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The various facts which have been observed and recorded regarding the geologic history of our State, and which have been briefly touched on here, show the manner in which it was brought into being, and in which the various formations were laid down, their relations to those of other regions and the character of life they evidence. These facts have a decided interest not only for scientists but for all thinking people. There is, however, still another phase of this geologic history which must also be of interest to every one, and that is the part which geologic processes have played in fitting the land for habitation, by preparing the soil and storing up water and fuel as well as in producing and preserving stores of valuable minerals for our use and comfort. This is the utilitarian side of geology, the value of which is coming to be more and more fully recognized.

The importance of a correct understanding of the geologic features of the region in this connection will be readily seen when we consider that practically all materials of economic value, such as ores, minerals, coals, oils, artesian water, etc., that occur within our borders, are found in some definite relation to one or the other of the various geologic formations that have been discussed; and any real investigation of these materials, looking toward their proper utilization, must take into consideration the fact and character of this relation and include the study of its geological significance.

It is my purpose here to enumerate the more important of

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these materials as we now find them, and to indicate briefly the relations between them and the rocks with which they are associated.

Among the granites and associated rocks of pre-Cambrian age in the Llano region there are many varieties of stone which are well suited for building as well as for decorative and monumental uses. Besides the red or pink granite, of which the State capitol is built and which enters into the structure of many other buildings, both public and private, in various portions of the State, there are gray granites, serpentines of different colors, quartz porphyry, etc., many of which stones are susceptible of high polish and will, in time, be used extensively.

The Texan marbles will also furnish a limited supply of desirable ornamental stone, occurring as they do in beds of medium thickness, even-grained and fully compact in structure, and of a snowy whiteness.

It is in connection with this group of pre-Cambrian rocks also that the principal mineral deposits of this region are found.

There are legends of "lost mines" of fabulous value in the Llano region; but although many men have made determined efforts to find them, all search for them has been in vain. Among these was the Bowie mine, supposed by some to have been in the Honey Creek region in the southeastern part of Llano county, but held by others to be farther north and west.

The story, which was formerly believed in by some who were contemporaries of Bowie and who spent much time in a search for it, is, briefly, that somewhere in this region Colonel Bowie found a cave or an old Spanish working in which native silver occurred in such large quantity that it could be cut out with a hatchet, and that when he left it he concealed
As a result of this search, caves and old workings have been found, but no trace of the wonderful silver-mine has ever been discovered.

Some placer gold has been recovered from the sands along Honey and Sandy creeks south of Packsaddle mountain, which probably comes from the disintegration of some of these older rocks, and small quantities, probably having the same origin, are found in the sands of the Colorado river as far south as Austin.

Years of prospecting in this region have brought to light, in the pre-Cambrian mica-schist, a few quartz stringers which carry gold in small quantity, and in the granites and schists some small veins of galena carrying silver, and irregular deposits of copper glance carrying both gold and silver. Platinum is also reported, and some work has been done at the locality where it was found. Many others of these occurrences have been prospected, and on some of them shafts of considerable depth have been sunk, but up to the present no workable deposits of the precious metals have been commercially developed.

It is believed by some in this region that further work on the copper-silver deposits of the northwestern part of Llano county will yet result in the development of paying mines. These copper deposits are found in the Babyhead region and west of Pecan creek. Considerable areas are found in which the highly colored carbonates are spread over the surface, and a number of shallow pits and tunnels were dug on these many years ago. The ores found were the carbonates with some sulphides—erubescite, gray copper, and pyrite—but only one locality afforded ore enough even for a small shipment. At another locality a considerable amount of ore was found in prospecting, but no shipment was made
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and no development has followed. It does not seem probable, therefore, that these ores occur in sufficient quantity to make mines of any considerable value.

The conditions in the trans-Pecos seem to have been more favorable, and workable ores of copper, lead, and zinc, principally silver-bearing, are found in connection with the granites of the Quitman mountains, the Hazel sandstone of the Diabolos, and the schists of other mountain ranges of the area. Some silicious gold ores are also found.

The Bonanza and Alice Ray mines in the Quitman mountains show veins of galena and blende which carry silver and some gold. These have produced some shipping ores and will probably become steady producers when conditions permit. There are many other prospects in these mountains, some of which appear to be well worthy of further investigation.

The Hazel mine in the Sierra Diabolos, north of Alamomore, has produced a considerable amount of gray copper and copper glance carrying good values in silver, and similar ores are found in other less developed prospects in the same vicinity.

In the other ranges prospecting has developed good indication of ores in rocks of this period; and while little mining has been done, the prospects are that good mines may yet be opened in them.

