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STRATIGRAPHY OF THE URANIUM-BEARING ROCKS OF THE KARNES COUNTY AREA, SOUTH-CENTRAL TEXAS-- A PRELIMINARY REPORT

By

D. Hoye Eargle and John L. Snider

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Trace Elements Investigations Report 488

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*This report concerns work done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

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ABSTRACT

Uranium was discovered near Tordilla Hill in Karnes County, south-central Texas, in the fall of 1954, in the upper part of the Jackson formation of late Eocene age. By July 1955, 14 uranium prospects were reported as far northeast as Fayette County, northeast of Karnes County, and southwest to Duval County, south Texas, over a distance of about 190 miles.

Uranium minerals or radioactive rocks have been found in tuffaceous sand, silt, or bentonitic clay in at least seven different stratigraphic positions ranging in age from late Eocene to Pliocene. The known radioactive materials occur in the Goliad sand of Pliocene age, the Oakville sandstone of Miocene age, and the Catahoula tuff of Miocene(?) age in Duval County; in the Oakville sandstone and the upper 500 feet of the Jackson formation in Karnes County; and in the Catahoula tuff in Gonzales County. This report presents the results of a preliminary investigation of the stratigraphy of the uranium-bearing formations through Karnes County and the adjoining counties to the southwest and of the correlation of the potentially uranium-producing beds in drill holes and surface exposures. During this study the following contacts were mapped in reconnaissance through the area: the base of the Oakville

sandstone, the base of the Catahoula tuff, the base of the Frio clay (Oligocene), and the base of the Jackson formation. All the formations strike northeastward in the region and dip southeastward toward the Gulf Coast. They are locally cut by a number of major and minor faults, trending generally parallel to the strike of the formations.

Uranium minerals have been found, to date, generally no deeper than 30 feet below the surface, chiefly filling interstices between, and replacing, grains of sandstone that lie above impervious clay. Some of the clay also contains uranium minerals, generally as a coating along joint and bedding planes. The richest concentrations of uranium, however, are found in sand that has a clayey matrix. Some of the sandbeds contain clay pebbles and small fragments of carbonaceous material.

Although detailed mineralogic studies have not been made, the following uranium minerals have been identified: autunite, carnotite, tyuyamunite, uranophane, schroeckingerite, and schoepite. Other epigenetic minerals such as pyrite, hematite, sphalerite, and ilsemannite are associated with the uranium minerals at one prospect near Tordilla Hill. Detrital minerals of the ore-bearing sandstones include many derived from igneous rock sources.

INTRODUCTION

Uranium was discovered in the upper part of the Jackson formation of late Eocene age in the Coastal Plain of south-central Texas in the fall of 1954. According to common report, G. H. Strodtman, pilot for Jaffe and Martin Associates, San Antonio, Tex., oil operators, discovered a radioactivity anomaly northeast of Tordilla Hill in western Karnes County while making radiometric surveys with an airborne scintillation counter in exploring for oil. Subsequently, uranium minerals were found in rock exposures and in soil at the foot of Tordilla Hill. Further airborne reconnaissance showed other anomalies in the vicinity. These discoveries led to increased leasing of ground, and some drilling and trenching of areas of anomalous radioactivity showed that the deposits were scattered over considerable area and that a new uranium district had been discovered. Samples of material collected by H. S. Stafford of the Atomic Energy Commission showed the presence of carnotite and other uranium minerals in the deposits.

By August 1955, extensive prospecting had been done on at least 12 farm properties, and uranium minerals or high radioactivity reported on several more. Uranium minerals or radioactive rocks are known in at least seven different stratigraphic positions from the base of the upper part of the Jackson formation (Eocene) to the Goliad sand (Pliocene). Uranium minerals occur at a number of localities over an area about 190 miles long, extending from central western Duval County northeast to Fayette County. The accompanying map (fig. 1) shows the area of this preliminary investigation, from northwestern Live Oak County to northern Karnes County.

The investigation was undertaken by the Geological Survey on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission. Brief field investigations were made in late spring and early summer of 1955, in coordination with investigations concurrently being conducted by the Atomic Energy Commission (S. R. Steinhauser and E. P. Beroni, 1955).

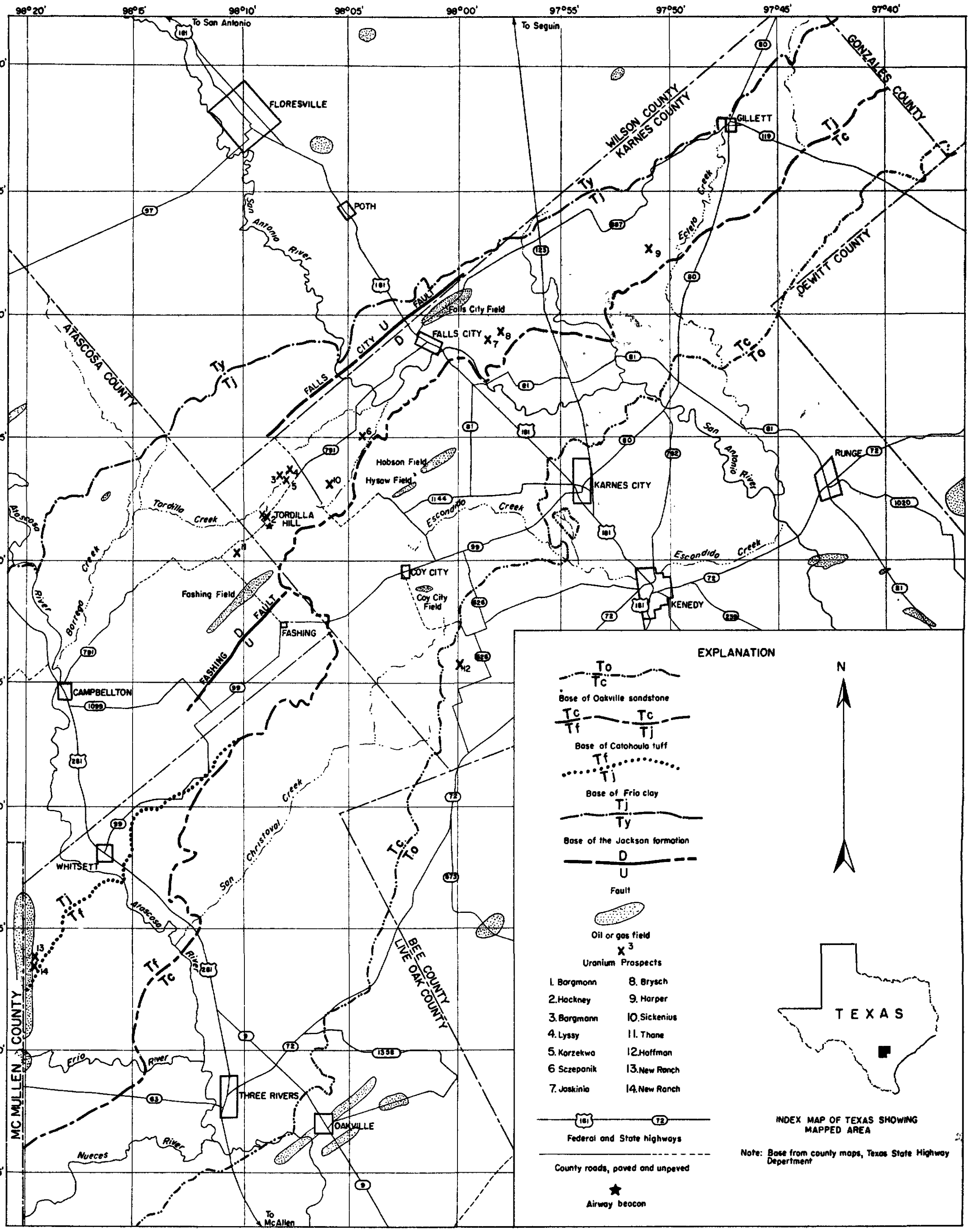


FIGURE I. GEOLOGIC MAP OF KARNES COUNTY AREA SHOWING LOCATION OF URANIUM PROSPECTS

Acknowledgments

A number of individuals and organizations contributed information and materials that made this investigation possible. Climax Molybdenum Company, through Fred Brooks and other geologists of that company, made samples from drill holes available for stratigraphic correlation. Samples of drill holes on the Jaskinia tract were obtained from the Wilson Oil and Exploration Company through the geologists of the Atomic Energy Commission. Dr. John Sandidge, Magnolia Petroleum Company, San Antonio, Tex., generously provided invaluable aid in the field especially in introducing the authors to the key exposures of the formations and to the areas where the structural relations of the formations could be observed. Ezra Powell of the same company also provided important stratigraphic information. K. A. Bishop of Southern Minerals Company provided information on the local geology of the region. Willis Storm, consulting geologist, San Antonio, gave permission to catch samples from the Edwin L. Cox No. 1 Poenisch well, 3 miles south of Coy City, Karnes County, while the well was being drilled. D. E. Hughes, San Antonio, Tex., allowed the authors to collect samples from the Shearer, Hughes, and Panuco Oil Leases No. 1 Elder well in southeastern Atascosa County. Dale Rowden, consulting geologist, San Antonio, Tex., provided subsurface information of the area in the vicinity of Tordilla Hill. The authors are indebted to E. P. Beroni and S. R. Steinhauser, geologists of the Atomic Energy Commission, who provided information and samples of the drill holes and pits in the deposits and areas in which they had been working. Dr. James K. Rogers, Arkansas Fuel Oil Company, San Antonio, furnished literature on the Jackson and Yegua formations in Atascosa County. Mrs. Alice D. Weeks of the U. S. Geological Survey identified minerals and provided lists of

minerals collected in November 1955 and notes on the significance of the mineral assemblages. The Bureau of Economic Geology, The University of Texas, through Dr. John T. Lonsdale, Director, provided office space and use of their library for this investigation. The authors profited greatly from discussions of the petrology and mineralogy of the deposits with Dr. Peter T. Flawn of that Bureau.

