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GEOLOGISTS AND FIELD TRIPS—HATS OFF TO A LONG TRADITION

No, the geologists in the cover photo are not looking for a lost contact lens. We aren't certain what has their attention, but heads (and hats) are bowed in close scrutiny of the outcrop, which, in this case, happens to be the Haragan Formation near White Mound, in sec. 20, T. 2 S, R. 3 E., Murray County, Oklahoma.

The occasion pictured here is a 1930 field trip of state geologists, and we presume that Dr. Hugh D. Miser, the gentleman with the pick, is exhorting the out-of-state geologists to tidy up the outcrop for future visits by Oklahoma geologists.

The cover for this issue was prompted by the discovery of the old by the new. Connie Smith, our new associate editor, was rummaging through "artifactual" material in her new office and happened on a box of old photographs belonging to the Oklahoma Geological Survey.

The photo of Dr. Gould (above) was made from a glass-plate negative, dated 1900, which was also found in the box. Dr. Gould came to Oklahoma in that year to found the Department of Geology at The University of Oklahoma. Eight years later he was elected the first director of the Oklahoma Geological Survey and served in this capacity until 1911. In 1924, after 13 years of private practice as a consultant, he resumed his post as director of the Survey and remained until 1931.

—Donald A. Preston

Editorial staff: William D. Rose, Elizabeth A. Ham, Connie Smith

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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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CORRELATION BETWEEN VEGETATION AND GEOLOGIC FORMATIONS IN OKLAHOMA

Lorna K. Rhodes[1]

Abstract—A map published by the Oklahoma Game and Fish Department (Duck and Fletcher, 1943) shows 15 vegetation types in Oklahoma, and the *Geologic Map of Oklahoma* (Miser and others, 1954) delineates outcrops of more than 100 geologic formations. Samples taken at the southeastern corner of each township in Oklahoma have been used to calculate association indices for vegetation types and geologic formations. For purposes of this paper, geologic formations have been grouped according to lithology.

Piñon-juniper proved to have strong association with sandstone formations. The distribution of *Pinus edulis* was found to be associated with Dakota (Cretaceous) sandstone. Short-grass high-plains vegetation is strongly associated with sandstone, and sand-sage grassland was found on high-terrace and dune-sand environments. Mixed grass has positive association with formations containing shale, and mesquite grasslands coincide with rock strata including both shale and gypsum. Tall-grass prairie shows positive association with sandstone. Stabilized dune vegetation correlates with high-terrace deposits. Shinnery oak shows positive association with dune sand, and post oak-blackjack forest develops on sandstone. Oak-hickory forest is associated most closely with chert-limestone rocks, less so with shale, and even less with sand. Oak-hickory thus is most strongly associated with rock that weathers to fine-grained soils. Oak-pine forest is found most often over formations containing sand, as is loblolly pine. Cypress-bottoms vegetation appears to have no significant association with any one type of rock. Bottomland vegetation is most significantly associated with alluvium and dune sand.

Thus types of vegetation and rock types are found to be significantly associated in Oklahoma.

Introduction

The types and characteristics of the rocks in an area have long been understood to be significant factors in the determination of the kinds and abundance of vegetation present.

Erickson and others (1942), in a study of forest glades of the northern Ozarks, concluded that the occurrence of glades was determined by the presence of thin strata of relatively pure dolomite, known locally as "cotton rock," in conjunction with high relief on southern and western slopes. In the same area, Beilmann and Brenner (1951) found a red cedar–chinquapin oak (*Juniperus virginiana–Quercus muhlenbergii*) association occurring in strips

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as narrow as 16–33 feet immediately bordering strata of the cotton rock both above and below outcrops on western slopes.

Cuyler (1931) reported that the contacts of a map of plants and plant associations of the Austin Quadrangle, Texas, coincided with those of a geologic map of the same area. He also noted that the presence and location of faults could be discerned by vegetation patterns alone.

Dyksterhuis (1948) attributed the boundaries of the vegetation types of the Cross Timbers region of Texas to the geologic substrate. The evidence indicates that sandy beaches and calcareous deposits were left behind as an ancient sea retreated to the east and south. The Eastern and Western Cross Timbers occupy the sandy areas, while the intervening Fort Worth Prairie covers the calcareous material.

The underlying bedrock affects the plant environment in several respects. The soil minerals available to vegetation are derived from it. The texture, porosity, and permeability of the rock determine moisture absorption and retention properties of the soil.

This study concerns association between vegetation types and geologic formations, or rock types, in Oklahoma. *A Game Type Map of Oklahoma* (Duck and Fletcher, 1943) is the source of data concerning regions dominated by major plant associations. The *Geologic Map of Oklahoma* (Miser and others, 1954) supplied information concerning the locations of geologic formations.

Appreciation is expressed to Dr. A. J. Myers of the Oklahoma Geological Survey for help in planning and executing this study, and to Dr. Robert O. Fay, also of the Oklahoma Geological Survey, for comments regarding geologic units and nomenclature.

Materials and Methods

The vegetation type and geologic formation at the southeastern corner of each township in Oklahoma were recorded. A count was taken of the number of times each vegetation type was found in association with any given geologic formation. Data for each pairing of geologic formation and vegetation type were arranged in a contingency table (Poole, 1974):

	Geologic formation present	Geologic formation absent
Vegetation type present	a	b
Vegetation type absent	c	d

a = the number of sample points at which the given vegetation type was coincident with the specific geologic formation.

b = the number of sample points at which the vegetation type was found in association with all other formations.

c = the number of sample points at which the given geologic formation coincided with any other vegetation type.

d = the number of sample points at which neither the given vegetation nor the given geologic formation was present. This number is not used in the present study, because of the possibility of negative association owing to spatial exclusion.

The formula $\frac{2a}{2a + b + c}$ (Goodall, 1973) was used to obtain an index of association value for each coincident vegetation type and geologic formation. Index values range from zero for no association to 1 for complete association. Complete association would be the case where a given vegetation type and a given geologic formation do not occur except in association with each other. The indices are used as a basis for comparison of degree of association.

Descriptions of Vegetation Types

The names and boundaries of the vegetation regions are taken from Duck and Fletcher (1943; see fig. 1). The distribution of *Pinus edulis* is described separately from the piñon-juniper-mesa type. Botanical nomenclature follows Waterfall (1960).

Piñon-juniper-mesa type.—The principal grasses of the region are buffalo grass (*Buchloe dactyloides*), blue grama (*Bouteloua gracilis*), and hairy grama (*B. hirsuta*). Some tall grasses grow on the mesa slopes. The steep, rock-littered slopes are covered in places with a low scrub consisting mainly of thick-leaved hackberry (*Celtis reticulata*), with some juniper (*Juniperus monosperma*) and live oak (*Quercus undulata*) (Blair and Hubbell, 1939). Western yellow pine (*Pinus ponderosa*) is also present in places (Duck and Fletcher, 1945). Cholla cactus (*Opuntia imbricata*) occurs in clumps (Blair and Hubbell, 1939).

Piñon pine.—Piñon-juniper vegetation is limited to a small area in the extreme northwestern corner of the Oklahoma Panhandle (Duck and Fletcher, 1945). Juniper and piñon pine (*Pinus edulis*) are found in mostly sparse but occasionally thick stands on north-facing slopes (Blair and Hubbell, 1939).

Short-grass high plains.—With the taller grasses unable to establish and reproduce themselves in competition with the short grasses, buffalo grass and blue grama have been experimentally demonstrated to be the climax vegetation of the region. Blue grama forms the most extensive and important consociation and is also a codominant. Hairy grama is also important. Little bluestem (*Andropogon scoparius*), wire grass (*Aristida* sp.), and side-oats grama (*Bouteloua curtipendula*) also occur (Bruner, 1931).

Sand-sage grassland.—Sand-sage (*Artemisia filifolia*) is the characteristic plant species of the sand-hill areas in northwestern Oklahoma. Associated with it are sand plum (*Prunus angustifolia*), stinking sumac (*Rhus aromatica* var. *trilobata*), hackberry (*Celtis* sp.), sand bluestem (*Andropogon hallii*), and Indian grass (*Sorghastrum nutans*) (Duck and Fletcher, 1945).