The lack of development of these deposits of precious metals is no doubt largely due to our land and mining laws. In this State the owner of the land is owner of all minerals occurring under it. The trans-Pecos region is largely occupied by blocks surveyed under various railroad grants, in which one-half the land is under private ownership, leaving the alternate sections alone belonging to the State or to the
schools or asylums; and it is only such of these State, school, or asylum lands as have not already been disposed of, which can be granted under mining laws. These conditions render prospecting so risky as practically to prohibit it, since even if mineral be found, the chance of getting title to it is altogether too uncertain.

When the region is better settled and the land lines more certainly known, this condition will be remedied and these valuable deposits will be sought by owners or prospectors, and the development that will follow will add greatly to the wealth of the State.

The iron ores of the Llano region have been long known. They comprise magnetites and hematites with only a small measure of limonite. The magnetites occur in connection with the pre-Cambrian rocks. The hematites and limonites, probably derived from these, are connected for the most part with the succeeding sedimentary deposits.

The magnetites occur as large lenses or bosses and have been pretty thoroughly prospected and their area determined by drilling. Many of them are of excellent quality and will furnish a large quantity of high-grade ore for use in connection with the smelting of the brown ores of east Texas. The origin of these ores is not definitely known. If it should prove that they are derived from the alteration of sulphides, their excellent quality may not be found to continue downward as far as is now believed probable.

Similar iron ores are found in west Texas also, but no work has been done on them.

Deposits of workable manganese ores occur in the eastern portion of Mason county, where they were prospected years ago at what was known as the Spiller mine, but no mining has ever been attempted.

Traces of tin ore have also been found in the Llano re-
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gion, and it was reported from this region by the Geological Survey. Later other parties found some stream tin in the eastern part of Mason county, in connection with crystals of topaz, but up to the present time no special work has been done on it.

In the Franklin mountains, however, 15 miles north of El Paso, tin ores occur in well-defined veins in connection with the granite, which is here supposed to be intrusive and later than the Cambrian beds.

Seven veins have been exposed by open cuts and are said to exhibit the usual characteristics of the tin beds of Cornwall. The surface values are good, a considerable area has been prospected, and some mining carried on. A small mill and reverberatory furnace were erected and several tons of very pure tin were made, when operations were temporarily suspended.

At Baringer hill, on the west bank of the Colorado river some 20 miles east of Llano, there occurs a deposit of rare-earth minerals which, so far as now known, is entirely unique, since at no other place have they ever been found in such large masses or in such quantities as here.

These minerals, which are valuable chiefly for their contents of rare-earths of the yttrium group, include gadolinite, fergusonite, allanite, and cyrtolite, with smaller quantities of a number of other species.

The hill was named for Mr. Baringer, who made the first discovery of gadolinite in 1887. It is not over 50 feet in height, is 100 feet or more in width, and between 200 and 300 feet in length, and owes its existence to the superior hardness of the pegmatite dike of which it is composed to the porphyritic granite into which it was intruded. In the center of the pegmatite there is a large mass of quartz, while at its outer edge, in contact with the granite country
rock, there is a band of very perfect graphic granite. The minerals occur both in the quartz and in the feldspar, but for the most part along the outer portion of the dike.

Gadolinite is the most abundant of the minerals and occurs in crystals and masses of irregular shape, sometimes weighing as much as 200 pounds, single crystals having been found that weighed over 70 pounds. One mass of allanite was found weighing over 300 pounds, and correspondingly large quantities of fergusonite, thoro-gummite, etc.

The radioactivity of some of these minerals is manifested by tanning the faces and arms of those who mine them.

The property is now controlled by parties who mine only such quantities of the minerals as are needed to furnish the incandescent glower used in the Nernst lamp.

There are other mounds of similar origin and structure in the vicinity in which small amounts of these minerals have been found, but so far no other locality has given promise of yielding them in commercial quantities.

The massive limestone of the Ordovician is very variable in character, and much of it has no special value as structural material. There are, however, in that portion of the formation called by Comstock the Hoover division a series of semi-marbles which give promise of yielding a large amount of very valuable structural and ornamental stone. These Burnet or San Saba marbles are even-grained, tough, and compact, and admit of a fine polish. Some are homogeneous in tint; others are variegated. The colors are white, pink, buff, and several shades of gray and blue. They occur at various points in Llano and surrounding counties, and it is only a matter of time when they will become the basis of a considerable industry.