Location and geography of the area

The area in south-central Texas which this report concerns (fig. 1), and in which the greater number of prospects for uranium are located, extends from the Live Oak-McMullen County line on the southwest to the Karnes-Gonzales County line on the northeast. The area centers about 50 miles southeast of SanAntonio and is traversed by two principal streams, the San Antonio and Atascosa Rivers. These rivers and several of the larger creeks flow generally southeastward, but some of the smaller creeks and drainages parallel the strike of the rocks--northeast or southwest.

Karnes City, the county seat of Karnes County, is a town of about 2,600 population located in the center of Karnes County. The largest city in the area, however, is Kenedy, with about 4,300 population. Falls City, 11 miles northeast of the area where the greatest number of uranium occurrences have been found, has about 450 population, is on the San Antonio and Aransas Pass Railway (Southern Pacific), and is near the San Antonio River. Campbellton, about 500 population, in Atascosa County about 12 miles southwest of Tordilla Hill, is on the San Antonio, Uvalde, and Gulf Railroad (Missouri Pacific), and on the Atascosa River. Several U. S. highways cross the area, and numerous State highways and county roads make all parts of the area readily accessible.

The physiography of the area is typical of that of most of the southern part of the Coastal Plain region of Texas. It is an area of low relief, of farms, and mesquite-brush-covered pastures. The interstream divides are generally less than 100 feet above the adjoining streams except near the rivers where drainage relief is 150 to 200 feet. An exception, however, to the low relief along the divides is Tordilla Hill, an asymmetric ridge on a northwest-facing cuesta that rises about 125 feet along its scarp slope above the adjoining plain to the north. This hill is topped with a prominent airway beacon, a landmark in the vicinity.

The area is in general covered with a deep soil which conceals most of the bedrock. More resistant sandstones, such as those on Tordilla Hill, are commonly exposed over the outcrop area of rocks of the upper part of the Jackson formation. The soils consist of dark-gray sandy or silty top soil and light-colored subsoil generally rich in caliche. Exceptions are along sandstone outcrops, where the subsoil is loose gray sand containing little caliche. The sandstones are generally indurated along the surface of the outcrop owing to deposition of secondary silica. Soils from the Catahoula tuff especially have a high content of white to gray caliche.

Along the major streams the alluvial plains are a quarter to a half mile wide and one or more terraces are found 20 to 50 feet above the streams. A few outcrops of resistant sandstone are found in stream beds and banks and the less resistant shales and tuffs are exposed in several undercut stream banks. Roadcuts are generally shallow and only soils or the more resistant sandstones are exposed.

STRATIGRAPHY

The area of this report (fig. 1) in which the uranium deposits have been found is underlain by five principal stratigraphic units. The generalized outcrop of these formations is shown on the accompanying map (fig. 1), and they are, in order of increasing age:

Oakville sandstone (Miocene)
Catahoula tuff (Miocene?)
Frio clay (Oligocene?)
Jackson formation (Eocene)
Yegua formation (Eocene)

The Oakville sandstone and the Catahoula tuff are chiefly of nonmarine origin. The Frio clay and the Jackson formation are chiefly of marine origin and contain brackish-water or marine fossils. The Yegua formation is dominantly nonmarine. All of these units, except possibly the Yegua, contain significant percentages of volcanic debris, although they differ from each other in total content of tuffaceous material. The sediments consist of only slightly indurated, fossiliferous and tuffaceous sandstones and bentonitic clay, and of soft silt made up chiefly of glass shards. Some of the sandstones have been indurated by the deposition of opaline cement. Most are carbonaceous, containing fragmental remains of plants and some thin beds of lignite. No uranium deposits have been found in the Yegua formation. As the principal deposits in the area of this report have been found in the upper part of the Jackson formation, most of the discussion on stratigraphy will concern the rocks of this formation.

Jackson formation

The upper part of the Jackson formation of south-central Texas is made up chiefly of beds of tuffaceous sand interbedded with bentonitic clay, and the middle and lower parts, chiefly of clay with some interbedded sand. The formation consists mostly of beds of fossiliferous sandstone alternating with beds of lignitic clay, and appears to be the result of cyclic deposition. The outcrop area of the formation ranges from 14 miles in width, in the southwestern part, to about 5 miles in the northeastern part of the area mapped.

Although the name Fayette sandstone (Penrose, 1890; Dumble, 1924; and Deussen, 1924) had been approved by the U. S. Geological Survey as the unit of formational rank equivalent to all of the Jackson (Wilmarth, 1938, p. 723-724) in Texas, the same beds are shown as Jackson group undivided on the Geologic Map of Texas (1937). Miss A. C. Ellisor (1933), however, who described the Jackson in the area which this report concerns, discarded the name Fayette sandstone and divided the unit into three formations, in order of increasing age: the Whitsett, the McElroy, and the Caddell (1933, p. 1297). The name Whitsett (Dumble, 1924), however, has been rejected by the U. S. Geological Survey because the upper part of the Whitsett beds of Dumble were included in the Frio clay as mapped by Deussen, and the lower part included in the Fayette sandstone, a name now replaced by Jackson formation. Plummer (1933, p. 685) considered the Fayette sandstone a formation equivalent to the Jackson group of former usage and divided it, in east Texas, into the members which Miss Ellisor proposed as formations, but, in central and south Texas, into the Whitsett and Lipan members which Dumble had proposed as the Whitsett and Lipan beds in 1924. The type localities of the Whitsett and Lipan members as used by Plummer (1933) are in Live Oak and Atascosa Counties, only a few miles from Tordilla Hill. Plummer considered his Lipan member to be approximately equivalent to his McElroy and Caddell of east Texas. Little work has been done in recent years to resolve the conflict in terminology in the area of this report.

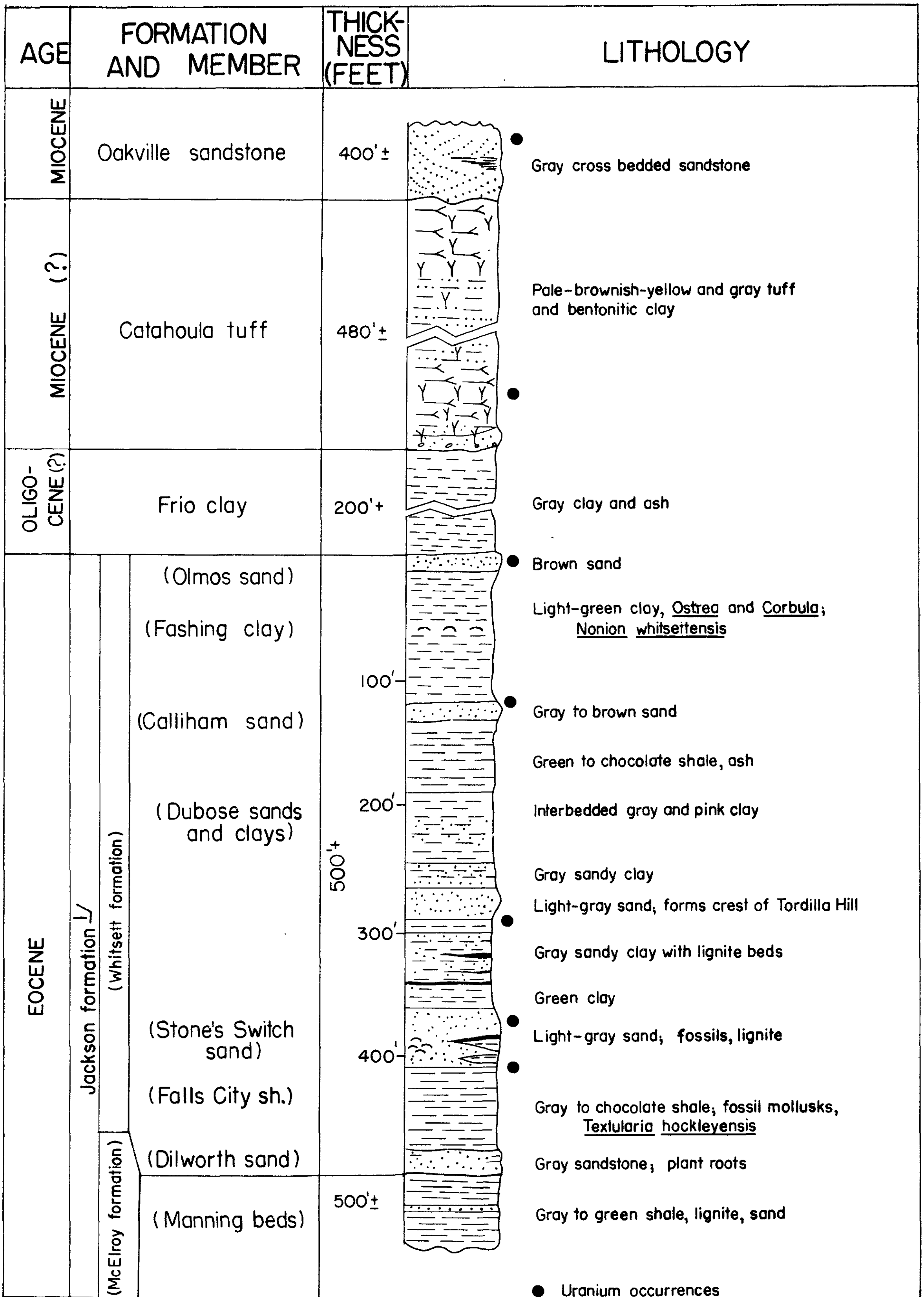
The Jackson formation contains three major foraminiferal zones (Cushman and Applin, 1926) -- the Textularia hockleyensis zone, the Textularia dibollensis zone, and the Bulimina jacksonensis zone. Textularia hockleyensis, which occurs in beds immediately below some of the major uranium deposits, has served in determining the relative position of the beds within the upper part of the Jackson formation.