Mixed-grass eroded plains.—This region covers most of the western one-fourth of the State, exclusive of the Panhandle, and is an area of overlap of the true prairie vegetation to the east with the short grasses of the high plains to the west (Duck and Fletcher, 1945). Plant dominance in the region is shared by both the tall and short grasses (Bruner, 1931). Duck and Fletcher (1945)

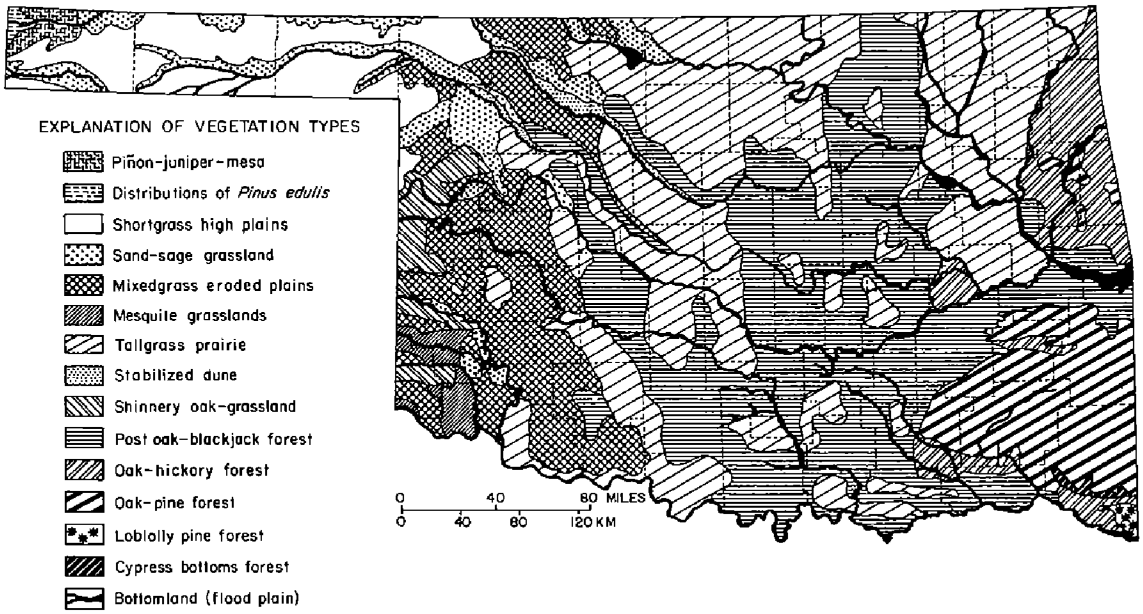

Figure 1. Generalized vegetation map of Oklahoma. Adapted from Duck and Fletcher (1943) and Marcher (1972).

listed buffalo grass, blue grama, and side-oats grama as the most numerous grasses. Bruner (1931) considered blue grama the most important single dominant. Little bluestem is a widely spread dominant in association with the short grasses (Bruner, 1931).

Mesquite grasslands.—The mesquite grasslands lie between the mixed-grass prairie and the short grasses of the high plains. Bruner (1931) stated, "Mesquite trees and shrubs abundantly occur, forming an open savannah of small trees eight to fifteen feet high." Blue grama is the most abundant of the short grasses that form a dense sod, with buffalo grass also present. *Yucca glauca* is a common perennial, and prickly pear cactus (*Opuntia* sp.) forms large mats in pastures (Bruner, 1931).

Tall-grass prairie.—Tall-grass prairie is the most extensive plant association in Oklahoma (Duck and Fletcher, 1945). In central Oklahoma, little bluestem is the principal sod-forming grass, occurring over large tracts in almost pure stands. Big bluestem (*Andropogon gerardi*) is also common (Bruner, 1931). Toward the drier west, there is a gradual increase of such species as buffalo grass, blue grama, and side-oats grama (Duck and Fletcher, 1945). To the east, the sod-forming grasses are big bluestem, little bluestem, Indian grass, and switchgrass (*Panicum virgatum*) (Blair and Hubbell, 1939).

Stabilized dune.—Duck and Fletcher (1945) described the vegetation as a variation of trees, shrubs, grasses, and weedy annuals. Typical species forming the overstory are American elm (*Ulmus americana*), hackberry (*Celtis* sp.), chittam wood (*Bumelia lanuginosa*), post oak (*Quercus stellata*), and

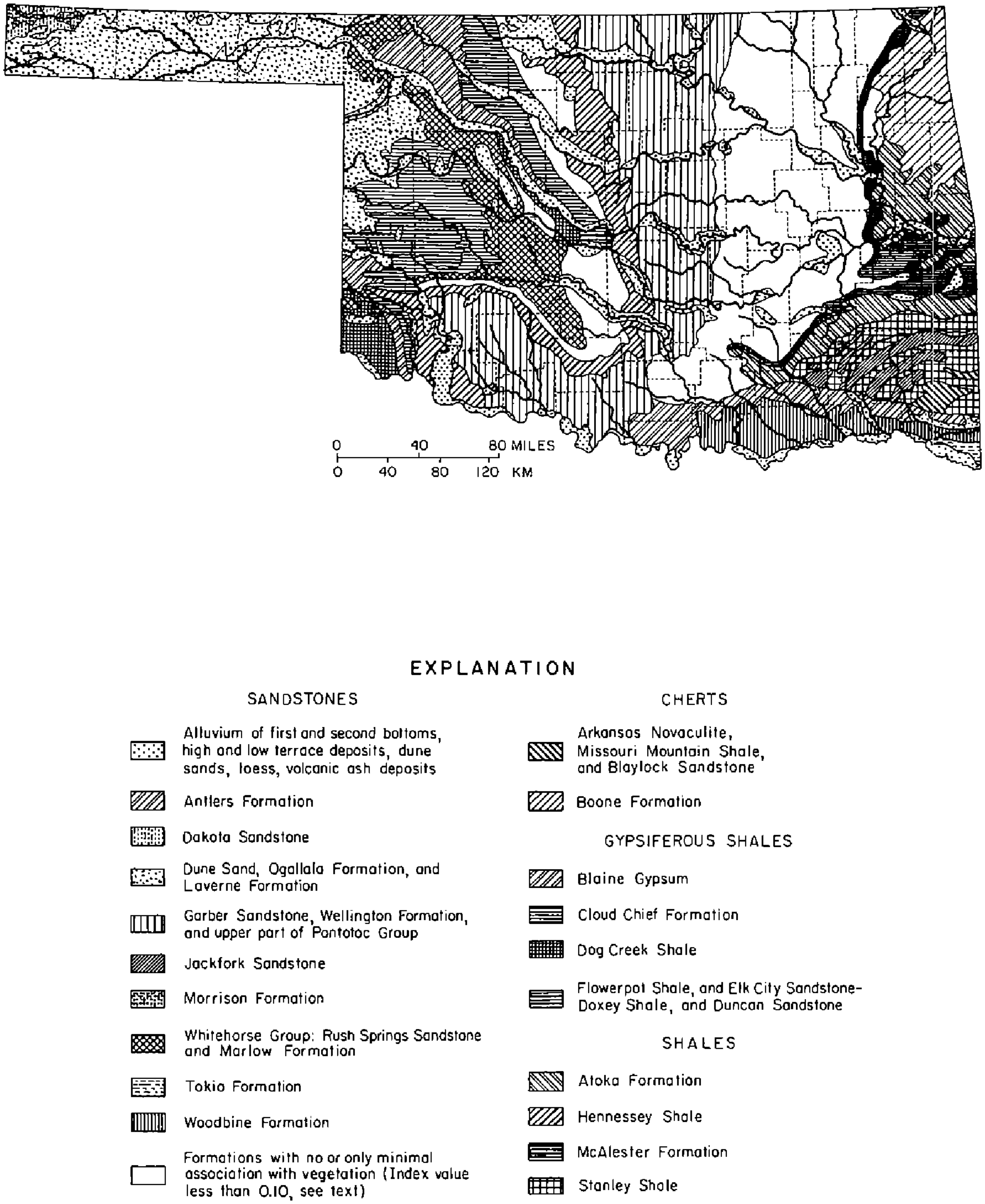

Figure 2. Generalized geologic map of Oklahoma. Adapted from Miser and others (1954), Bellis (1972), and Marcher (1972).

blackjack oak (*Q. marilandica*). Also found here are the wild grape, sand plum, dogwood (*Cornus drummondii*), stinking sumac, sumac (*Rhus aromatica*), and tall grasses typical of deep western sandy soils.

Shinnery oak–grassland.—The grassy slopes of this region are dotted with motts of oak (Duck and Fletcher, 1945). The clumps of shin oak that give the region its name are especially abundant in overgrazed pastures and abandoned fields. The oaks have been identified as *Quercus mohriana*, post oak, and *Q. vaseyana* (Bruner, 1931). The most common oak, however, is now considered to be *Q. havardi* (Wiedeman and Penfound, 1960). Little bluestem is the dominant grass. Shorter grasses grow in more compact soils (Duck and Fletcher, 1945).

Post oak–blackjack forest.—This vegetation type is an ecotone between the eastern deciduous forest and the tall-grass prairie. The dominant trees are post oak, blackjack oak, and black hickory (*Carya texana*). The chief grasses are little bluestem and big bluestem (Duck and Fletcher, 1945).

Oak-hickory forest.—The oak-hickory forest of northeastern Oklahoma is continuous with the eastern deciduous forest (Bruner, 1931). The dominants of this area are post oak, blackjack oak, black hickory, and winged elm (*Ulmus alata*) (Blair and Hubbell, 1939). Deep, moist soils support mixed forests that include red oak (*Quercus rubra*), black oak (*Q. velutina*), and shellbark hickory (*Carya laciniosa*). White oak (*Q. alba*) is rare, being confined to moister areas, as is sugar maple (*Acer saccharum*). Rice and Penfound (1959) reported that Shumard's oak (*Q. shumardii*) and mockernut hickory (*C. tomentosa*) are also important dominants in this forest type and red oak is rare.