The only ores of value that are found in connection with the Cambro-Ordovician rocks are the beds of hematite and
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limonite iron. These occur at many localities through the Llano region, and analyses show that many of them are high in iron, although a number are also high in phosphorus.

Up to the present time, however, little or no prospecting has been done on the various outcrops, and we know, therefore, very little as to the real extent or value of the deposits.

The Carboniferous rocks of the west are deposits of the sea, with little or no admixture of materials derived from the land, and they show no coal-beds nor deposits of petroleum, nor are any mineral deposits known in them.

The rocks of the Pennsylvanian in northern Texas, however, toward which the wash from the land surface contributed a great amount of material, contain deposits of coal, petroleum, and gas which are of very great value.

The Bend division, which is the continuation of the Caney shale of Oklahoma, like it, is highly bituminous and yields both oil and gas. Up to the present the yield from wells drilled into it in our territory has not been very large, but is sufficient to prove its character as an oil-bearing formation and to warrant a careful investigation into its structure in an effort to locate more favorable points for drilling.

This is especially true of the region east of the Lampasas geanticlinal, where the Bend is overlain by the Cretaceous.

In the Strawn division, which overlies the Bend, we find the seam of coal which has been worked for so many years in Parker, Palo Pinto, and Erath counties. While the bed is not as thick as many of those of Oklahoma, the coal has proved very serviceable and an acceptable fuel. The outcrop of the coal-bed, beginning at a point a few miles west of Decatur, extends southwestwardly across the counties named until it passes under the Cretaceous hills northwest of Stephenville. Mines have been opened at different points, but those along the Texas and Pacific railroad have
been most fully and successfully developed, probably because of the better facilities for transportation.

The Cisco, or upper division of the Pennsylvanian, of this region also carries a seam of coal, the outcrop of which can be followed from Bowie across Jack, Young, Stephens, Eastland, Brown, and Coleman counties to the Colorado river. The thickness of the seam is variable and in places it is too thin or too impure to work, but the extension of rail lines along it has caused its development at the more favorable localities and it is furnishing large quantities of excellent fuel. From present indications it bids fair to rival the lower seam in production.

The economic value of the Cisco division is not, however, found alone in its coal-bed; for to the westward it is the principal source of the oil and gas which are being produced in the region extending from Burkburnett, on Red river, to the Texas and Pacific railroad. During the last four years a number of oil-pools have been opened up in this region, including Petrolia, Iowa Park, Fowlkes, Electra, Burkburnett, and Moran.

The oil is of very high gravity and has a paraffin base. The wells are from 700 to 1900 feet or more in depth, and the production for 1913 was nearly 9,000,000 barrels.

The indications are that other producing pools will be found, and that the oil territory may spread nearer to the foot of the plains.

Vast quantities of natural gas are also found, and many cities and towns are now being supplied with it from wells drilled into this formation.

In all such occurrences the geologic structure is one of the prime factors. As we have seen, we have here a synclinal basin, the axis of which is probably east of the border of the
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plains. The oil was deposited either already formed or as fatty matters derived from partial decay of animal and vegetable remains which were later transformed into oil and gas by fermentation or pressure-distillation, and these oils and gases, acting under natural laws, are concentrated in the more elevated portion of folds in the inclosing beds. No great amount of orogenic action has occurred here, and consequently the lines of uplift are small and often masked by later deposits. While this is true, the chances of finding oil and gas along such lines are so much greater than in ordinary “wild-catting” that every effort is being made to locate them and so lessen the chances of getting dry holes.

The region is now being carefully studied by several corps of geologists who are endeavoring to locate such existing structural lines as may in any way influence the concentration of the underground oil supply, as an indication of suitable places for drilling new wells.

In the trans-Pecos area the limestones of Permian age form the country rock of the ore bodies which have been worked for many years by the Presidio Mining Company at the mines on Cibolo creek northeast of Presidio del Norte. The silver ores which occur here are found in cavern-like openings or chambers in the limestones which are connected by fissures of less or greater width. These mines have been the most reliable and productive yet found in Texas, and have been worked since the year 1884.

The principal ore is horn silver or silver chloride, although pockets of galena rich in silver also occur, together with smaller amounts of other lead and zinc ores.

Similar deposits of zinc ore also occur in these limestones in this region, but have not yet been mined to any extent.

The principal mineral deposits occurring in connection
The copper of this formation does not occur in veins as in the older rocks, but it was deposited in beds of blue clay at or near the time they were laid down beneath the waters. Whatever may have been the origin of the copper, it was probably carried in solution in the percolating waters and precipitated by the action of the organic matter carried out with the clays and sands.