Subdivisions of the Jackson, as recognized by Ellisor (1933), and with some lithologic names slightly modified, are as follows:

Whitsett formation	Olmos sand
	Fashing clays
	Calliham sand
	Dubose sands and clays
	Stone's Switch sand
	Falls City shales
	Dilworth sand
McElroy formation	Manning clay
	Wellborn sands
	Wooley's Bluff clays
Caddell formation	Upper chocolate clay
	Lower marl

The Whitsett formation of Ellisor is the only part of the Jackson in which uranium deposits have been discovered in this area; hence this discussion will be limited to that part of the Jackson. (fig. 2).

The Olmos sand (a name pre-empted by the Olmos formation of Cretaceous age) of Ellisor (1933) consists of brown-weathering loose sand



1/ Subdivisions of Jackson formation as used by A.C. Ellisor (1933, p. 1312) are shown in parentheses

FIGURE 2. GENERALIZED STRATIGRAPHIC SECTION, KARNES COUNTY AREA, TEXAS.

of medium texture and gray color, 10 to 15 feet thick. Underlying the Olmos sand of Ellisor (1933) is the Fashing clays of Ellisor (1933) which is a fossiliferous, bentonitic and olive green unit. This clay contains several zones of marine fossils, chiefly species of Corbula and Ostrea, as well as the foraminifer Nonion whitsettensis. It is 110 feet thick in the vicinity of Whitsett, northern Live Oak County.

The Calliham sand of Ellisor (1933), underlying the Fashing clays of Ellisor (1933) is a fossiliferous gray sand ranging from fine to coarse grained. It is about 20 feet thick in southern Atascosa County, but is believed to be generally thicker in Karnes County. It contains abundant and well preserved borings of Halymenites major.

The Dubose sands and clays of Ellisor (1933) consist of over 200 feet of light-gray sand interbedded with green, gray, and pale-pink clay. The unit also contains beds of lignite. Some of the beds are fossiliferous and some contain abundant plant fragments and silicified wood.

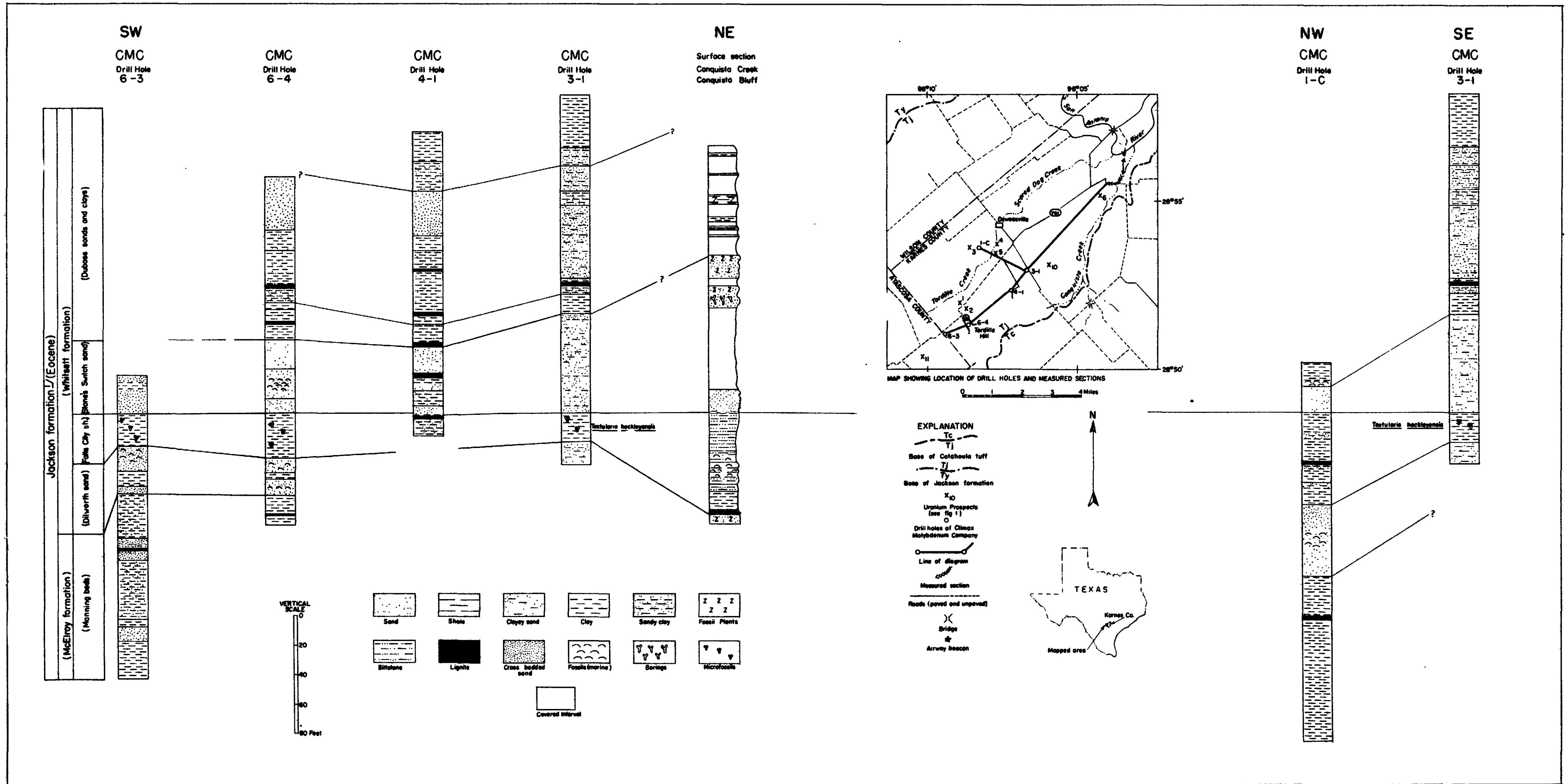
The Stone's Switch sand of Ellisor (1933) consists of lenticular beds of fine sand with considerable tuffaceous material in the matrix. This sand contains Halymenites major and other borings and in some places fossil shells. Locally, it contains a few lenses of bentonitic clay. Ellisor (1933) gives a thickness of 12 to 20 feet for this unit in the vicinity of Atascosa River, but a bed of sand in this part of the section in the vicinity of the uranium deposits in western Karnes County is considerably thicker, as much as 40 feet having been drilled in some places.

The Falls City shales of Ellisor (1933) is a gray to chocolate, laminated, bentonitic clay, containing scattered fossil mollusks and the foraminifer Textularia hocklenensis. An excellent exposure is a bluff on the south side of the San Antonio River near the old Conquista crossing, 4 miles southwest of Falls City (fig. 3), where the unit is about 70 feet thick, and consists of pale-gray to chocolate bentonitic clay. In the vicinity of Tordilla Hill, however, the Falls City shales of Ellisor (1933) is considerably thinner -- only 20 feet thick in some of the drill holes (fig. 3).

Ellisor's Dilworth sand is fine grained, in places fossiliferous, and some beds contain conspicuous vertical plant-root impressions and borings. Its thickness differs considerably from place to place, ranging in drill holes (fig. 3) from 30 to more than 70 feet. According to Ellisor (1933), the Dilworth sand is remarkably uniform in other physical characteristics throughout the region. It is underlain by what Ellisor (1933) called the Manning beds of her McElroy formation, which are laminated, in places lignitic, fossiliferous clays.