Oak-pine forest.—On the rocky ridges of the Ouachita Mountains in southeastern Oklahoma, oak and hickory intermingle with the shortleaf pine (*Pinus echinata*). The species of the open forest include shortleaf pine, white oak, post oak, blackjack oak, black hickory, and black locust (*Robinia pseudoacacia*) (Blair and Hubbell, 1939). The willow oak (*Quercus phellos*) and basswood (*Tilia americana*) are also common to the area (Duck and Fletcher, 1945). The most common ground cover is huckleberry (*Vaccinium vacillans* var. *crinatum*) (Blair and Hubbell, 1939). Mockernut hickory is also a common dominant of the oak-pine forest in Oklahoma (Rice and Penfound, 1959).

Loblolly-pine forest.—This forest type covers about 120 square miles in southeastern McCurtain County (Duck and Fletcher, 1945). On cut-over land, loblolly pine (*Pinus taeda*) is found mixed with shortleaf pine and sweetgum (*Liquidambar styraciflua*). In areas that are not cut or sprayed with phytocides, the dominants of this type are post oak and loblolly pine (Rice and Penfound, 1959). Water oak (*Quercus nigra*) and willow oak are important in localized areas.

Cypress-bottoms forest.—The cypress swamp occurs along Little River, Mountain Fork River, and their tributaries in southeastern Oklahoma (Duck and Fletcher, 1945). The bald cypress is the dominant vegetation of these swamps (Blair and Hubbell, 1939). Trees found in association with the cypress are sweet gum, sour gum (*Nyssa sylvatica*), white oak, willow oak, water oak, Ward's willow (*Salix longipes* var. *wardii*), and American holly (*Ilex opaca*) (Duck and Fletcher, 1945). Shrubs are buttonbush (*Cephalanthus occidentalis*), alder (*Alnus rugosa*), and French mulberry (*Callicarpa americana*).

Bottomland type.—Bottomland vegetation extends into all other major vegetation regions along the channels of all major streams (Duck and Fletcher, 1945). In the drier regions to the west, tall and short grasses make up the principal bottomland vegetation (Duck and Fletcher, 1945). The trees of the first stage of flood-plain forest appear intermittently along streams with continuous water supply. These are black willow (*Salix nigra*), peach-leaved willow (*S. amygdaloides*), sand-bar willow (*S. interior*), and cottonwood (*Populus deltoides*) (Bruner, 1931).

Duck and Fletcher (1945) listed the bottomland vegetation of the tall-grass prairie as typically including American elm, chinquapin oak (*Quercus muhlenbergii*), post oak, blackjack oak, hackberries (*Celtis occidentalis* and *C. laevigata*), chittam wood, cottonwood, sand plum, fragrant sumac, smooth sumac, and rough-leaved dogwood.

In the northeast, common trees of the flood plain include the sweet gum, sour gum, willows (*Salix* spp.), hackberries (*Celtis* spp.), white oak, water oak, willow oak, and red oak (Duck and Fletcher, 1945).

The flood plains of the Ouachitas are heavily forested with white oak, black oak, sweet gum, sour gum, basswood (*Tilia floridana*), mockernut hickory, water hickory (*Carya aquatica*), and sugar maple. Shrubs include the spice bush (*Lindera benzoin*), sassafras (*Sassafras oficinalis*), and papaw (*Asimina triloba*) (Blair and Hubbell, 1939).

Descriptions of Geologic Formations

Mapping data have been taken largely from the *Geologic Map of Oklahoma* (Miser and others, 1954; see fig. 2). In several cases, groups of related formations are mapped as a single unit. Of the 111 units that appear on the geologic map by Miser and others (1954), 83 were present at sampling points. Descriptions of the units with index numbers that rounded to 0.10 or above are from Gould (1925) unless otherwise referenced.

Antlers Formation.—The Antlers Formation (Cretaceous) consists of well-rounded, well-sorted, crossbedded, generally dark-reddish-brown to light-gray sand that is poorly consolidated and friable (Hill, 1894; Huffman and others, 1975).

Arkansas Novaculite, Missouri Mountain Shale, and Blaylock Sandstone.—The Arkansas Novaculite (Devonian-Mississippian), a type of chert, is exposed in the central part of the Ouachita Mountains. The middle section of the formation is interbedded with black shales and slates. The total thickness is 250 to 540 feet.

The Missouri Mountain Shale (Silurian) is a red and green metamorphosed shale and slate with carbonated pyroclastic material near the top. The thickness is 70 to 100 feet.

The Blaylock Sandstone (Silurian) is made up of 800 feet of layered, thin-bedded, fine-grained, greenish-gray, resistant sandstones and interbedded shaly sandstones and dark shales that weather to red.

Atoka Formation.—The Atoka Formation (Pennsylvanian) consists of 3,000 to 10,000 feet of shales with lenses and thin ledges of sandstone (Gould, 1925). It becomes more arenaceous in the frontal Ouachitas (Berry and Trumbly, 1968).

Blaine Gypsum.—The Blaine Gypsum (Permian) is composed of five beds of massive gypsum interbedded with red shales and containing thin beds of dolomite at the base of some of the gypsum beds (A. J. Myers, unpublished manuscript; R. O. Fay, personal communication, 1979).

Boone Formation.—A dominant feature of the Ozarks, the Boone Formation (Mississippian) is composed of layers of interstratified chert and cherty limestone that range from almost pure chert to limestone. The thickness of the Boone ranges between 100 and 400 feet.

Cloud Chief Formation.—Schoff (1939) described the Cloud Chief Formation (Permian) as red shale and clay, with minor amounts of gray and green clay, buff to brown sandstone, and some gypsum. Gould (1925) described the gypsum layer as a massive white or pinkish gypsum irregularly interbedded with red clay shales.

Dakota Sandstone.—The Dakota Sandstone (Cretaceous) typically is characterized by two beds of crossbedded, massive sandstone and a middle shale, uniformly about 200 feet thick, ranging in color from buff to brown or black (Gould, 1925; R. O. Fay, personal communication, 1979).

Dog Creek Shale.—The Dog Creek Shale (Permian) is a brownish-red gypsiferous shale and clay shale with thin beds of siltstone, sandstone, marlstone, gypsum, and fine-grained dolomite (A. J. Myers, unpublished manuscript; R. O. Fay, personal communication, 1979).

Duncan Sandstone.—The Duncan (Permian) is a thick-bedded gray to brown sandstone, separated by shales, ranging from 40 to 200 feet thick.

Flowerpot Shale.—The Flowerpot Shale (Permian) is a maroon and reddish-brown gypsiferous shale and silty shale containing a few thin beds of calcareous clay shale, siltstone, and sandstone. The formation ranges from 30 feet thick in the northwest to 220 feet in the southeast (A. J. Myers, unpublished manuscript; R. O. Fay, personal communication, 1979).

Garber Sandstone, Wellington Formation, and upper part of Pontotoc Group.—The Garber Sandstone (Permian) is composed of crossbedded layers of fine-grained, loosely cemented subangular to subrounded fragments of quartz sand that are irregularly interbedded with shale; the most common cement is a fine red mud.

The Wellington Formation (Permian) is made up of bluish-gray, greenish, and reddish shales with thin beds of sandstone that contain important salt beds in their lower parts and scattered thin layers of limestone (Gould, 1925).

The upper part of the Pontotoc Group (Permian?) is composed of red shales and coarse red sandstones (Gould, 1925).

Hennessey Shale.—"The Hennessey Shale [Permian] consists dominantly of reddish-brown shale containing layers of siltstone and fine-grained sandstone" (Wood and Burton, 1968).

Jackfork Sandstone.—The Jackfork Sandstone (Pennsylvanian) is a massive, medium- to fine-grained gray sandstone with some dark interbedded shales. Its thickness ranges from 2,600 to 6,000 feet (Gould, 1925; R. O. Fay, personal communication, 1979).

Laverne and Ogallala Formations.—The Laverne Formation (Tertiary) consists of sand, gravel, caliche, limestone, silt, and clay of various colors (Myers, 1959). Myers (personal communication, 1979) described the formation as essentially a calcareous sand.

The Ogallala Formation (Tertiary) is composed of sand, clay, and gravel cemented by lime. The great bulk of the formation is a fine-grained, poorly sorted brown sand (Schoff and Stovall, 1943).

McAlester Formation.—The McAlester Formation (Pennsylvanian) comprises 2,000 feet of shale divided into three parts by sandy layers (Gould, 1925; R. O. Fay, personal communication, 1979).

Marlow Formation.—The Marlow Formation (Permian) consists of a lower division of crossbedded sandstone with a few shales and an upper division of friable fine-grained sandstone with a few layers of thin sandy shales, dolomites, and gypsum beds near the top (A. J. Myers, unpublished manuscript; R. O. Fay, personal communication, 1979).

