from private and municipal wells and were analyzed for their uranium content. The redox potential (Eh) and pH were determined for more than forty water samples. Gamma ray logs and car-borne scintillometer surveys were used to locate radioactive deposits in the target areas. Petrographic analyses were conducted on potential host rocks in the study area.

Findings and Conclusions: The geochemical anomalies showed a relationship between radioactive mineralization and oil-producing structures which displayed alteration of red beds. Migrating hydrocarbons from oil reservoirs trapped along the structures had caused precipitation of uranium from ground waters moving onto the anticlines, resulting in the formation of ore deposits. Hydrogen sulfide needed for this process was produced through reduction of sulfate by the migrating hydrocarbons or contained within the light fraction of the hydrocarbons. Uranium mineralization also was found in sandstone channels in association with carbonaceous material. The host rocks in southern Oklahoma are fine- to very fine grained sandstones of Upper Pennsylvanian and Permian ages. The source for the radioactive materials was the Wichita and Arbuckle Mountains. Geochemical anomalies and other oil-producing structures displaying surface alteration (West Cement, Chickasha, Velma-Cruce, Eola and Healdton) suggest targets for future exploration.

Clay Minerals and Hydroxy Interlayers in Selected Oklahoma Soils

MOHAMMAD HASSAN ROOZITALAB, Oklahoma State University, Ph.D., 1978

Scope and Method of Study: Six Oklahoma soils (Dennis, Bernow, Aydelotte, Konawa, Ulysses, and Dill) were selected for this study. The soils represented formations of five major geologic ages and four soil orders in Oklahoma. Soil cation exchange capacity, exchangeable cations, exchangeable Al and H, organic matter, carbonates, pH, and particle size distribution were determined. Coarse and fine clay fractions were separated. Free iron oxides, amorphous aluminosilicates, and hydroxy-Al and -Fe interlayers were determined on the coarse and fine clay fractions using a sequential dissolution technique. X-ray diffraction patterns were obtained from the coarse and fine clay fractions. Kaolinite plus halloysite were determined quantitatively by the selective dissolution analysis. Total K_2O content was used to estimate illite. Montmorillonite and vermiculite were determined by the cation exchange analysis technique.

Findings and Conclusions: Hydroxy-Al is the major compound blocking the interlayer spaces of expansible clay minerals. The coarse clay fraction of the surface horizons contains relatively larger amounts of interlayers, particularly in the A horizon of Bernow, Konawa, and Dennis. The fine clay fraction contains smaller amounts of interlayer materials which are distributed somewhat uniformly in the A and B horizons. Fe is not present in large amounts in the interlayer space.

Illite is the dominant clay of the shales studied in central and eastern Oklahoma. Montmorillonite and kaolinite are the next most dominant clays. Montmorillonite is the dominant clay in the sandy sediments studied in western Oklahoma. Montmorillonite and illite are the major components of clay minerals in the loess and alluvial deposits studied. Illite is present in smaller amounts in the upper portion of the soil profile in Dennis and Aydelotte. Kaolinite has been depleted in the coarse clay fraction in the A horizon of Bernow, Dennis, and Konawa. Montmorillonite and illite are the major components of the coarse clay fraction in Aydelotte, Ulysses, and Dill. Interlayered expansible clay, kaolinite, and illite are all present in the coarse clay fractions of Bernow, Dennis, and Konawa. Montmorillonite dominates the fine clay fraction in the studied soils. Kaolinite is found in larger amounts in Bernow. Vermiculite and chlorite are not present in large amounts in these soils.

U.S. Bureau of Mines Releases Circular

An information circular, IC8772, recently released by the U.S. Bureau of Mines, covers pertinent data concerning fuel-related projects in the 24 states west of the Mississippi River. The 199-page report includes figures, maps, and tables that list the name and location of these projects. *Projects to Expand Energy Sources in the Western States—An Update of Information Circular 8719* [abbreviated title] is by Charles H. Rich, Jr., with contributions by Bureau of Mines liaison officers from the western states. To order, request GPO Stock No. 024-004-01926-3 from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. The cost is \$3.50. Include your name, address, and zip code plus \$1.00 for each mail order.

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