Renick (1936) and some other geologists consider the *Textularia hockleyensis* zone to be the top of the McElroy formation as they interpret it. The Falls City shales of Ellisor (1933), therefore, are considered by these geologists to be in the upper part of their McElroy formation, or the middle unit of the Jackson formation as now used.

Many of the beds of sand in the Jackson formation are generally light gray, noncalcareous, and distinctly crossbedded. Some are lenticular, enclosed by beds of clay, and have a direction of strike, as shown in pits dug for uranium exploration, diagonal to the strike of the Jackson formation. Some are fairly massive with few or no beds of clay, and contain borings of *Halymenites major*. Some, however, are thin bedded and contain abundant fossils, whereas others in the same sequence contain plant impressions and vertical plant rootlets. On the outcrop the sand at the surface is generally indurated by secondary deposition of silica, but at



1/ Subdivisions of Jackson formation as used by A.C. Ellisor (1933, p.1312) are shown in parentheses

FIGURE 3 — COLUMNAR SECTIONS OF EOCENE ROCKS IN THE VICINITY OF URANIUM DEPOSITS IN THE WESTERN PART OF KARNES COUNTY, TEXAS.

depth, grades into friable material.

The beds of sand alternate with beds of bentonitic clay and carbonaceous tuffs and thin beds of lignite. On weathered surfaces the tuffs are almost white, platy, light in weight, and contain abundant flattened plant impressions, mostly of a reed-type of vegetation. Unweathered, they are chocolate colored. The lignite is soft, dark brown or black, and rarely crops out except in stream banks and excavations.

The clay of the Jackson formation varies from olive or light green to pink or lavender, generally depending on the degree of weathering. Some of the clay is slightly calcareous and gypsiferous, and in places contains thin pelecypods, many of which are <u>Corbula</u> sp., some shells of <u>Ostrea</u> sp. and other mollusks, and Foraminifera. Some of the clay is of chocolate color and is carbonaceous, containing finely divided organic matter and minute fragments of stems and leaves.

Bailey (1926, p. 38-44) was the first to describe in detail the lithology of the Jackson, as well as the overlying formations, and to point out the volcanic origin of much of the material. Bailey's analysis of typical samples (1926, p. 39, 41) of sandstone of the Jackson showed that it is composed in large part of grains of plagioclase and opaline silica, with lesser amounts of quartz and chert, and traces of a number of different heavy minerals. Many of the mineral grains in the sand are subrounded, showing that they have been reworked. In places, small redeposited Foraminifera of Cretaceous age are found in the rocks.

Bailey found that the mineral of the clay is montmorillonite, for it has a mean index of refraction of about 1.51. As montmorillonite is the principal mineral of bentonite, he believed that the clay was formed by the alteration of volcanic glass, although he found only a few angular shards.

Further evidence as to the volcanic origin of some of the materials constituting the sediments of the Jackson formation, and of the environment in which they were deposited, has been brought out by A. D. Weeks (written communication):

"Bailey's optical identification of montmorillonite in the Jackson formation is supported by our X-ray examination. Further evidence of volcanic origin is given by the thick euhedral grains of biotite and by the sharp elongate crystals of zircon and tourmaline showing no water-worn appearance... That the Jackson formation was deposited in marine or brackish water is supported by the presence of zeolites believed to have formed by alteration of volcanic ash in saline water."

That the sediments were deposited by streams and subjected to strong current action to form deltas and bars is shown by the cross-bedded lenticular nature of the sands. The presence of fossils of land plants and of lignite show that these materials were deposited in low-lying lands where swamps were common; whereas the presence of marine borings and megafossils, and the alteration of volcanic ash presumably under saline conditions, indicate that the land was inundated with brackish or salt waters at least part of the time. The detrital materials, derived from the erosion of older rocks, mixed with the volcanic materials in the sediments show that the sediments were accumulating at the same time volcanoes were ejecting ash and some coarser granular fragments. Bailey points out, however, that some of the volcanic material may have accumulated on the land surface to the west and northwest from which the rest of the sediment was derived and was washed into the coastal lowlands and redeposited there.

The Jackson formation in the area of this report conformably overlies the Yegua formation of the Claiborne group. The thickness of the Jackson formation in this area is about 1,000 feet, of which approximately half is the Whitsett formation of Ellisor (1933).

Frio clay

The Frio clay, exposed only in Live Oak County in the mapped area, forms a low-lying area of gentle relief. The Frio is present, however, in the subsurface beneath the Catahoula tuff in central and southern Karnes County. The formation consists of light greenish-gray clay that is bentonitic and slightly calcareous, and which weathers to a characteristic brown silty or clayey soil. Although its strike is apparently the same as that of the underlying beds, the Frio clay rests unconformably on the sands of the Jackson formation.

The basal conglomerate of the Frio is exposed in a new cut on a county road 2 miles east of Whitsett, where it is made up of detrital materials including much silicified wood, pebbles of reworked sandstone of the Jackson formation, and other coarse materials. Southeastward down the dip, the lower part of the Frio of the subsurface contains a fauna characteristic of the Vicksburg of the east Gulf Coastal Plain, and the formation is therefore classed as Oligocene(?) in age.

The materials constituting the Frio were probably laid down under marine conditions in a protected bay or shallow sea. Its thickness is about 200 feet, as revealed in wells in southern Karnes County.

Catahoula tuff

Because of its low degree of resistance to erosion, the Catahoula tuff forms a gently sloping plain in this area. In its unweathered state, as revealed from a study of well samples, it consists mainly of silty, pinkish-gray, calcareous clay, and volcanic glass shards. Much of the clay is bentonitic, of very smooth texture, fairly hard and brittle, and has a conchoidal fracture. The formation also contains several beds of sand which are found to be water bearing in some places. One bed of sand, found near the middle of the formation in one well studied in the area, appears to be about 30 feet thick. Another, about 10 feet thick, and at the base of the formation, consists of coarse grains of clear feldspar and quartz, and black, red, and brown chert and volcanic material. The "rice sands" of counties northeast of Karnes County is a thick sand and conglomerate of volcanic material and bentonitic clay at this stratigraphic position. The formation also contains thin beds of lignite and a few beds of white to pink limestone, 1 to 5 feet thick. This limestone and the calcareous silt and clay are believed to give rise to the caliche that is very characteristic of the soils covering the outcrop of the formation.

Some of the beds of the Catahoula consist of pale-gray volcanic ash consisting of almost 100 percent shards of volcanic glass. The ash is light in weight, soft, and of silty texture. These beds are in some places more than 10 feet thick and are interbedded with hard bentonitic clay. The Catahoula is believed to be of nonmarine origin as it contains no marine fossils and has beds of lignite. It unconformably overlies and overlaps the Frio clay just west of Karnes City in northern Live Oak County. In this area the Catahoula has a slightly wider outcrop to the southwest than to the northeast, owing partly to overlapping of the Catahoula by the Oakville to the northeast, but also partly to the thickening of the Catahoula to the southwest. The Catahoula in the mapped area unconformably overlies and progressively overlaps the underlying Frio clay and the upper part of the Jackson formation from the southwestern to the north-central part of the area. The overlap of the Frio is complete in the northern extremity of Live Oak County, and through northwestern Karnes County the Catahoula progressively overlaps and lies unconformably on the beds of the upper Jackson. From northern Live Oak to northern Karnes County, the Catahoula overlaps the formations below it at the rate of about 50 feet per mile of linear outcrop. According to Dr. John Sandidge of the Magnolia Petroleum Company (personal communication), the Catahoula is about 480 feet thick in the southern part of Karnes County, but along the outcrop, is believed to be thinner in the northeastern part of the county. Because of its stratigraphic relations it is believed to be of early Miocene(?) age.

Oakville sandstone

The basal bed of sandstone of the Oakville, about 50 feet thick, is fine to medium grained, crossbedded, and contains quartz, chert, minor amounts of feldspar, and abundant varicolored grains that may be of volcanic origin. Abundant clay balls are distributed throughout the sandstone. Other material in the basal sandstone is finely laminated mudstone. Some of the latter beds show polygonal cracking and strong induration along the cracks. The rest of the formation consists of thick beds of carbonaceous bentonitic clay and some beds of sand. The sands have been partly indurated near the surface; and, because they overlie the weaker tuffaceous rocks of the Catahoula, the formation stands out as an escarpment above the plain on the Catahoula. Because of this escarpment and because there is a conspicuous soil change at this horizon, the base of the Oakville is mapped fairly easily.

The rocks of the Oakville are presumed to be of continental origin, the coarser material consisting of channel-filling sands and bar deposits, and finer material of lacustrine, lagoonal, or swamp deposits. The Oakville is composed, in large part, of detrital material eroded from the older formations. According to Bailey (1926, p. 57), the Oakville contains more tuff to the south, and near the Rio Grande it contains beds of soft, powdery, pinkish-white tuff of andesitic composition. In some places the basal Oakville is said to contain a high proportion of reworked Cretaceous fossil material, including both large pelecypods and small Foraminifera.