Morrison Formation, Exeter Sandstone, and Dockum Formation.—The Morrison Formation (Jurassic) is made up of an alternating succession of variegated sandstones, limestones, dolomites, shales, clays, and conglomerates. Sandstones of widely varying textures are important (Schoff and Stovall, 1943).

The Exeter Sandstone (Jurassic) is a massive, cliff-forming, white and buff crossbedded sandstone (Schoff and Stovall, 1943).

The Dockum Formation (Triassic) is composed of variegated, brilliantly colored strata of shale, clay, conglomerate, sandstone, and marl. Near Black Mesa the unit is predominantly marl. An exposure north of Boise City is deep-red sandstone (Schoff and Stovall, 1943).

Rush Springs Sandstone.—The Rush Springs Sandstone (Permian) is a friable, red, crossbedded, well-lithified, fine-grained sandstone with interbedded red siltstone and gray to red shales. Gypsum, dolomite, and a few calcite inclusions are present (A. J. Myers, unpublished manuscript).

Stanley Shale.—The Stanley Shale (Mississippian) consists of thin-bedded, ripple-marked, fine-grained, dark-colored, resistant sandstones and blue clays, shales, and slates irregularly interbedded in one vast series (Gould, 1925). A large area of the Ouachita Mountains is formed by the 10,000-foot-thick Stanley (R. O. Fay, personal communication, 1979).

Tokio Formation.—The Tokio Formation (Cretaceous) is made up of 100 to 150 feet of light-gray, crossbedded and poorly sorted quartz sand, gravel, and clay shale lying upon a lower bed of gravel (Davis, 1960).

Woodbine Formation.—The Woodbine Formation (Cretaceous) is divided into a lower tuffaceous sand and an upper sand that are intermixed with bituminous laminated clays. The thickness ranges from 0 to 355 feet (Davis, 1960).

High and low terrace deposits and alluvium of the first and second bottoms.—Alluvial deposits along the larger stream valleys indicate cycles of erosion and deposition. Erosion of the original land surface was followed by deposition of the oldest flood plain, the high terrace. The thick deposits are lithologically similar to the Ogallala Formation and are separated from it only by a topographic break (Kitts, 1965).

Further erosion was followed by deposition of a new and lower flood plain, the low terrace, which consists of gravel, sands, and clays. Quartzite pebbles, cobble conglomerates, and coarser grained sands are typically present (Kitts, 1959).

Subsequent erosion and deposition established another lower flood plain, the second bottom. The alluvium of the second bottom is characteristically finer grained than terrace sediments (Kitts, 1965).

Further erosion and deposition formed the lowest bottomland, the present flood plain (Kitts, 1965). During flood stages, silts and clays are distributed over the flood plain (Schoff, 1939).

Gravels and sands, silt, and clay are being deposited at present within the stream channels (Schoff, 1939).

Dune sand.—Dunes consist of recent deposits of fine- to medium-grained quartz sand forming small steep hills about 25 feet high (Schoff, 1939). The dunes are most common on the north and east sides of the channels and flood plains of major streams (Kitts, 1965) in western Oklahoma. At least some of the dune sand has been blown from areas of dry stream beds. Some of the sand may have been derived from sandstone deposits (Gould, 1925).

Loess and volcanic ash.—Loess deposits cover much of the Oklahoma Panhandle and are composed of up to 25 feet of tan to gray to pink, fine- to medium-grained quartz sand (Oklahoma Water Resources Board, 1973).

Widely scattered deposits of volcanic ash found in western, central, and east-central Oklahoma are associated with high terraces and evidently were deposited in quiet water (Burwell and Ham, 1949).

Results and Discussion

Compilation and tabulation of data from 1,935 sampling points showed 227 separate pairings of vegetation type with geologic formation or rock type. Table 1 lists the 37 pairings with index-of-association values that rounded to 0.10 or above.

Piñon-juniper-mesa type.—The piñon-juniper-mesa vegetation coincides with the region of broad valleys and erosion remnants found in northwestern Cimarron County. The geologic map shows about half the area to be underlain by the Morrison Formation and the other half by the Dakota Sandstone.

TABLE 1.—OCCURRENCES OF VEGETATION TYPES ON GEOLOGIC FORMATIONS

Vegetation type	Geologic formation	Number of occurrences	Index of association [1]	Dominant lithology	Total incidences of vegetation type	Total number of formations with vegetation type
Piñon-juniper-mesa	Morrison Formation	2	0.50	Sandstone	5	3
	Dakota Sandstone	2	.40	Sandstone		
	1 other	1	—			
Pinus edulis	Dakota Sandstone	1	.33	Sandstone	1	1
Shortgrass	Dune sand	119	.73	Sand	147	9
	Rush Springs Sandstone and (or) Marlow Formation	8	.10	Sandstone		
	7 others	20	—			
Sand-sage grassland	High-terrace deposits	28	.24	Sand	73	11
	Dune sand	28	.22	Sand		
	9 others	17	—			
Mixed grass	Cloud Chief Formation	49	.36	Shale and gypsum	219	17
	Garber Sandstone	43	.18	Sandstone		
	Hennessey Shale	16	.11	Siltstone		
	Dog Creek Shale	12	.10	Gypsiferous shale		
	13 others	99	—			
Mesquite grassland	Blaine Gypsum	8	.32	Gypsum and shale	28	6
	Flowerpot Shale with Duncan Sandstone	7	.30	Gypsiferous shale		
	Dog Creek Shale	7	.24	Gypsiferous shale		
	3 others	6	—			
Tall-grass prairie	Garber Sandstone	129	.32	Sandstone	550	55
	Hennessey Shale	47	.15	Shale		
	Flowerpot Shale	29	.10	Gypsiferous shale		
	Alluvium	35	.10	Sand		
	High-terrace deposits	35	.10	Sand		
	Rush Springs Sandstone	30	.10	Sandstone		
	49 others	245	—			

TABLE 1.—*Continued*

OCCURRENCES OF VEGETATION TYPES ON GEOLOGIC FORMATIONS

Vegetation type	Geologic formation	Number of occurrences	Index of association [1]	Dominant lithology	Total incidences of vegetation type	Total number of formations with vegetation type
Stabilized dune	High-terrace deposits	7	.16	Sand	11	3
	2 others	4	—			
Shinnery-oak grassland	Dune sand	21	.20	Sand	35	8
	7 others	14	—			
Post oak–blackjack	Garber Sandstone	87	.22	Sandstone	516	56
	High-terrace deposits	49	.14	Sand		
	McAlester Formation	29	.10	Shale		
	Rush Springs Sandstone	28	.10	Sandstone		
	52 others	323	—			
Oak-hickory forest	Boone Formation	44	.56	Chert and limestone	104	
	Atoka Formation	17	.21	Shale (north) Sandstone (south)		
	Antlers Formation	10	.13	Sand		
	12 others	33	—			
Oak-pine forest	Jackfork Sandstone	42	.46	Sandstone	140	17
	Stanley Shale	29	.34	Sandstone and shale		
	Atoka Formation	22	.22	Shale (north) Sandstone (south)		
	Antlers Formation	9	.10	Sand		
	Arkansas Novaculite	7	.10	Chert		
	12 others	31	—			
Loblolly pine forest	Tokio Formation	2	.57	Sand	5	3
	Woodbine Formation	2	.16	Sand		
	1 other	1	—			
Cypress bottoms	1 insignificant one	1	—			
Bottomland type	Alluvium	69	.52	Sand	99	22

[1]See text.

Of the five occurrences of piñon-juniper-mesa type, two were on the Morrison and two on the Dakota. Both formations are sandstone.

Distributions of Pinus edulis.—The geologic formation associated with the one sample point that fell within the region of distribution of *Pinus edulis* was the Dakota Sandstone. The index of association, 0.33, agrees with the observation of Blair and Hubbell (1939) that piñon occurs in mixed stands with juniper on sandstone outcrops of north slopes.

Short-grass high plains.—The 147 instances of short-grass vegetation were associated with nine formations. There were 119 occurrences on dune sand, the Ogallala Formation, and the Laverne Formation as a unit, with an index number of 0.73. The unit mapped as Rush Springs Sandstone and Marlow Formation appeared at eight sample points and attained an index of 0.10. Significant associations of short-grass vegetation were with sandy formations.

Sand-sage grassland.—Sand-sage vegetation was located at 73 sample points on 11 geologic formations. Twenty-eight occurrences were on high-terrace deposits with an index value of 0.24, and there were 28 occurrences on the Ogallala-Laverne unit with an index of 0.22. There were 17 other occurrences on nine other formations. The sand-sage thus is associated with sand deposits.

Mixed-grass eroded plains.—There were 219 occurrences of mixed-grass vegetation on 17 formations. Forty-nine occurrences on the Cloud Chief Formation yielded an association index of 0.36. There were 43 occurrences on the Garber-Wellington unit, giving an index of 0.18. Sixteen occurrences on the Hennessey Shale and 12 occurrences on the Dog Creek Shale resulted in an index of 0.10. There were 99 other occurrences on 13 other formations. All the formations with significant index numbers were chiefly shales or mixed sandstones and shales. Mixed grass thus shows positive association with shale.