It now occurs scattered through these clays in the form of sulphide of copper, which, near the surface, has been oxidized and now shows stainings of copper carbonates. In places it is more concentrated and is found in the form of nuggets or as replacements of fragments of wood or even whole trunks of trees, and of the bones of animals. Such deposits are frequently of considerable value.

The beds of clay are from three to four feet thick and are continuous over long distances. The copper disseminated through them is more abundant in some parts than in others, and in places is in sufficient quantity to make mining possible if the ore could be separated from the clay.

There are three distinct horizons at which the copper occurs. The first is in the Wichita beds, and its outcrop begins on Red river near the mouth of Cache creek (where it was first observed by Captain Marcy in his exploration of Red river in 1852), and extends southward through Archer county.

It is from these beds that the largest amounts have been taken. Pockets carrying several thousand pounds of high-grade ore were found some years ago and the material shipped, but nothing has been done with them lately.

The second bed is found in the Clear Fork division, ex-
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Tending from Buffalo Gap northeastward by way of California creek in Haskell county on to Red river.

The upper beds are in the Double mountain division and occur at Kiowa peak, Buzzard peak, and Cedar mountain, at the head of Raggedy creek and the north side of Pease river.

The occurrence of this copper in this manner is somewhat similar to that of the copper ore found in the Permian of Germany, which has been the basis of an industry employing 50,000 men and producing both copper and silver.

The Texas clays are not so bituminous as those of Germany, the beds are thicker, and the copper ores are for the most part disseminated through the entire thickness of the bed instead of being concentrated within the bottom twelve or fifteen inches. In the Mansfeld district, also, vast quantities of water are encountered in mining the copper shales; while in Texas the ore occurs in a region so dry that there is not sufficient water supply to wash and concentrate the ore properly.

Only the richer pockets have so far been utilized, and these are so separated and of such uncertain occurrence that no regular mining has been done on them. It is hardly probable that this copper, vast as it must be in aggregate amount, will be utilized until some cheap process of separating the ore from the clay has been devised.

The gypsum deposits of the Permian cover an extensive area and are of such great thickness that they are practically inexhaustible for all uses now known. They are found both in the region lying east of the Staked Plain and in the valley of the Pecos west of that plateau. On the eastern side of the Plain they extend from Red river to the line of the Texas and Pacific railroad in a belt from 20 to 50 miles wide. The beds are of varying thickness. Some are no
thicker than a knife-blade, and others are 30, 40 and even 60 feet in thickness. The material is found in clear transparent masses of selenite, in compact snowy beds of alabaster, in beautiful rounded masses of thin rose-like leaves, colored reddish pink, known as “rose gypsum,” in massive beds, and as a pulverulent sandy mass known as gypsite. This last is the material of which the cement plasters are made, and is the variety which is at present most sought for manufacturing purposes, being the basis of operations of several large mills near Quanah.

The deposits west of the Plain are of equal value with those east, but, owing to their location, have not yet been opened up.

This gypsum is an integral part of the geologic history of our State. It marks distinct stages in the evaporation of the waters of the Permian sea when it was so shut off that not enough fresh water could enter to hold these mineral salts in solution and thus the gypsum and salt were deposited.

The gypsum-beds, by reason of their insolubility and resistance to erosion, form permanent benches throughout the area, while the salt-beds, because of their ready solubility, are not so well known. The salt manifests itself, however, in numerous salt springs and wells in the Permian area. All the rivers and streams passing through the area are more or less impregnated with it, so that at low stages some of them are almost brine. For miles at such times the banks of the rivers are as white as snow. Salt Croton creek is especially briny. All the rocks around the falls above its junction with the Brazos are incrusted with salt, and the water of the pool below the falls is of a density approaching that of Great Salt Lake. Salt is deposited along the banks in sheets and is gathered for use. This salt, of course, has its origin in the deposits in the clays of the Permian, from which it is dis-
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solved by percolating waters, brought to the surface, and redeposited.

Beds of rock-salt also occur, but they have been utilized only by wells at Colorado Springs, in Mitchell county, where, in boring for water, rock-salt was encountered at a depth of 850 feet. Below this depth there were found, within a distance of 250 feet, strata of rock-salt with a total thickness of 140 feet. Water is found in connection with the salt-beds, and this rises to within 170 feet of the surface. It is a saturated brine and seems inexhaustible. It is pumped to the surface and evaporated, and has been utilized for many years in the manufacture of a fine grade of salt.