The Oakville sandstone unconformably overlaps the Catahoula tuff, although in this area there appears to be little difference of strike between the two. The Oakville, however, shows a lower angle of dip toward the coast than the Catahoula. As the Oakville consists in part of material eroded from older beds up the dip, some tilting must have preceded the deposition of the Oakville. The Oakville sandstone in this area is about 400 feet thick. In a number of places in outcrops of the formation, a continental vertebrate fauna of Miocene age has been found.

STRUCTURE

The formations trend generally southwest through Karnes County. Southwest of Karnes County, however, they strike somewhat more southerly. Seventy or eighty miles to the southwest, toward the Rio Grande, the strike gradually changes to a southern or somewhat southeastern direction.

The strike of the base of the Jackson formation averages about N. 60° E. throughout the area of this report, and the beds of sandstone in the upper part of the Jackson formation trend about N. 55° to 60° E. In contrast to this trend, the base of the Catahoula tuff in western Karnes County trends approximately N. 15° E., causing this formation to overlap sharply the Frio clay and the upper part of the Jackson in that area. It may be of some significance that this strong overlap lies in the area between the ends of two en echelon faults. It may also be significant that the richest uranium deposits have been found here. In northeastern Karnes County, however, the Catahoula nearly parallels the Jackson, and the overlap practically ceases.

According to Bailey (1926), the dip of the Oakville sandstone is 40 to 50 feet per mile southeast, and that of his Gueydan formation of 1924 (Catahoula tuff) is 80 to 100 feet per mile southeast. Beds of the Jackson formation through Karnes County dip about 125 feet to the mile. Thus it appears that the beds were tilted slightly toward the Gulf after, or perhaps during, the time of their deposition.

This region shows considerable normal faulting, as do many other places in the Gulf Coastal Plain of Texas. Many of the numerous oil fields in this region are due to structural traps produced by these faults and most of the oil fields in the Karnes County area are along fault lines. The two major faults which specifically involve the Karnes County area are the Falls City fault about a mile north of Falls City, and the Fashing fault in southeastern Atascosa County. The Falls City fault, which gave rise to the Falls City oil field, is downthrown on the southeastern side of the fault, and the Fashing fault, along which the Fashing field, 8 miles west-southwest of Karnes City, is located, is downthrown to the northwest of the fault line. Other oil fields along the general trend of the Fashing fault are the Hobson and Hysaw fields, 8 and 9 miles respectively west of Karnes City and in the area of the outcrop of the Catahoula tuff. The Fashing fault, however, may not be continuous or associated with the faults along which the Hobson and Hysaw fields are located. Another fault not shown on the map (Fig. 1), along which the Coy City field is located, is about 9 miles southwest of Karnes City. Some of these faults are believed to have been contemporaneous with the sedimentation, and the thickness of the producing sands (generally in the Carrizo sand and in the Wilcox group, middle and lower Eocene, respectively), is greater on the downthrown side of the fault.

In the vicinity of Tordilla Hill several transverse faults and fractures, not shown on the maps (Fig. 1 and 3), trend north across the area between the Fashing fault on the southwest and the Falls City fault on the northeast. The western side of Tordilla Hill is bounded by either a fault or large fracture that trends a few degrees west of north. Some of the borings in the Lyssy tract reveal a possible fault with a throw of only a few feet that probably trends a few degrees east of north.

URANIUM MINERALS

The richest uranium deposits discovered to date are in tuffaceous sand in the Jackson formation generally no deeper than 30 feet below the surface. In several of these deposits the uranium minerals are more abundant near the base of the zone where the sands overlie a relatively impervious bentonitic clay. In others, the minerals are most abundant in lenses of sand that contain fragments of carbonaceous material and clay flakes. In at least one deposit they are found in a thin bed of lignite.

Beds of clay generally contain less uraniferous material than do beds of sand. In most beds of sand, however, montomorillonitic clay forms a matrix for the sand grains. Flawn (1955) reports, in a preliminary study of the uranium-bearing rocks from the Tordilla Hill area, that the uranium minerals partially replace the clay matrix in forming a new matrix, and the result is an earthy mixture of clay and uranium minerals. He says that there is evidence that iron, as limonite, has been expelled from this mixture, that there is a suggestion that the uranium minerals began growth at the boundary between the sand grains and the matrix, and that the uranium minerals formed rims around the grains and expanded to replace the matrix. Flawn (personal communication) adds: "Evidence on exclusion of limonite is purely subjective. More or less clear microspherulitic uranium minerals occur in a dark-brown iron-rich clay. The clear spherulites are bordered by a dense limonitic rim. (See Flawn, 1955, photomicrograph No. 5.) The interpretation that this bordering rim of limonite was expelled during growth of the spherulite seems reasonable, but I do not regard it as unequivocal."

Flawn further states that the uranium minerals selectively replace certain grains in the sand. Feldspar, particularly of the potassium variety, appears to be most susceptible. The uranium-bearing solutions entered the feldspar grain along cleavage planes and from there replacement spread out to include the rest of the feldspar grain. Altered volcanic rock fragments and quartz were also susceptible to replacement. The edges of the quartz grains have been corroded and the uranium minerals extend into the grains along fractures, but generally the whole grain has not been replaced. In some of the rocks the grains are surrounded by iron oxide, but the uranium minerals fill interstices and replace the grains without replacing the limonite. These limonite rims define the original texture where most of the rock has been replaced by uranium minerals. Flawn found that the rocks having montmorillonitic clay matrices are more mineralized than the opal-cemented rocks.

According to Steinhauser and Beroni (1955, p. 15), almost the entire bed of sandstone, as much as 25 or 30 feet thick, is in some places mineralized to greater than 0.10 percent U_3O_8, but more commonly only the lower part of the sandstone, 1 to 6 feet thick, contains 0.10 percent U_3O_8 or more. The latter is true in such deposits as the Thane, Korzekwa, Lyssy, Sczepanik, Jaskinia, and Brysch prospects. (From southwest to northeast, see fig. 1, localities 11, 5, 4, 6, 7, 8.) Of these deposits the Korzekwa and Lyssy contain chiefly uranyl phosphates. Where the ore is near the base of the sandstone, Steinhauser and Beroni (1955, p. 15) say that a halo of low-grade material overlies the ore and may extend to the surface. In some places where the sandstone lies beneath only a shallow soil cover or is exposed, uranium minerals are concentrated in the upper 2 or 3 feet of the sandstone. These minerals are generally vanadates which may be more resistant to weathering and leaching than the phosphates. They also report (1955, p. 16) some mineralization along joint and bedding planes in the bentonitic clay that normally underlies the sandstone deposits.

In a prospect pit on the Korzekwa property where lenses of sandstone are highly mineralized, the richest bodies of ore are those which contain carbonaceous trash as well as clay. The sandstone, in addition to containing a yellow uranium mineral matrix, contains segregations consisting almost entirely of yellow minerals that appear to have been plant fragments that were replaced by the uranium mineral. When the soft yellow mineral is removed from these segregations, the remaining cavity is striated like the stems of reedlike plants and has the tabular form of plant fragments. The segregations are similar in size and shape to many lignite fragments found in unmineralized rocks in the area. The authors believe, therefore, that carbonaceous material as well as montmorillonite clay has served to localize the uranium minerals.

In a prospect pit on the Lyssy property adjoining the Korzekwa property, A. D. Weeks found that the sands contain zeolites. Little carbonaceous material, however, is found in this sand. In this pit a band of manganese oxide (psilomelane) is found at the base of the ore.

In the Hackney prospect uranium minerals are concentrated in outcropping rocks, and even in the soil just below the surface of the ground. In these rocks uranium minerals form part of the matrix of the sandstone. On this property some of the sandstones are dark gray to almost black and are highly indurated owing to the secondary deposition of the opaline silica. Some of the opaline silica cement is blue. In addition, the grains are coated with a light blue molybdenum mineral, ilsemannite. A laboratory study of a specimen from this locality collected by W. I. Finch was made by J. W. Adams, U. S. Geological Survey (written communication). A thin-section of the specimen shows that opal and minor chalcedony cements subangular to round sand grains, and that the chalcedony is stained blue by ilsemannite. A heavy mineral separation showed zircon, garnet, tourmaline, pyrite, magnetite, ilmenite(?), sphalerite, and a yellow uranium mineral that is probably carnotite. A polished-section of the same specimen showed pyrite as minute octahedral crystals to be the most abundant metallic mineral. The pyrite shows growth with, or replacement by, marcasite. Hematite is present as black crystals. The yellow uranium mineral is probably carnotite. The spectroscope shows molybdenum and titanium present, and chemical tests show arsenic also present, although no arsenic mineral was identified. According to Steinhauser and Beroni (1955, p. 16) assays of more than 4 percent molybdenum and 1 percent arsenic have been obtained from soft sandstones from this locality. A. D. Weeks reports (written communication) that uranium minerals at this locality include tyuyamunite, metatyuyamunite, probably carnotite, autunite (or related mineral), a new unnamed uranyl phosphate, and fluorescent opal.