Mesquite grasslands.—There were 28 occurrences of mesquite on six formations. Eight occurrences were on the Blaine Gypsum, giving an index of 0.32. Seven occurrences were on the gypsiferous Flowerpot Shale with Duncan Sandstone, giving an index of 0.30. Seven occurrences on the Dog Creek Shale, also gypsiferous, gave an index of 0.24. There were six other occurrences of mesquite on three other formations. All the units with significant indices of association included both shale and gypsum.

Tall-grass prairie.—There were 550 occurrences of tall-grass prairie vegetation on 55 formations. The highest association index, 0.32, was for the 129 occurrences on the Garber Sandstone. The index of association, with 47 occurrences on the Hennessey Shale, was 0.15. Twenty-nine occurrences on the Flowerpot Shale, 35 on alluvium, 35 on high-terrace deposits, and 30 on the Rush Springs Sandstone all had index values of 0.10. The tall-grass prairie is correlated predominantly with formations with sand, but it also occurs on limestone in the eastern third of the State.

Stabilized dune.—There were 11 occurrences of stabilized-dune vegetation on three formations. Seven of the occurrences were on high-terrace deposits, yielding an index of 0.16. Four other occurrences on four other formations resulted in low index values.

Shinnery oak–grassland.—Of the 35 occurrences of shinnery oak, 21 were on dune sand, giving an index value of 0.20. There were 14 other occurrences on seven formations. Shinnery oak thus is demonstrated to be positively associated with sand.

Post oak–blackjack forest.—There were 516 occurrences of post oak–blackjack on 56 formations. There were 87 occurrences on the Garber Sandstone, giving an index of 0.22. Forty-nine occurrences on high-terrace deposits resulted in an index of 0.14. Twenty-nine occurrences on the McAlester Formation and 28 on the Rush Springs Sandstone both gave association values of 0.10. There were 323 occurrences on 52 other formations. The indices indicate positive association with sand.

Oak-hickory forest.—There were 104 occurrences of oak-hickory forest on 15 formations. Forty-four of the occurrences were on the Boone Formation, yielding an index value of 0.56. Seventeen occurrences on the Atoka Formation resulted in an index of 0.21. Ten occurrences on the Antlers Formation yielded an index value Of 0.13. There were 33 other occurrences of oak-hickory on 12 other formations. Oak-hickory thus shows a tendency to occur on strata that weather to fine-textured soils.

Oak-pine forest.—There were 140 occurrences of oak-pine forest on 17 formations. Forty-two of these on the Jackfork Sandstone gave an index value of 0.46. Twenty-nine occurrences were on the Stanley Shale, giving an index of 0.34. Twenty-two occurrences were associated with the Atoka Formation, resulting in an index value of 0.22. Nine occurrences on the Antlers Formation and seven on the Arkansas Novaculite both yielded index values of 0.10. There were 31 other occurrences on 12 other formations. Since the Stanley Shale embodies a great deal of sandstone, and the Atoka Formation is arenaceous in its most southern reaches, oak-pine forest is positively correlated with sand.

Loblolly-pine forest.—There were five occurrences of loblolly-pine vegetation on three formations. Two occurrences on the Tokio Formation yielded an index of 0.57, and two on the Woodbine Formation resulted in an index of 0.16. One other occurrence on another formation yielded a low index. Loblolly-pine forest thus is shown to be associated with sandy substrates.

Cypress-bottoms forest.—Cypress-bottoms vegetation, which appears only in swamp environments, was present on one formation at two sampling points but did not result in a significant index of correlation.

Bottomland type.—Bottomland vegetation appeared at 99 sampling points on 22 geologic formations. Sixty-nine occurrences were on alluvium, giving an index of 0.52. Thirty others were associated with 21 other geologic formations.

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GSA Publishes Book on Nuclear Power Plants

Geology in the Siting of Nuclear Power Plants, edited by Allen W. Hatheway and Cole R. McClure, Jr., presents in detail the expanded role of geology in the selection of sites for nuclear power plants. This publication has been issued by The Geological Society of America as Volume IV of *Reviews in Engineering Geology*.

The 256-page volume consists of 16 papers that are divided into three parts. It costs $41.00 and can be purchased from The Geological Society of America, Publication Sales Department, P.O. Box 9140, Boulder, Colorado 80301.

Report Treats Materials and Manpower Requirements for U.S. Oil and Gas Development

The National Petroleum Council, a federal advisory committee to the Secretary of Energy, has issued a report analyzing the materials and the manpower requirements for domestic oil and gas development. *Materials and Manpower Requirements for U.S. Oil and Gas Exploration and Production—1979-1990* focuses on the requirements associated with the accelerated development of domestic oil and gas resources for this period. In addition, the report examines the service and supply industry's capability of fulfilling these oil- and gas-resource requirements.

The report is available for $25.00 from Publications Department, National Petroleum Council, 1625 K Street, N.W., Washington D.C. 20006.

AAPG Releases New Studies in Geology

Two volumes issued recently by The American Association of Petroleum Geologists in its Studies in Geology series should be of great interest both to petroleum geologists and to those working in basic science.

Currents in Submarine Canyons and other Seavalleys, by Francis Parker Shepard, Neil F. Marshall, Patrick A. McLoughlin, and Gary G. Sullivan, AAPG Studies in Geology 8, is a scholarly and well-researched 173-page report presenting results obtained from 200 records recovered in continuous monitoring of current meters in 25 submarine canyons worldwide. Information acquired has been used to interpret sedimentation patterns and high- and low-velocity turbidity currents, data of value to petroleum and other geologists and also useful in engineering and waste-disposal projects.

Paleoclimate, Paleomagnetism, and Continental Drift, by J. Konrad Habicht, AAPG Studies in Geology 9, developed from an internal report prepared for the Exploration and Production Department of Shell Internationale Petroleum Maatschappij as an aid in its search for hydrocarbon reservoirs. The study goes beyond paleoclimate indicators, such as carbonate deposits, reefs, evaporites, coal, tillites, and oxygen isotope measurements, to the reasons for climatic change, which are interpreted through the shifting of the poles as determined by geomagnetic measurements. The separation and coming together of continental masses in continental drift is also considered as an important agent in climatic changes and in the development of sedimentary basins. The text (29 pages) in the spiral-bound, coated-paper volume is followed by 11 large foldout maps that present interpretations of paleoclimates, pole positions, and paleolatitudes for each of the major geologic time periods.

These books can be ordered from the AAPG Bookstore, P.O. Box 979, Tulsa, Oklahoma 74101. The price of Studies in Geology 8 is $9.00 to members of AAPG-SEPM, $11.00 to others; no. 9 is $12.00 to members, $15.00 to others.

U.S. Board on Geographic Names Decisions

The U.S. Board on Geographic Names recently approved two Oklahoma place names that were published in the July through September 1979 issue of *Decisions on Geographic Names in the United States* (Decision List 7903).

Clear Creek has been adopted to identify a stream, 19.3 km (12 mi) long, that heads 6.4 km (4 mi) northeast of Carrier at 36°29'47" N., 97°57'05" W., and flows south-southwest to Turkey Creek, 12.9 km (8 mi) southwest of Enid, Garfield County, Oklahoma; sec. 36, T. 22 N., R. 8 W., Indian Meridian (36°20'25" N., 98°00'25" W.). (*Not* Sand Creek.)

Hodgen has been adopted to identify a community 5.6 km (3.5 mi) south-southwest of Heavener, Le Flore County, Oklahoma; secs. 1 and 12, T. 4 N., R. 25 E., Indian Meridian (34°50'30" N., 94°37'52" W.). (*Not* Hodgens, Houston.)

AN EFFICIENT DEVICE FOR HEAVY-LIQUID SEPARATION

A. V. Chadwick[1]

A heavy-liquid-separation technique in common use involves pouring off the float from a tube of heavy liquid after gravity separation. This method works well when efficient sample recovery is not a consideration and when the specific gravity of the liquid is sufficiently different from float and sediment to effect good separation. In cases where sample recovery is important, a modification of this technique, in which doubled Nalgene tubing is inserted in a test tube, has sometimes been used (Funkhouser and Evitt, 1959). This method permits efficient recovery of the float but is more time consuming, frequently messy, and not especially applicable to larger samples.

After experiencing numerous difficulties with presently accepted techniques for heavy-liquid separation, we developed a clean and highly effective device for separating float from sediment with nearly 100 percent efficiency even for very large samples.