In the region around San Angelo where the rocks of the Albany division are found in good exposures they contain beds of shales and limestones that are distinctly petroliferous. Asphalt has been reported from wells in this vicinity, and it is probable that the indications will lead to the sinking of test wells at least.

Between the Delaware mountains and the Pecos river both oil and sulphur are found at numerous localities in connection with the Permian deposits, and in some cases apparently in connection with those of Quaternary age as well.

Several wells drilled in the Toyah valley have encountered small quantities of oil at comparatively shallow depths, and deeper drilling has shown a number of petroliferous beds underlying it. The uppermost beds are found in connection with the pulverulent gypsum and other late deposits which form the surface materials, while the lower beds are either Permian or Cretaceous. So far only wells of small production have been brought in in this area.

Sulphur deposits occur in the same connection, being found mingled with the gypsum and impregnating other beds adjacent to or lying between the oil-sands.
In the valley between the Rustler hills and the Delaware mountains there are also sulphur impregnations in the gypsum, but these have not been so thoroughly prospected as the beds east of the Rustler hills and the Toyah valley.

While the sulphur occurs in sufficient quantity to be commercially valuable, it is at present too far from market to make its development attractive in competition with the great deposits of the coast country of Louisiana and Texas.

The deposits of economic value occurring associated with rocks of the Cretaceous include quicksilver ores, coal, petroleum, salt, gypsum, and artesian water-beds.

The presence of cinnabar in the trans-Pecos region was known to the Indians, who used it in painting their faces and bodies, but all search for the place from which they obtained it was in vain for many years. In September, 1894, a large piece of the mineral which had been found in the southern part of Brewster county was given me and was presented before the Texas Academy of Science at Austin as the first find of mercury in Texas. In 1895 Professor Blake made an examination of the region, which had then been located for mining mercury, and his is the first published account of it. This was followed by the location of other prospects in the neighborhood, but, owing to the scarcity of fuel and the distance from transportation, development was rather slow for a time. Part of the trouble also grew out of the land conditions and the State Mining Law, as in the case of prospecting for gold and silver.

Several good mines, however, were opened and furnaces erected which have produced large amounts of quicksilver. At present only one of them is active.

The production is from the vicinity in which the ore was first discovered, but prospecting has shown several other localities where the mineral occurs apparently in commercial
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quantities, and it is probable that a stronger demand for the metal and better transportation facilities will bring about a considerable increase in mining and smelting in this region.

This ore occurs in connection with rocks of the Cretaceous series which apparently were more or less faulted and shattered by movements accompanying the intrusion of the igneous rocks which we now find breaking through them at various places and interbedded with them as sills at others. In the crevices and openings thus formed the mercury was deposited and is found in several forms, the principal one of which is cinnabar. It is found in the Eagle Ford shales, Buda limestones, Del Rio clays, Washita and Edwards limestones, and, while the exact manner of its occurrence may vary somewhat with the different classes of material in these beds, the ore persists in depth as far as mining has yet been carried.

The coal deposits of the Cretaceous are found in connection with the Taylor marls occurring in the Big Bend of the Rio Grande and in the vicinity of Eagle Pass. Coal has also been found in the vicinity of the Eagle mountains and near Fort Hancock some thirty miles east of El Paso, but, so far as now determined, these latter are not of economic importance.

The coal occurring in the San Carlos field and southeastern in the Chisos mountain region, although it may not occur in sufficient bodies nor of good enough quality to warrant its being mined for shipment as fuel for general use, will certainly, when this region is opened up as it should be, become of very considerable local value as fuel supply for the quicksilver ores, for steam uses, and for the generation of electric power.

The deposits around Eagle Pass are of greater value. We have here a bed of coal which, with one or more part-
The oil deposits of the Cretaceous occur at various horizons and are of great value.

In Burnet county the sandy limestone of the Paluxy is, in places, saturated with asphaltum derived in all probability from seepages from the underlying Bend shale. This occurrence and the wells drilled in the vicinity of South Bosque, each of which yields a few barrels of oil daily, suggest the possibility of similar occurrences of oil at other localities east of the Lampasas anticlinal when structural conditions are favorable.

In west Texas small quantities of asphaltum are found in connection with the Washita limestone, but, so far as is known, this series carries no workable oil deposits in this region.

The first oil found in the Cretaceous was in the Taylor marls at Corsicana and San Antonio, and the former has furnished a field for long-continued development and is still producing. It yields oil of two grades: one very heavy and asphaltic; the other, though also of asphaltic base, much lighter in gravity. The gas of the Mexia region is also found in the Taylor marls.