In the Sickenius prospect, green flaky uranium minerals are disseminated in lignite. Also a yellow uranyl vanadate, probably carnotite, according to A. D. Weeks, is found in loose friable sandstone to a depth of several feet below the lignite.

Steinhauser and Beroni (1955, p. 16) report that in the Harper prospect (fig. 1, loc. 9) and in a prospect pit on the Bargmann property (fig. 1, loc. 1) autunite and meta-autunite have been found. Both these prospects are in bentonitic clay where the minerals are concentrated along joint and bedding planes in bentonitic clay.

The following uranium minerals from prospects in the Jackson formation in the Karnes County area have been identified by the U. S. Geological Survey's laboratories: autunite, meta-autunite, carnotite, tyuyamunite, schoepite(?), uranophane, and a uraniferous opaline material. From the one prospect in the Oakville sandstone (Hoffman prospect, fig. 1, loc. 12) Steinhauser and Beroni (1955, p. 17) report the presence of a yellow mineral that is most likely metatyuyamunite (A. D. Weeks, written communication), and powellite, a calcium molybdate-tungstate.

DESCRIPTION OF INDIVIDUAL PROSPECTS

Hackney prospect

A prospect on the Hackney property (fig. 1, loc. 2) is located at the foot of Tordilla Hill, north of the airway beacon on the southeast side of State Highway 791, which connects Falls City, 11.4 miles northeast of Tordilla Hill, with Campbellton to the southwest. It is 0.1 to 0.2 mile east of a conspicuous 90-degree turn to the southeast in the highway.

The prospect is about 125 feet below the top of Tordilla Hill, and the principal zone of mineralization showing on or near the surface of the ground is in the lowermost of two sandstone beds and in the soil on the slope below this lower sandstone bed. The sandstone beds are 2 to 4 feet thick and a 20-foot unit concealed by soil intervenes between the two. The sandstone is indurated with calcareous and siliceous cement, is light gray, and very fine grained. The upper bed contains yellow uranium minerals in a few places, and also contains marine fossils of <u>Corbula</u> sp. and other pelecypods, calcareous concretions that have a cone-in-cone structure, fragments of silicified wood, and hard silicified zones. The lower bed of sandstone is light gray, very fine grained, contains abundant plant-root impressions and some borings. Zones of this sandstone are dark gray and cemented with dark blue-gray opaline cement. Most of the grains appear to be smoky quartz, but the rock also contains feldspar, chert, and other clastic minerals. Some of the grains are coated with ilsemmanite. Uranium minerals are found essentially at the surface of the rock exposures and form a part of the matrix of the sandstone. Uranium minerals are also found in the soil down the slope from the outcrop of the lower sandstone bed and form a part of the matrix of the soil and the rock fragments.

The mineralized zones of the Hackney property are exposed in several places for several hundred feet along the foot of Tordilla Hill, but the depth below the soil and the distance down the dip beneath Tordilla Hill that the mineralization extends are not known because of the limited exploration that has been carried out there. The sandstones that are exposed there are in the upper part of the Stone's Switch sand of the Whitsett formation of Ellisor (1933). They are about 140 to 150 feet stratigraphically below the top of the sandstone in the lower part of the Dubose sand and clay, that forms the crest of Tordilla Hill, and are believed to be about 200 to 210 feet below the top of the Jackson in this area, where, because of the overlap by the Catahoula tuff, the upper part of the Jackson does not crop out.

A. D. Weeks (written communication) reports that the uranium-bearing minerals at this locality "include tyuyamunite, metatyuyamunite, probably carnotite, autunite (or related mineral), a new unnamed uranyl phosphate, and fluorescent opal. The firmly cemented dark blue-gray sandstone contains pyrite and marcasite, also a blue stain of ilsemannite in the secondary silica cement..." According to Weeks, the new unnamed uranyl phosphate occurs also in the Superior Oil Company pit on the Bargmann property across the road from Tordilla Hill [the Hackney property] in aggregates of tiny bladed crystals and might be mistaken for uranophane in the field.

Bargmann prospects

A prospect pit on the Bargmann property (fig. 1, loc. 1) on the opposite or north side of the road from the Hackney property, has been excavated by the lessee, the Superior Oil Company. The pit was excavated for a length of about 150 feet and a depth of about 9 feet in light-gray laminated montmorillonitic clay. The clay contains scattered calcareous concretions averaging more than 1 foot thick and a few concretions about 3 feet long and about 2 feet thick, the long axes of which are parallel to the bedding. It also contains a thin layer of white tuff about 1 inch thick. The bedding planes are stained with iron and manganese oxides, especially in the vicinity of the concretions. Uranium minerals appear in places throughout the pit as scattered pale yellow and pale green crystals along joint and bedding planes in the clay. According to A. D. Weeks the new uranyl phosphate that may be mistaken for uranophane in the field, and occurring as small bladed crystal aggregates, has been found here.

The foraminifer, Textularia hockleyensis, was found in a washed sample of clay from this pit by Philip S. Morey of the Bureau of Economic Geology, The University of Texas. According to Ellisor (1933, p. 1308) this is an index fossil of her Falls City shales and the associated underlying clays. This prospect is believed, therefore, to be in the upper part of the Falls City shales of Ellisor. As the top of Ellisor's Falls City shales is normally about 30 feet below the top of her Stone's Switch sand, and as the prospects on the Hackney property on the opposite side of the highway from this tract and only a few feet higher in elevation than this pit, are in the lower part of the Dubose sands and clays of Ellisor (1933), a small fault with perhaps as much as a 25-foot throw separating these tracts is suggested.

Another prospect pit on the Bargmann property (fig. 1, loc. 3) about 200 feet long and 9 feet deep excavated by bulldozer on the northeastern part of the tract, shows the following section.

Section in pit on the northeastern part of the Bargmann ranch about 9½ miles S. 60° W. of Falls City:

	Feet
Soil, black, clayey	2
Clay, light to olive green, laminated, conchoidal fracture, gypsiferous; stained black along joints with manganese oxide; contains $CaCO_3$ concretions as much as 18 inches in diameter	2
Sand, clayey, medium-grained; tuffaceous matrix; $CaCO_3$ cement; abundant fossil impressions	0.3
Sand, friable, medium-grained, gray; manganese oxide stained, very fossiliferous	1
Sand, indurated, calcareous cement, gray, medium-grained, very fossiliferous; no sharp contacts above or below; about	1
Sand, friable, fossiliferous, some calcareous zones, grades downward into less fossiliferous material; about	3

Yellow uranium minerals are disseminated through the upper 5 feet of the sands in this pit and in some places the fossil cavities are filled with the minerals. This section, by reason of lithology and stratigraphic position, is assigned to the basal part of the Stone's Switch sand of Ellisor.

Lyssy and Korzekwa prospects

The Lyssy and Korzekwa prospects are on adjoining properties (fig. 1, locs. 4 and 5), northwest of State Highway 791, 3 to 3½ miles northeast of the Karnes-Atascosa County line in Karnes County. The Korzekwa property lies along Highway 791 west of the crossing of a county road that trends northwest through Deweesville; and the Lyssy property adjoins the Korzekwa property on the northwest. The ore bodies, although on adjoining tracts, are believed to be separated laterally by a few hundred feet. Both properties had been leased to Jaffe and Martin Associates, San Antonio, Tex., but were being explored by Climax Molybdenum Corporation at the time of this investigation. The properties were explored chiefly by dry-drilling, sampling, and gamma-ray logging. In addition a pit was excavated by bulldozer on each of the two properties.

The pit on the Korzekwa property had been excavated prior to this investigation and was about 250 feet long and 4 to 5 feet deep. Later the one across a part of the Lyssy ore body was excavated about 300 feet long and to a maximum depth of about 30 feet. The exploratory drill holes were generally being drilled to depths of 30 to 40 feet, and showed sections, as revealed by a study of cuttings, of an average of 12 to 26 feet of light gray sand and clayey sand underlain by 2 to 7 feet of light gray sandy clay or sand under which lies 2 to $6\frac{1}{2}$ feet of light-brownish-gray clay (fig. 4). Beneath the light-brownish-gray clay is the "blue clay" of drillers, or medium-gray clay, in which many of the holes bottom. Some cuttings from the clayey sediments contain fossil shells and selenite crystals.

In the pit on the Korzekwa property (fig. 1, loc. 5), beneath about $1\frac{1}{2}$ feet of black soil, tuffaceous sand contains thin beds of montmorillonitic clay (fig. 4). The clay is gray, laminated, contains plant fragments, and is vertically jointed. The sand is in lenses that appear to be bar deposits oriented in a northeastern direction. The sand is conspicuously crossbedded, contains carbonaceous plant fragments, has a clayey matrix, and contains considerable clay breccia. Characteristic bedding of the material is graphically shown in figure 5.