The device consists of a centrifuge vessel of varying dimensions to which a length of plastic tubing has been fitted. The fit is effected by heating the tubing in boiling water and applying it to the neck of the vessel while soft. The seal is made secure with one to several heavy elastic rings (e.g., Elastrator brand obtainable at livestock supply houses). The type of vessel being used may vary depending upon the application. We have had in use for a number of years a set of bottles made by replacing the necks of 100-ml glass Babcock bottles with plastic tubing. Such a flask has the advantage that co-precipitation is minimized by the larger volume of liquid in the base, while the float is funneled into the smaller volume of the neck whence it is easily removed. These bottles are accommodated in IEC 367A buckets designed for 100-ml centrifuge tubes. We have also successfully used polypropylene and teflon Erlenmeyer flasks of up to 1,000-ml volume when larger samples were being handled. The sample is removed after centrifugation by clamping off the plastic tubing below the float with a pair of locking hemostats and pouring off the float (fig. 1, *b–d*). The neck can then be rinsed clean.

Excess heavy liquid used in the larger bottles is recycled by filtering and adjusting the specific gravity back to the required value.

The entire operation can be performed in less time than is required by either of the other methods with the added advantages of less contamination, more complete recovery, and the ability to handle larger samples. The materials are readily available and are relatively inexpensive.

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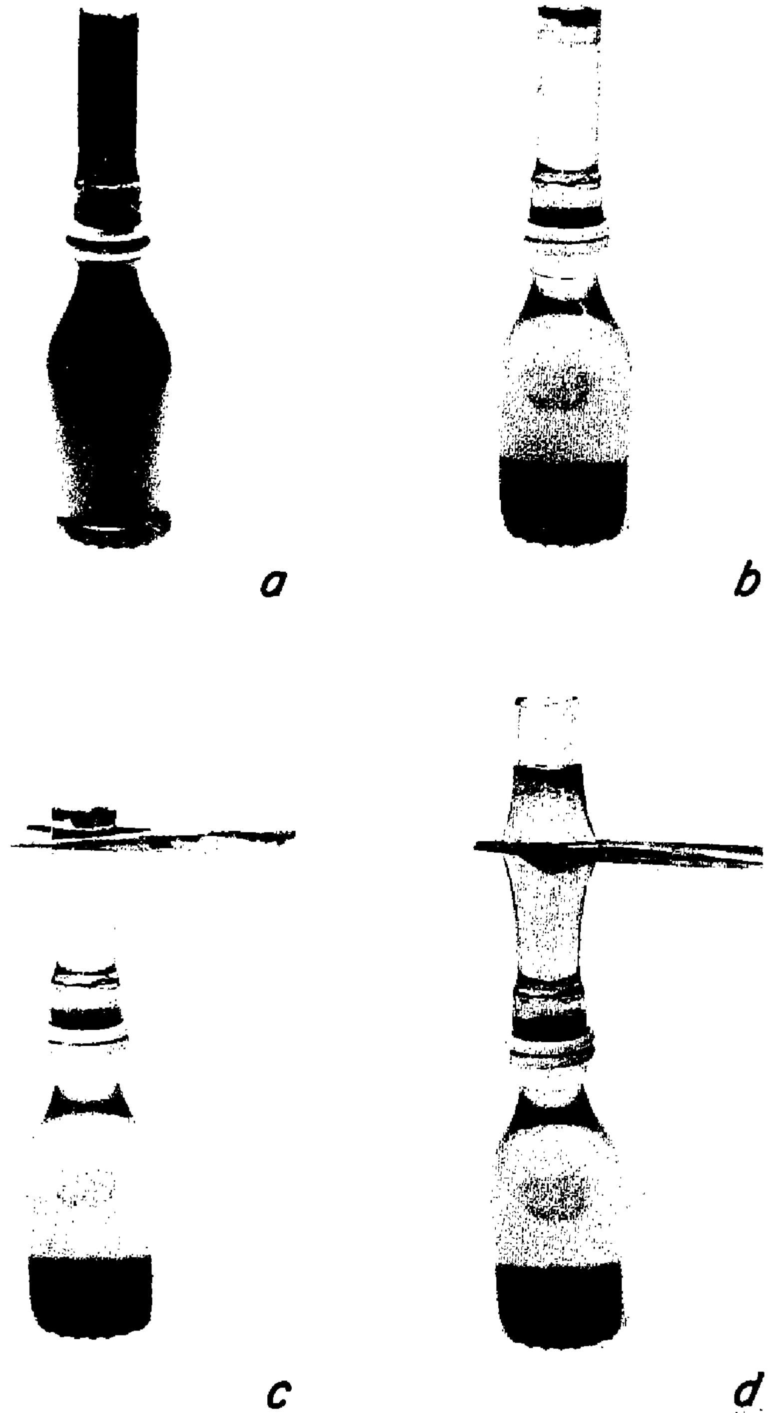

Figure 1. Heavy-liquid-separation bottle: *a*, bottle loaded with sediment suspension in $ZnBr_2$ prior to centrifugation; *b*, clear separation of components after 10 minutes at 1,500 rpm; *c*, *d*, technique for removing float from bottle to assure complete recovery of sample.

Underground Coal Mine Proposed for Bokoshe

The residents of Bokoshe, in northwestern Le Flore County, Oklahoma, may soon witness the reopening of a nearby mine once operated as a surface mine by Garland Coal & Mining Co. CF&I Steel Corp. has received approval from the U.S. Office of Surface Mining of a mining and reclamation plan for a proposed underground mine on two federal leases near Bokoshe.

CF&I plans to open mine entries in the last surface cut at Garland's former operation. By 1982 the mine is expected to be producing at full capacity, at the rate of 250,000 tons of coal per year.

DOE Releases NURE Open-File Reports

Four uranium-related reports have been released by the U.S. Department of Energy's Grand Junction office as a part of the National Uranium Resource Evaluation (NURE) project.

High Resolution Gamma-Ray Spectroscopy Applied to Bulk Sample Analysis is a 63-page report prepared by K. L. Kosanke, C. D. Koch, and R. D. Wilson.

Helium Emanometry as an Indicator of Deeply Buried Uranium Deposits is a 384-page report by Louis A. Pogorski and G. Stewart Quirt.

Hydrogeochemical and Stream-Sediment Reconnaissance Procedures of the Uranium Resource Evaluation Project is a 56-page report prepared by J. W. Arendt, T. R. Butz, G. W. Cagle, V. E. Kane, and C. E. Nichols.

Hydrogeochemical and Stream Sediment Detailed Geochemical Survey for Texas, Gulf Coast is a 147-page report by the staff of the Oak Ridge Gaseous Diffusion Plant (ORGDP), Oak Ridge, Tennessee.

The Kosanke report, GJBX-4(80), the Pogorski report, GJBX-22(80), the Arendt report, GJBX-32(80), and the ORGDP report, GJBX-34(80), have all been placed on open file at the Oklahoma Geological Survey. They are also available on microfiche at a cost of $3.00 for the Kosanke, Pogorski, and Arendt reports and $5.00 for the ORGDP report. Orders for microfiche should be sent to Bendix Field Engineering Corp., Technical Library, P.O. Box 1569, Grand Junction, Colorado 81502.

Petroleum-Industry Directory Published

USA Oil Industry Directory was recently released by Petroleum Publishing Co., publisher of *The Oil and Gas Journal.*

This 1980 directory, which lists every major integrated oil company, is a basic reference for the petroleum industry. In addition, the directory lists more than 25,000 personnel and includes information on government agencies, historical sketches of major companies, and an index by company and personnel.

Copies are available for $50.00 plus postage from Petroleum Publishing Co., P.O. Box 1260, Tulsa, Oklahoma 74101.

It's AAPG Time in Denver

The "Mile-High City," the "Queen City of the Plains," the "Carnation Capital of the World," or, more formally, Denver, Colorado, is the site of the 1980 annual convention of The American Association of Petroleum Geologists and its divisions—the Society of Economic Paleontologists and Mineralogists (SEPM), the Energy Minerals Division (EMD), and the Division of Professional Affairs (DPA).

General chairman for the meeting is John P. Lockridge of Mountain Petroleum Corp. in Denver. The theme this year is " What's New—Advances in Exploration Science." The dates are June 8–11.

Technical sessions for the annual convention will meet June 9–11, with short courses on "Deltaic Sedimentation," "Organic Maturation and Paleotemperatures," and "Exploration Techniques in Thrust-Fold Belts" scheduled earlier on June 7 and 8. An SEPM core-study seminar and five SEPM research colloquia will also be offered June 8. Fifteen field trips will cover nearby structures, stratigraphy, and sedimentology; the Wyoming-Utah overthrust belt; New Mexico geothermal development; and uranium, oil-shale, and coal deposits in the Rockies.

The Oklahoma Geological Survey will be represented at the 1980 convention by Charles J. Mankin, director; Kenneth S. Johnson, associate director; S. A. Friedman, senior coal geologist; Salman Bloch, minerals geologist; Robert L. Eutsler, minerals geologist; Kenneth V. Luza, engineering and environmental geologist; and William D. Rose, geologist/editor. Also, the Survey will present an exhibit displaying OGS projects in energy resources.