On the eastern line of the State, in Marion county, we find the western extension of the Caddo oil-field of Louisiana, which has produced such large amounts of oil. This oil
also occurs in the Taylor marls and Woodbine sands of the Cretaceous, and a proper study of structural conditions will probably result in the finding of other continuations of this field in other parts of eastern Texas. It is of a paraffin base and is of high gravity.

Still another occurrence of oil in the Cretaceous is found in the Cline asphalt-bed, where the highly fossiliferous limestone of the Anacacho is found strongly impregnated with a high-grade asphaltum.

The most productive beds are those connected with the limestone deposits, and the occurrence of the oil in these beds lends color to the theory that they were produced from the minute unicellular organisms of that time and deposited synchronously with the limestones with which they are now associated.

A very interesting occurrence, and at the same time one of very considerable commercial value, is that of the salt deposits associated with beds of the upper Cretaceous. These salines, as they are called, are found at various places in eastern Texas and Louisiana, generally as outliers from the main body of the formation, and surrounded, if not covered, by deposits of the Tertiary. Among the best known of them are Grand Saline in Van Zandt county, Brooks and Steen salines in Smith county, and the salines in Anderson county west of Palestine. The salt in these salines exists as deposits of pure rock-salt of dome shape. Borings at Grand Saline indicate a length of nearly a mile for the bed of salt, which has a thickness of over 200 feet. Similar salt-domes also occur in the Tertiary beds themselves in connection with the oil and sulphur. The way in which these accumulations were brought about is still a problem, but there is little doubt that they are all directly connected in some manner.
All of the salines named have produced salt at different times, and Grand Saline and Anderson saline have been steady producers for years.

While gypsum occurs in quantity in connection with the clays of the Cretaceous, it is usually in separated masses or individual crystals and fragments. In the Malone mountain, however, it occurs as a great body of gypsite and massive gypsum.

The gypsum in this locality seems to belong to two or three different horizons. The upper beds occur in connection with the Washita, while similar beds occur also in the series of rocks referred to the Glen Rose or Fredericksburg. This occurrence is without parallel in the Cretaceous of Texas, but a somewhat similar condition has been brought to light by recent oil-wells drilled on the Panuco river west of Tampico.

While the Cretaceous has added its full quota to our comfort and convenience by the materials of economic value preserved within its sediments, it has given us in addition a boon greater than all this in the belts of water-bearing sands which spread over so large a portion of the State, and which are not only the source of the beautiful creeks and rivers of central and southwestern Texas, but of innumerable artesian wells scattered over a far greater area.

The Trinity, Paluxy, and Woodbine sands are all to a greater or less extent water-bearing, and throughout a large portion of their productive area they yield water well adapted for all purposes.

To the east and south of the outcrop of these lower sands for a distance of 75 to 100 miles they yield a supply of water which flows from the wells in many places; and even when the surface has too great an elevation to permit this, as in the Edwards plateau, the water can easily be pumped to the
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surface and thus made available where all other supply is lacking.

This in itself is ample warrant for a very close study of the geology of the region, since in many places they form the only lasting and sufficient supply obtainable.

The minerals of the Tertiary include iron ores, gypsum, salt, sulphur, tripoli, and fullers' earth, together with such other important substances as lignites, petroleum, and natural gas.

The iron ores of east Texas are wide-spread in their occurrence, their quality is excellent, and the aggregate amount available for mining and shipment is possibly greater than that of any of the other States of the Union outside the Lake region. These deposits are on or near the surface, and the areas underlain by them, which were carefully mapped by the State Geological Survey, aggregate nearly 1000 square miles.

These ores are all connected with or derived from the Marine stage of the Eocene Tertiary. This stage is markedly ferruginous throughout its entire extent. It still carries in places large amounts of greensand which represent those portions of the original amount deposited in the sands and clays of this period which have escaped the oxidation, solution, and redeposition through which the vastly greater portion of this glauconitic material has been transformed into iron ores, ferruginous conglomerate, and sandstones.

The ores are of two general forms, called from their structure the nodular and the laminated. The former occurs usually embedded in sands in the form of nodules or boulders from a few inches to one or two feet in length. The laminated ores occur in thin laminae of dark brown or chestnut color, sometimes interstratified with similar laminae of bright yellow.
The deposits vary greatly in thickness, the laminated ores being more regular in deposition than the nodular, but both occur in workable quantities in many localities. The ores are limonites, or brown iron ores, and the contents of metallic iron are frequently over 50 per cent.