In this pit the uranium minerals are disseminated in sandstone and clay but are concentrated in irregular pods and lenses as long as 50 feet and as thick as 6 inches to 2 feet. Uranium minerals also are disseminated

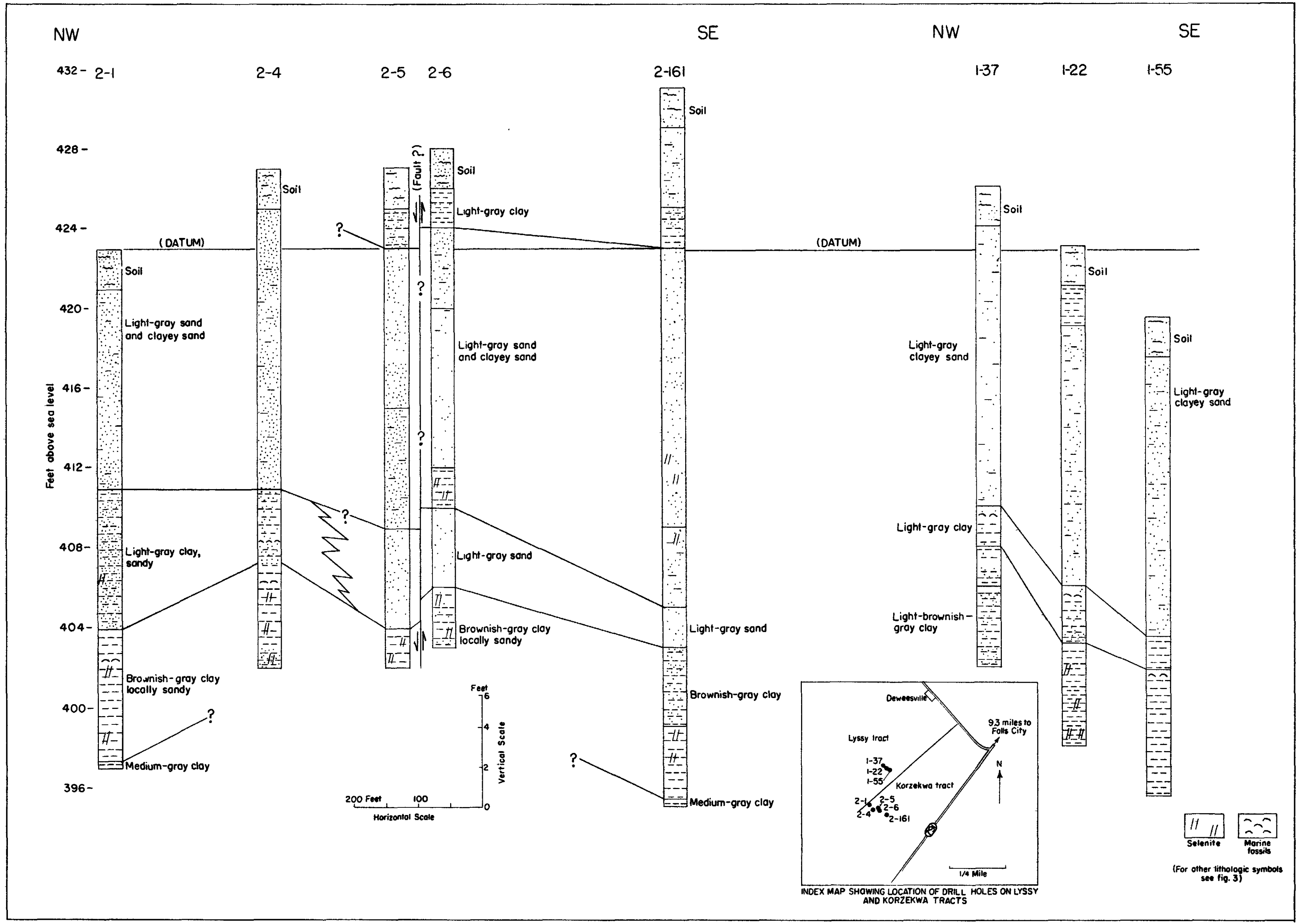


FIGURE 4.— COLUMNAR SECTIONS OF ROCKS PENETRATED IN DRILL HOLES ON THE KORZEKWA AND LYSSY PROPERTIES.

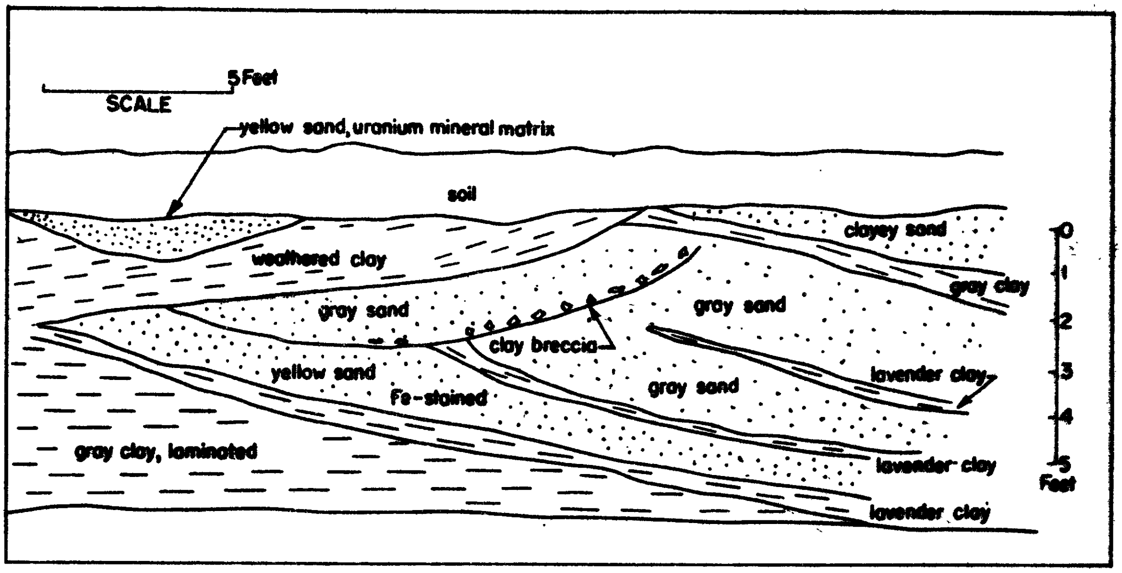


FIGURE 5. SECTION OF KORZEKWA PROSPECT PIT, SHOWING TYPICAL CROSS BEDDING OF MINERALIZED SEDIMENTS

along joint and bedding planes in the clay. Reportedly, the ore body outlined by drilling is very irregular in outline, and the richer part is probably confined to several sand lenses in predominantly clayey rocks.

On the Lyssy property (fig. 1, loc. 4), adjoining the Korzekwa property on the northwest (fig. 4), the ore deposit that contains the largest concentrations of uranium minerals is reported to be dendritic shaped with the long axis oriented in a nearly north-south direction. In the walls of the pit on the Lyssy property, the uranium minerals were found chiefly near the base of channel-filling sandstones, closely associated with dark streaks of manganese dioxide, and disseminated through the clayey material beneath the sands particularly along joint and bedding planes.

Both the Lyssy and Korzekwa prospects are believed to be in the same beds, probably either the basal beds of the Dubose sands and clays of Ellisor (1933) or in the upper part of the Stone's Switch sand of

Ellisor. As the deposit on the Lyssy tract, where it adjoins the Korzekwa tract, is at a slightly lower elevation (fig. 4) than the Korzekwa, a fault with a vertical displacement of about 10 feet or more is believed to exist between the two bodies. Both deposits, in addition, are cut by faults of smaller displacement. A typical minor fault is shown diagrammatically on figure 4 between holes 2-5 and 2-6.

The sequences of beds and the general lithologic characteristics are similar in both deposits. Both deposits were bottomed in the "blue clay" of the drillers, which is most likely the Falls City shale of Ellisor (1933), although no diagnostic fossils were found that would place the deposits more definitely stratigraphically.

A. D. Weeks (written communication) found that the minerals in the pits on the Lyssy and Korzekwa tracts are similar, though the pit on the Lyssy tract is deeper:

> "The Lyssy pit has meta-autunite (spectrographic analysis to determine whether pure or related mineral not yet available), a new unnamed uranyl phosphate, black bands of psilomelane and traces of uranyl vanadates. The rock contains montmorillonite and phillipsite, and the heavy minerals include thick grains of biotite, and euhedral tourmaline and zircon grains. The minerals in the Korzekwa pit are similar to those in the Lyssy pit. Pinkish-tan shaly ash beds have been altered to jarosite along bedding planes by oxidation of pyrite."

Weeks also noted pyrite and marcasite in a drill core (140-foot depth) from the Lyssy tract, and in rusty bands at the Korzekwa pit. R. G. Coleman reported that the sulfides in the drill core contain 0.024

percent selenium. Grains of a zeolite from this core sample were tentatively identified as phillipsite by Weeks.