Mankin will present a report to the Governing Board of the American Geological Institute on the status of a proposed memorial to honor Ian Campbell, former chief of the California Division of Mines and Geology and professor emeritus of the California Institute of Technology, who died in 1978. The Association of American State Geologists has recommended the establishment of a medal to be awarded to worthy recipients in recognition of Campbell's outstanding contributions in public service. Mankin will also participate in a meeting of AAPG's Committee on Stratigraphic Units of North America (COSUNA). He is coordinator for this region in this program to develop correlation charts for the numerous formations in each sedimentary basin in the United States. He will also participate in a meeting of the AAPG Academic Liaison Committee.

Bloch and Johnson will present a poster session on "Distribution and Alteration of Ogallala Volcanic-Ash Deposits and Their Possible Relation to Uranium Mineralization in Western Oklahoma." Bloch will join a field trip to examine the stratigraphy and structure of the Front Range west of Denver, where rocks ranging in age from Precambrian through Tertiary are well exposed. Emphasis will be on fossil-fuel development in the various formations covered.

Friedman, a founding member of the EMD and incoming vice-chairman of the division, will attend technical sessions and will accompany a postmeeting EMD trip covering the coal geology of Yampa Valley and North Park, Colorado.

Rose is a member of the AAPG Public Information Committee and will meet with that group.

The 1980 meeting will be the fifth general convention of AAPG to be held in Denver and the first since 1972. For more information, contact the AAPG Convention Department, P.O. Box 979, Tulsa, Oklahoma 74101 (phone, 918–584-2555).

USGS Issues Report on Ogallala Aquifer

U.S. Geological Survey Open-File Report 79-565, *Digital-Model Projection of Saturated Thickness and Recoverable Water in the Ogallala Aquifer, Texas County, Oklahoma*, by Robert B. Morton, presents results of a quantitative hydrologic study conducted in cooperation with the Oklahoma Water Resources Board to assess ground-water reserves in Texas County and surrounding areas.

The Ogallala is the principal source of ground water in the region, and withdrawal of water for irrigation, which began in the mid-1960's, has resulted in a decline of the water table of from 1 to 7 feet per year. This 34-page report makes predictions of saturated thickness and water in storage in the aquifer for specified periods extending into the year 2050.

USGS Open-File Report 79-565 is free on request from the Oklahoma Water Resources Board, Northeast 10th Street and Stonewall, Oklahoma City, Oklahoma 73152.

Stearns Named Monnett Professor of Energy Resources

David Winrod Stearns, former chairman of the Department of Geology at Texas A&M University, College Station, has accepted the V. E. Monnett Chair in Energy Resources in the School of Geology and Geophysics at The University of Oklahoma. Announcement of the appointment was made in mid-February by the OU Board of Regents, and Stearns will arrive on campus at the beginning of the fall semester.

Stearns, a native of Muskegon, Michigan, earned his bachelor's degree in geology in 1953 from Notre Dame, and in 1955 he received a master's degree from the South Dakota School of Mines and Technology, where he also served as an instructor. In 1955 he joined the geological staff of Shell Oil Co. and later transferred to Shell Development Co. In 1967 he became a member of the faculty of Texas A&M University. He received a Ph.D. from Texas A&M in 1969. He is a member of The American Association of Petroleum Geologists, The Geological Society of America, and The American Geophysical Union.

Establishment of the Monnett Chair was approved in July 1978 by the regents, following a fund-raising drive initiated in June 1976 by the Alumni Advisory Council to the School (see *The Sooner Geologist*, v. 6, p. 9–10, and *Oklahoma Geology Notes*, v. 38, p. 190–191). Efforts of the fund-raising committee, under the leadership of Frank A. Schultz, Dallas independent and a 1940 OU geology graduate, were so successful that the goal of $750,000 was oversubscribed. Contributions were received from alumni at all levels, from friends of the School and the University, and from corporations.

The professorship, founded to advance the training offered in energy-related fields by the School, is appropriately named to honor a geologist who played a major part in furthering such instruction during his long tenure on the geology faculty at OU.

An OU alumnus himself (b.a. geol., 1912), Victor Elvert Monnett joined the faculty as an assistant professor in 1917, following a year of graduate studies at the University of Michigan and a four-year instructorship at Cornell University. Upon receipt of his doctorate from Cornell in 1922, he was advanced to a full professorship and was made director of the School of Geological Engineering at OU, a position he held until 1942. He became chairman of the Department of Geology and Geography as well, in 1924, retiring from that position in 1955. He was named a David Ross Boyd professor in 1954 and retired from the faculty in 1960 as Boyd Professor Emeritus. He died in 1972.

Monnett's directorship of what became the School of Geology and Geophysics encompassed some good times and some bad times for the petroleum industry, and geology at OU has always followed the course of the petroleum industry. Enrollment, staff size, curricula, acquisition of equipment and literature, have all been commensurate with hiring by the industry. During the "Monnett Era" the number of courses offered increased to a total of 64, and the size of the faculty increased accordingly to handle this load. By Monnett's own reckoning (Monnett, History of School of Geology, undated, unpublished manuscript), there were 758 majors in geology in 1948, with 69 graduate students, plus 200 pre-majors and hundreds of other students in elementary courses. He says that this enrollment "is believed to be the largest number of students majoring in geology that were ever registered at any university at any time." He was rightly called the "mentor of probably more geologists than any teacher in history."

We are glad Dr. Stearns is coming to occupy the Monnett Chair, and we welcome him and his wife to the campus and to Norman.

Russian Energy and Mineral Bibliography Published by AGI

A new bibliography issued by the American Geological Institute lists 1,400 citations in English on mineral and energy resources of the Soviet Union. The publication, which was compiled by Eugene A. Alexandrov of the Department of Earth and Environmental Science of Queens College (CUNY), developed from a reading list for a seminar held at CUNY in 1976. Entries cover 18 volumes of AGI's *International Geology Review*, plus other significant Russian papers that have been translated into English. Listings are by author, by subject, and by geographic locality.

This 92-page volume, covering the earth resources of a country that takes in one-sixth of the surface of the Earth, should prove to be a valuable reference.

Mineral & Energy Resources of the USSR: a Selected Bibliography of Sources in English can be ordered from the American Geological Institute, One Skyline Place, 5205 Leesburg Pike, Falls Church, Virginia 22041. The price is $5.00 to subscribers to *International Geology Review* and $10.00 to others.

1979 Uranium-Seminar Proceedings Issued by DOE

Uranium resources and exploration, and uranium supply, are two of the many topics discussed in the U.S. Department of Energy's *Uranium Industry Proceedings, October 16–17, 1979.* The 276-page report contains 16 papers presented at last year's seminar. Other topics discussed include uranium-enrichment policies and plans, the uranium market, the status of national uranium-resource programs, and international activities.

The report, GJO-108(79), is available for $10.00 from the Technical Library, Bendix Field Engineering Corp., P.O. Box 1569, Grand Junction, Colorado 81502.

The 1980 Uranium Industry Seminar will be held October 22 and 23 at Two Rivers Plaza in Grand Junction.

GeoRef to Add Bibliographic Data

The American Geological Institute has been awarded a contract of $92,000 from the U.S. Geological Survey to cover 78.77 percent of the cost of adding approximately 288,000 old bibliographic references to AGI's GeoRef data base.

By September 30, 1981, GeoRef's coverage of North American literature in geoscience will be extended back to 1785, the time of Thomas Jefferson. The citations will be taken from the *Bibliography and Index of North American Geology* and from the *Bibliography and Index of Geology Exclusive of North America.*

USGS Publishes Study on Mississippian Tectonics

A professional paper that should be of interest to Oklahoma geologists has recently been published by the U.S. Geological Survey.

Professional Paper 1010, *Paleotectonic Investigations of the Mississippian System in the United States*, by L. C. Craig, C. W. Conner, and others, is part of a series of paleotectonic maps and texts that summarize the knowledge of a geologic system as represented in the contiguous United States. This study comprises three parts, including 559 pages of text and a set of 15 map plates.

This paper can be obtained from the Branch of Distribution, U.S. Geological Survey, 1200 South Eads Street, Arlington, Virginia 22202, for $29 a set.

OKLAHOMA ABSTRACTS

GSA Annual Meeting, Southeastern Section
Birmingham, Alabama, March 27–28, 1980

The following abstract is reprinted from *Abstracts with Programs* of The Geological Society of America, v. 12, no. 4. The page number is given in

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OKLAHOMA ABSTRACTS is intended to present abstracts of recent unpublished papers relating to the geology of Oklahoma and adjacent areas of interest. 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.

brackets below the abstract. Permission of the author and of Jo Fogelberg, managing editor of GSA, to reproduce the abstract is gratefully acknowledged.