These ores have been worked for many years. Prior to the Civil War small bloomaries existed where the ores were smelted and iron utensils were manufactured. During the war the number of these increased, but most of them were shut down at its close. Later more modern furnaces were erected at Rusk, Jefferson, and elsewhere; but on account of the high cost of fuel, and with the coming in of strong outside competition by reason of better transportation facilities, these were closed down one by one until not a single one remains.

The ores, however, are now in process of development, and if plans which have been outlined in the press are carried out they will be carried to the Coast, where cheap fuel will meet them, and will there be smelted and manufactured; or they may be shipped from the Coast by water to northern points where furnaces exist and cheap fuel is at hand, until such time as conditions warrant the building of furnaces in Texas.

The quantity of the ore is so vast and its quality so good that these deposits will in due time be of great commercial advantage to the State.

The brown coal or lignite deposits are principally confined to two of the divisions of the Tertiary. The lower, from the prevalence of these deposits, has been termed the Lignitic; the upper is the Yegua clays. Lignite is also found in the Fayette sands and in the Marine beds, but in thinner and usually less important deposits.
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These brown coals do not occur in such continuous beds as we find in coals of the Carboniferous, but are usually in lenticular masses, some of which are of very considerable extent but nevertheless limited in comparison with older coal-beds. They were probably the results of deposition within local basins scattered over the Tertiary area, and with the shifting of these basins we find a corresponding change in the beds of brown coal. The beds have thicknesses of from a few inches to twenty feet, beds of six to twelve feet in thickness being not uncommon. Since the Tertiary belt stretches diagonally across the State from the Sabine to the Rio Grande and these brown coal-beds occur throughout its longitudinal extent, the total amount of coal available is very great. Owing to more favorable conditions of deposition, by far the greater amount of this coal lies east of the Colorado river, but the beds west of that stream are both numerous and of good thickness.

These brown coals carry a much larger percentage of moisture than do the older coals, and they have the quality of slacking when drying on exposure to the air. While this quality is a distinct disadvantage, they can be used satisfactorily as fuel.

Mines have been developed at various localities, and the annual production is now about equal to that of the Carboniferous coal.

During the progress of the State Geological Survey, extensive investigations were carried on in an effort to find ways of utilizing this abundant and cheap fuel supply. It was found that with proper arrangement of fire-boxes and draft it could be used advantageously in steam-making, both for steam-plants and locomotive fuel; and had not the discovery of oil given temporarily a cheaper and better fuel,
there is no doubt that the present development of the lignite deposits would have been much greater than it is. The use of oil as fuel has, however, only postponed the day of usefulness of the brown coal; for, with the exhaustion of the oil or its withdrawal from fuel uses, we shall be compelled to fall back on the lignite. The delay has really made for its better economic use, since it has made new methods available which add to its efficiency with corresponding decrease in cost.

It is probable that the near future will see it used both under stationary boilers and on locomotives as a powdered fuel sprayed into the fire-box in somewhat the same manner as oil is now sprayed. Its greater use, however, will be in the generation of electric power which will in time take the place of much that is done with steam. The adaptability of the lignites for this purpose has been fully proved by the government's experiments in the manufacture of producer gas from it. This producer gas, by means of gas-engines, can be made a source of electric power at a cost lower even than that of water-power plants. Since these deposits cross the entire State, electric-power plants located in the vicinity of the mines could use the coal as mined and transmit the power over its entire extent east of the Pecos at least. This, it seems to me, is our future hope for cheap fuel.

This discovery and development of the oil-pools of the Coastal strip have greatly aided the general development of the area in every way and added very materially to the wealth of the State.

The existence of indications of oil in the area was recognized half a century before the bringing in of the Spindletop gushers, and there was a small production in Nacogdoches county fifteen years before the Lucas well came in. This well, however, stimulated the search for oil in all likely
and many unlikely places and resulted in the discovery of many pools of greater or less extent and productivity.

All of this oil, so far as has been determined, occurs in the sands and shales of the Tertiary. Beginning with the Marine stage, we find that it furnishes the wells near Melrose, which have only a small production, and this is characteristic of all wells getting oil in these beds. While the Yegua has not as yet yielded any oil, it is the gas-bearing series of the Tertiary. Wells drilled into it in Washington and Fayette counties have given heavy flows of gas, as did the wells at Aguilares east of Laredo. There are doubtless many localities in the area underlain by these beds where gas-fields of economic value will be found when they are properly prospected.