Thane prospect

Two pits have been excavated on the Thane property in Atascosa County about 2 miles southwest of Tordilla Hill (fig. 1, loc. 11), by The Texas Company. One pit about 8 feet deep on the crest of a sandstone escarpment showed several feet of indurated sandstone grading downward irregularly into friable sand. Uranium minerals observed were in the soft sand near the base of the 8-foot section. Another pit about 0.4 mile southwest on the same lease was about 200 feet square and good sections were exposed in two directions. The following section was recorded there:

	Feet
Soil, dark-gray sandy loam, averages	2.0
Sand, tuffaceous, and interbedded clay, very pale gray, laminated but basal 1 to 1½ feet is massive fine loose sand showing faint cross-bedding. Irregular base. Ferruginous staining	4.0
Silt, clayey, light gray, moderately indurated slightly ferruginous, irregularly bedded, contains small flecks of carbonaceous matter, and some yellow uranium minerals near base	2.0
Tuff, lignitic, chocolate to pale purple, flaky, contains carbonaceous flecks and some uranium minerals	0.3 to 0.4
Sand, gray, slightly indurated, non-bedded, contains root casts, and, along top 0.3 foot is stained yellow with uranium minerals	0.5+

This section is believed to be near the base of the Dubose sands and clays of Ellisor, and in approximately the same stratigraphic position, below the sandstone that caps Tordilla Hill, as the Hackney prospect at the north foot of Tordilla Hill.

Weeks (written communication) reports the following minerals were found in the sediments:

> "...Friable sandstone beneath the silicified cap ...., contains carnotite. The heavy minerals in the friable sandstone include thick grains of biotite, euhedral grains of zircon and tourmaline, and traces of magnetite. Soft white 'veins' crossing the bedding of the sandstone are calcite."

Jaskinia prospect

The Jaskinia prospect (fig. 1, loc. 7), located about $1\frac{1}{2}$ miles east of Falls City, is in sandstone that forms a low escarpment but is not well exposed. The prospect has been explored by drilling. Samples were collected from three holes which range from 40 to more than 50 feet deep, and they were examined under the microscope and described lithologically. In general, the beds consist of 10 to 20 feet of yellowish-gray very fine clayey sand and yellowish-gray clay overlying about 20 feet of yellowish-gray very fine to medium-grained sand. The lower sand is somewhat clayey toward the base and contains an average of 10 percent brown and black mineral grains, in part apparently of volcanic origin, Beneath this sand is brownish-gray to medium-gray clay in which the holes bottomed. The sand in these borings is in the Stone's Switch sand and the Falls City shales of Ellisor (1933). In this area the Catahoula tuff lies in close proximity stratigraphically to Ellisor's Stone's Switch sand, her Dubose sands and clays being almost, if not entirely, overlapped by the Catahoula tuff.

Sickenius prospect

Several pits have been excavated by bulldozer in an area about a thousand feet long on the Fred Sickenius property, (fig. 1, loc. 10) $8\frac{1}{4}$ miles S. 47° W. of Falls City. The following section was taken in the easternmost pit, which is about 150 feet long, a maximum of 10 feet deep, and down the dip from the other pits. A hole was dug more than 10 feet deeper in the bottom of the pit. This pit is located in the bottom of a swale where both surface and ground water has been concentrated.

Section in prospect pit on Fred Sickenius property:

	Feet
Soil, black, clayey, tight	6
Clay, gray, tuffaceous, very tight	1
Tuff, yellow, friable	1.3
Lignite, brown, friable	0.2
Tuff, gray friable	0.25
Lignite, brown, friable; contains plant stems, white gypsum and pale-green uranium minerals	1
Sandstone, tuffaceous, olive-green; upper surface indurated, friable below; maximum depth observed in all pits about	18

In other pits to the northwest of this one, and in which loose sand lies below an indurated silica- and carbonate-cemented crust, some yellow uranium minerals stain the sand to about 6 feet below the surface. The sands in these pits are believed to be in the Calliham sand of Ellisor (1933). This sand is 70 or 80 feet stratigraphically higher than the sandstone which forms the crest of Tordilla Hill.

According to Steinhauser and Beroni (1955, p. 16), as much as 0.25 percent uranium is common in samples of the lower lignite bed.

In one sample of ash from a pit on the Sickenius property, Weeks (written communication) found low-temperature cristobalite. On a sample of opalized and silicified sandstone from another pit on the same property she found a very thin coating of uranyl vanadate, probably carnotite.

Brysch prospect

The Brysch prospect (fig. 1, loc. 8) is located about 3 miles east of Falls City, east of a county road which trends north-northwest. A pit has been excavated by bulldozer to about 40 feet deep and about 250 feet long. The pit walls are made up of fine tuffaceous sand nearly 40 feet thick which has borings of *Halymenites major* and several segregations of soft clay, some of which surround lignite. The pit bottoms in a brownish-gray clay. The sand is said to contain scattered flakes of fluorescent, pale-green uranium minerals. The sand here is the lower part of the Stone's Switch sand of Ellisor (1933), and the clay at the bottom of the pit is believed to be the Falls City shales of Ellisor.

Hoffman prospect

A prospect on the Hoffman tract (fig. 1, loc. 12), about 2 miles southwest of Lenz and 10 miles southwest of Karnes City, is located near the head of a small stream about 0.2 mile east of a county road that trends north-northwest. The prospect is in cross-bedded coarse sandstone that contains many dark and varicolored grains of possible volcanic origin, and some bentonitic clay. It is near the base of the Oakville sandstone and is the only uranium occurrence found to date in that formation in the area.

The indurated sandstone from which the soil has been stripped in the vicinity of the stream shows considerable staining with, and streaks of, yellow uranium minerals in an exposure of a hundred square yards or more. A. D. Weeks (written communication) indicates that the mineral that Steinhauser and Beroni (1955, p. 17) reported as unidentified, but resembling a synthetic barium-uranium vanadate, may be metatyuyamunite, inasmuch as the X-ray patterns of these two minerals are similar. Steinhauser and Beroni also report that powellite, a calcium molybdate-tungstate, has been found here.

About 300 feet downstream from the mineralized zone, a lenticular body of cross-bedded coarse sand projects downward at several places into olive-colored bentonitic clay containing shards of volcanic ash. The sand lenses apparently have compressed the bentonitic clay, for beneath the thicker part of the lenses the clay beds are considerably thinner and bedding planes can be traced into the less compressed clay away from the lenses. The beds of clay have not been truncated, as would have been the case if channelling had taken place. This sandstone lens is essentially non-radioactive.

New Ranch prospects

The most southwesterly radioactive deposit of this area is on the Mable New ranch (fig. 1, locs. 13 and 14), known locally as the old Bronson ranch, about 6 miles southwest of Whitsett, and near the Live Oak-McMullen County line. At the time of inspection the prospect consisted of two pits about a mile east of a north-south road. The pits, about half a mile apart, were excavated by a bulldozer in friable fine- to medium-grained sand. The material exposed in one pit consists of about

$2\frac{1}{2}$ feet of soil overlying pale, yellowish-brown sand. The sand is laminated, faintly crossbedded, slightly tuffaceous, and contains some organic matter and bentonitic clay. The most radioactive zone in each pit is 4 to 6 feet below the surface and is about 6 to 18 inches thick. Although the sand is relatively highly radioactive, no uranium minerals were seen. The sand in which these prospects are located forms a dip slope beneath the Frio clay and is most likely the Olmos sand of Ellisor (1933).

SUMMARY

Uranium has been found in commercial quantities in rocks in the upper part of the Jackson formation of late Eocene age, in Karnes County, Tex., in tuffaceous sandstone containing some clay and organic matter. The rocks containing the uranium-bearing beds are interbedded sandstone and bentonitic clay. In part they are cemented with secondary silica in surface exposures and contain opalized wood. Most of the rocks contain fragments of carbonaceous matter and some prospects contain thin beds of lignite. Some of the beds of sandstone contain abundant shells of mollusks, and some of the clay, microfossils. The sandstones are presumed to be chiefly delta and bar deposits, accumulated in low-lying swamps near the coast, which were periodically invaded by brackish or marine waters. Volcanic ash was probably added to the waters as sediment was being washed into the basins.

The richest uranium deposits found to date are located in the vicinity of Tordilla Hill, westernmost Karnes County, in an area between the ends of two major en echelon faults. In the vicinity of the deposits, the block lying between these two faults is cut by smaller faults nearly at

right angles to the major ones.

The uranium-bearing minerals which have been identified include autunite, carnotite, tyuyamunite, metatyuyamunite, a new unnamed uranyl phosphate, fluorescent opal, schroeckingerite, and schoepite(?). The known deposits found by surface prospecting and near surface exploration are mostly at depths less than 30 feet below the surface, and they occur mainly in carbonaceous tuffaceous sandstones that have a clay matrix and overlie beds of impervious clay. With the present information at hand, it is believed by the writers that the source of the uranium was in the tuffaceous sediments and that the uranium, leached from the tuffaceous sediments, was concentrated by evaporation or by interaction with clays and carbonaceous or other materials where ground waters were concentrated in stratigraphic or structural (fault) traps or channels.

Occurrences of uranium minerals in the Catahoula tuff, the Oakville sandstone, and the Goliad sand, over an area of about 150 miles to the northeast and southwest, indicate that uranium is widespread in this region.

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