A Potential Heat Source for Mississippi Valley Type Deposits—an Example from the Arbuckle Mountains, Oklahoma

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Small deposits of epigenetic, colloform and replacement sphalerite are exposed in brecciated dolomite of the Cambro-Ordovician Butterly Formation, Arbuckle Mountains, Southern Oklahoma. Mineralization is of the Mississippi Valley type, strongly resembling sphalerite ores of East Tennessee where white sparry dolomite crystals encrust earlier deposited ZnS. Carbonate facies patterns mimic the ore settings of Southeast Missouri; a coarse, sparry dolomite formation, the Royer—similar to Missouri "white rock"—occupies a shallower depositional environment than most of the mineralized dolomite and deeper marine limestone. Mineralized and unmineralized stratiform breccias occur within several primary facies settings often exhibiting multiple stages of brecciation, all of which post-date the formation of the Royer Dolomite. The Arbuckle Zn deposits occupy a tectonic setting similar to the Pine Point Zn–Pb deposits, NWT, Canada, straddling the uplifted flank of an aulacogen.

Problematic to the origin of Mississippi Valley deposits is the source of heat (60–200°C). Since mineralization in the Arbuckles predates the Arbuckle and Ouachita orogenies neither orogeny is the likely heat source. A model for heat generation from the breakdown of radioactive elements in underlying basement is proposed: heat produced through radioactive decay of granites and rhyolites caused ore forming fluids to migrate toward the apices of basement highlands. Precipitation of sulphides occurred where favorable facies and stratigraphic conditions were present. A thick sedimentary cover was necessary to retain ore forming fluids at Mississippi-Valley temperatures. [205]

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Phenetic Analysis of *Fistulipora* (Bryozoa) from the Henryhouse Formation (Silurian) of Southcentral Oklahoma

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R-mode principal components and Q-mode cluster analysis of 48 zoaria of *Fistulipora* from two stratigraphically separated localities in the Henryhouse Formation indicate the presence of three phenetic groups. Each zoarium was coded for 16 quantitative skeletal characters; three are meristic (counts); 13 are continuous. All but intermonticular distance were obtained from oriented longitudinal and tangential sections. Extraction of the first three principal components from the 16 characters accounts for 66% of the total variance. Component 1 (39%) is a factor of cystopore and zooecial spacing, cystopore size, and zooecial diameter. Component 2 (17%) is a factor of diaphragm spacing, lunarial depth and curvature. Component 3 (10%) is a factor of monticule spacing, lunarial width and thickness. These components, plotted as a 3-dimensional projection, show separation of the specimens into three well-defined groups. Cluster analysis, based on matrices of average distance coefficients and product-moment correlation coefficients, yield nearly identical groups, indicating the robustness of the taxonomic structure. The groups are interpreted as three species of *Fistulipora*. Two of them are tentatively referrable to the Brownsport species *Fistulipora hemisphaerica* (Roemer) (25 zoaria) and *Dybowskiella brownsportensis* Perry and Hattin (3 zoaria). The third group (20 zoaria) may represent a new species. Firm species assignments should await comparative studies of the 44 named Silurian species. In the lower sampling interval, *F.* cf. *hemisphaerica* is predominant over the unnamed species, and *F.* cf. *brownsportensis* is absent. In the upper interval, *F.* cf. *brownsportensis* is present, and the unnamed species predominates over *F.* cf. *hemisphaerica*. [218–219]

Geology of Sphalerite in Coal

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Middle Pennsylvanian (Desmoinesian) bituminous coals of certain areas of Oklahoma, Kansas, Missouri, Iowa, and Illinois contain sphalerite in veins, clastic dikes, and related deformational structures. These areas are located in proximity to Mississippi Valley–type lead-zinc deposits.

The mineral paragenesis (kaolinite–pyrite–sphalerite–calcite) is the same for all veins in these coals. Preliminary data from fluid inclusion studies indicate that sphalerite was deposited from brine having Na>Ca>K>Mg, total salinity of about 3.4 molal, and Na:K of 44.

The ratio of gases extracted from these fluid inclusions not condensable at the temperature of liquid nitrogen (i.e., CH_4, N_2) to those condensable at the temperature of liquid nitrogen (i.e., CO_2, CH_2) ranges from 0.29 to 3.57. The principal gases produced in the coalification reaction are H_2O, CO_2, CH_4, CH_2, and N_2; these gases may be the sources of the gases in the fluid inclusions.

Homogenization temperatures of fluid inclusions from selected sphalerites range from 83° to 94°C. The mean reflectance of vitrinite in adjacent coals ranges from 0.54 to 0.63 percent (R_0max). Estimated maximum temperatures of coalification of the coals, derived from correlations of reflectance, temperature, and duration of burial, are in close agreement with the measured temperatures of fluid homogenization in the sphalerite inclusions. This agreement suggests that formation of the sphalerite coincided approximately with the time of maximum burial of the coal.

Deposition of the sphalerite probably resulted from connate brines which prevailed in the sedimentary basins at the time of maximum burial and maximum temperature. Brittle fracturing of lithotype banding accompanying mineralization suggests that the coal had achieved at least the rank of sub-bituminous coal. [222]

A Reconstruction of the Unusual Apparatus of *Histiodella*

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Histiodella is a biostratigraphically valuable conodont genus which evolved rapidly through several species in the lower Middle Ordovician. Sampling of the Joins Fm. in Oklahoma provided over 9,200 specimens assignable to several form elements considered as part of the newly recognized *Histiodella* apparatus on evidence of relative abundance, stratigraphic range, morphologic similarities and parallel phylogenetic development. The apparatus does not homologize well with existing apparatus models. The following form generic terms are used to convey the morphology of the elements: bryantodontiform (*H. altifrons, H. minutiserrata, H. sinuosa, H. serrata*); short bryantodontiform (undescribed); twisted bryantodontiform (undescribed); trichonodelliform (*H. triquetra*); zygognathiform (undescribed); and oistodontiform (undescribed).

Abundance ratios of the elements vary within broad limits from sample to sample, but the number of bryantodontiform elements relative to trichonodelliform elements is consistently high (ranging from 20:1 to 50:1). If this apparatus reconstruction is correct, the presence of variable element ratios may be explained in two ways: 1) the observed ratios are the result of post-mortem sorting, or 2) the observed ratios are biologically accurate. The element ratios are not so variable as to indicate option 1, so option 2 is preferred. This reconstruction, consisting of an extremely large and variable number of bryantodontiform elements (perhaps added sequentially during ontogeny) is unlike any other proposed conodont apparatus. [250]

OWRB Issues Synopsis of State Water Plan

The Oklahoma Water Resources Board's recent Publication 94-S, *Synopsis of the Oklahoma Comprehensive Water Plan*, presents a generalized review of a design formulated in response to a 1974 legislative directive to develop a feasibility study for a system to provide needed water supplies to all parts of the State.

Phase 1 of the plan, covering the 33 southern Oklahoma counties of the Red River Basin, was presented in 1975 in OWRB Publication 60. Subsequent planning has involved the 44 counties of the two-thirds of the State in the Arkansas River Basin. For purposes of the study the State has been divided into eight planning regions.

The plan, which is flexible in response to supply and demand, is projected through the year 2040, with projections shown in tabular form. It involves a system of storage reservoirs and conduits, which are displayed on a double-page map in the publication. The synopsis discusses the development of the plan, its goals, considerations, costs, benefits, and alternatives, and offers recommendations that should be followed for its implementation.

OWRB Publication 94-S is free on request from the Oklahoma Water Resources Board, 1000 Northeast 10th Street, Oklahoma City, Oklahoma 73152 (phone, 405–271-2555).

DOE Releases Report on McAlester Quadrangle

The U.S. Department of Energy has recently placed on open file an aerial radiometric and magnetic report that covers the McAlester 1° by 2° Quadrangle.

The report, *Aerial Radiometric and Magnetic Survey, McAlester National Topographic Map, Arkansas and Oklahoma*, presents sections on instrumentation, data reduction, geology, and data analysis, along with appendixes containing statistical data, single and average record listings, and a production summary. Also included in the report are record locations and geologic maps.

A copy of the report can be examined at the Oklahoma Geological Survey. A microfiche version can be obtained from DOE's Grand Junction, Colorado, office for $5.00. Prepaid orders should be sent to Bendix Field Engineering Corp., Technical Library, P.O. Box 1569, Grand Junction, Colorado 81502.

A computer-readable magnetic tape for the quadrangle, containing measurement, analysis, and location data, is available for $80.00 from Dalton Atkins, GJOIS Project, UCC-ND Computer Applications Department, 4500 North Building, Oak Ridge National Laboratory, P.O. Box X, Oak Ridge, Tennessee 37380.

New Inventory of Master's Theses Published

Volume 23 of *Masters Theses in the Pure and Applied Sciences*, edited by Wade H. Shafer and published by Plenum Press, lists 10,432 master's theses written at 247 academic institutions in the United States and Canada in 1978. The titles in the 292-page publication cover 44 scientific and technical disciplines, including the geological sciences; excluded on an "arbitrary basis" are mathematics and most of the life sciences. Similar bibliographies of science theses have been prepared annually since 1957 by the Center for Information and Numerical Data Analysis and Synthesis (CINDAS) at Purdue University.

This volume of *Master's Theses* can be ordered from Plenum Publishing Co., 227 West 17th Street, New York City, New York 10011. The price is $75.00. Back copies are also available from the publisher.

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