The most of the oil that has been found in the Coastal area is in connection with the upper Tertiary. In a few wells fossils have been found that indicate the presence of deposits of Jackson age, but by far the greater number of wells in the gusher-fields strike their supply of oil in beds of the upper Miocene or Pliocene. This is true of Spindletop, Sour Lake, Saratoga, Batson, and Humble, and of the Louisiana fields as well. The oil-pools are of rather limited extent, usually less than 800 acres. They are each apparently located at the apex of a subterranean dome and are connected in some unexplained way with deposits of rock-salt, gypsum, and sulphur. The cause of this doming has not yet been determined; but as we learn more of the underground geology of the Coast country through the interpretation of the results obtained in drilling deep wells, we are more and more confronted with the fact that prior to the beginning of the era in which the Coast clays, which now present a surface so nearly level, were laid down, the preceding beds had been folded and eroded. Thus the floor on which the Coast clays
rest is very uneven, and it is highly probable that the forma-
tion of the domes was connected with the earth movements of the Pliocene.

The production of the oil-fields of the Coast has been enormous, and there is still a possibility, if not a strong probability, that other fields may yet be found in this region which will yield quantities of oil equal to many of those already exploited.

The mineral which occurs most abundantly in the Coast country is salt. It is preëminently the mineral of the domes and is usually found in them, whether oil and sulphur are present or absent. The beds vary in areal extent and are of such great thickness that no well has ever penetrated them far enough to find their lower limit. The rock-salt of these deposits is of very pure quality.

The prospecting for oil has brought to light many exten-
sive deposits of rock-salt in our Coast country. The most important of these as known at present occur at Dayton, Pierce Junction, Blue Ridge, and Damon's Mound. There are many other localities, for similar beds, some of them of great extent, have been found in nearly every oil-field; but these are of special value by reason of their suitability for actual development and because of being uncontaminated by oil. Their areas have been fairly well defined by drilling, and wells have penetrated them to depths ranging from 200 to 2100 feet. It is estimated that these deposits alone would furnish more than one billion tons of salt.

In connection with the superficial deposits of the lower Rio Grande country we find the important salt lakes, the Sal Vieja and the Sal del Rey. The Sal del Rey, which has been the source of salt supply for the lower country and northeastern Mexico for many years, is some five miles in circumference and has a depth of only three or four feet.
The bottom of this lake is solid rock-salt, and the water a very concentrated brine.

Sulphur also occurs in variable quantity in connection with the oil and salt of the different Coast fields. In some places it is found simply as crystals disseminated through the sands, at others in more massive form mingled with gypsum or inclosed in cavernous limestone. It occurs in commercially valuable deposits at several localities, but the only one of these as yet developed in Texas is at Freeport on the Brazos river, where the sulphur is mined by a process of pumping superheated steam into it and melting the sulphur, which is then pumped to the surface and becomes solid on cooling. These deposits are most favorably located for development and will be a prominent factor in the world's supply of sulphur for many years.

While gypsum occurs in the various Coastal fields in connection with the oil, it is not often in such form as makes it available for mining.

There are, however, in southwestern Texas deposits of pure gypsum which are of economic importance. The principal of these is the Loma Blanca, a few miles east of Falfurrias. This hill, which is 75 to 100 feet high, is composed of pure gypsum, and its crest shows an exposure of clear, transparent selenite which covers several acres and has been proved by drilling to have a thickness of 1000 feet.

This occurrence is not the only one in the region, and the relation of these mounds to the Sal del Rey and other salt deposits lying at no great distance south of it is a most interesting problem.

Throughout the Coastal plain from the Sabine to the Rio Grande there exists in connection with the sandy layers of the upper Tertiary a supply of artesian water that is secondary only to that contained in the sands of the Cretaceous.
The Geology of Texas

It furnishes the water supply for nearly all the Coastal cities, including Houston and Galveston, and yields great quantities of water for aid in irrigation and for farm and ranch supply.

The sands of the Eocene also furnish large supplies of water, and it is probable that the entire producing area of the Tertiary will equal that of the Cretaceous. Like the Cretaceous, some of the water obtained from the Tertiary is more or less mineralized, but the amount of pure water yielded by it is of immeasurable benefit.

Time forbids more than this hasty sketch of the various minerals and materials of economic importance which are found within the State, and many occurrences of local value cannot even be touched on. It is hoped, however, that what has been said of the geologic growth of our territory in its broader relations and individual conditions, of the great variety and wide-spread occurrence of mineral and other substances of economic value, and the evidence we have of the intimate relation of all these materials to this growth, will bring out the full force of the necessity for an accurate knowledge of the geology of the State as a basis for the work of the discovery and development of these resources as well as for the cultural results which grow out of the study of the subject.

EDWIN THEODORE DUMBLE.