tions, and how such relate to oil company and contract geophysical efforts. In view of Western Hemisphere reserve position, rising nationalism in foreign areas and in spite of current surpluses along with depressed product prices, a more favorable and stabler climate must be developed for the explorationist in order to keep petroleum competitive in the total energy market.

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February 10, 1964

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"The Geology and Economic Future of the Salt Deposits of Oklahoma"

Permian salt and associated evaporates within a 20,000-square-mile region in western Oklahoma and the Texas Panhandle are Leonardian and Guadalupean, and possibly Ochoan, in age. This report is concerned chiefly with the subsurface geology of the three principal evaporate sequences, each of which is 300 to 1,000 feet thick and consists mainly of rock salt and salty shale interbedded with anhydrite. These evaporite sequences contain all the rock salt known in Oklahoma. The evaporites occur with red clastic sediments in a sequence 4,000 feet thick, embracing all strata from the base of the Wellington formation to the top of the Dog Creek Shale. Four stratigraphic sections accompanying the report illustrate the distribution and facies relationships of these beds. The youngest evaporites of the region—relatively thin anhydrite beds in the Cloud Chief formation, of possible Ochoan age—are not considered herein.

The evaporites are classed in ascending order as Wellington, Cimarron, and Beckham. Wellington and Cimarron evaporite units known in the subsurface of Kansas are here extended and mapped into Oklahoma and the Texas Panhandle. The term "Beckham evaporites" is a new term that includes (ascending) the Flowerpot salt (new), Blaine anhydrite, and Yelton salt (new). Each evaporite sequence is widely distributed, occurring as eastward-thinning tongues or wedges within the framework of Permian clastic sediments. Together the evaporites have a maximum thickness of 2,500 feet. The evaporite strata, excluding clastics, consist of halite (about 80 percent), anhydrite, and thin beds of dolomite (less than 5 percent). No potassium salts were found or were indicated by investigations for the present study.

The oldest halite-anhydrite sequence in Oklahoma, called the Wellington evaporites, is of Leonardian age and normaly ranges in thickness from 1,000 to 1,300 feet. It is divided into a lower anhydrite-salt unit, a shale unit, and an upper anhydrite unit. The salt in the upper part of the lower unit is equivalent to the Hutchinson Salt of Kansas. Depth to the salt in the Wellingon ranges from 800 feet in northwest-central Oklahoma (Grant County) to 3,900 feet near Elk City in Beckham County. Over an area of approximately 16,500 square miles the average aggregate thickness of salt strata in the Wellington is 225 feet.

Above the Wellington are the Hennessey shales, which are overlain by the Cimarron evaporites. The Cimarron evaporites consist of lower and upper salt units separated by the Cimarron anhydrite and have a maximum thickness of 1,000 feet. The lower salt and Cimarron anhydrite are especially persistent, and the anhydrite is a valuable structural datum. Total thickness of Cimarron salt strata over 13,000 square miles of western Oklahoma is generally 500 feet, and the depth range is between 215 and 2,420 feet. The lower salt unit is noteworthy because it locally consists of massive salt more than 400 feet thick, and thus is probably the thickest salt in Oklahoma.

Red shales above the Cimarron are classed as Flowerpot-Hennessey. They are overlain by the Beckham evaporites (Guadalupean), the youngest salt-bearing strata of western Oklahoma and the eastern part of the Texas Panhandle. The middle unit of the Beckham sequence is the well-known Blaine anhydrite, 150 feet thick, which crops out extensively in western Oklahoma and occurs so persistently in subsurface that it is a valuable stratigraphic datum. Salt beds directly below and directly above the Blaine, respectively called Flowerpot and Yelton, have much less geographic distribution, yet each attains a thickness in excess of 250 feet. The Flowerpot salt has an average thickness of 200 feet and a maximum thickness of 625 feet (including salty shale). It occurs over more than 7,000 square miles of western Oklahoma and is found at depths as shallow as 30 feet in northern Oklahoma, and as deep as 1,655 feet in southwestern Oklahoma in the area north of the Wichita Mountains. The Yelton salt occurs chiefly in Beckham and Washita Counties, Oklahoma, and in Wheeler County, Texas, at depths of 390 to 1.285 feet. Much of the Yelton sequence is massive rock salt, reaching a maximum thickness of 287 feet in the eastern part of Beckham County.

Included in the report are maps showing distribution, thickness, and depth from surface of the principal salt beds.

As outlined by structural mapping at the base of the Blaine anhydrite and of the Wellington evaporites, the major structural feature of the region is the Anadarko syncline. It trends west and northwest across much of western Oklahoma into the Texas Panhandle, its axis following a line just north of the Wichita Mountains. Permian strata on the south limb dip as much as 250 feet per mile, whereas on the north limb they dip 9 to 40 feet, or an average of 20 feet, per mile.

With the exception of the Yelton salt, which occurs in the axial part of the syncline, the Permian evaporites bear no obvious relationship to major structure. Multiple rather than single salt basins were developed for any given sequence, and the maximum salt thickness for one stratigraphic unit does not coincide structurally or geographically with the maximum thicknesses of the other evaporites.

Salt reserves in western Oklahoma are estimated to be more than 21 million million (21,000,000,000,000) short tons. Although much of the salt is thick and nearly pure, the reserves are virtually unexploited. Within the area studied, a small amount of salt is produced from brine wells in the Upper Cimarron salt in Beckham County, and some of the salt beds are used for underground storage of liquefied petroleum gases. Four salt caverns are currently being used, one each in a salt bed of the Blaine anhydrite (Beckham County), in the Flowerpot salt (Beaver County), in the lower Cimarron salt (Beaver County), and in the Lower salt-anhydrite unit of the Wellington (Grant County). Total storage capacity of these facilities is nearly 250,000 barrels.

Future uses of the salt probably will include expanded production for livestock and human consumption, and for such chemical purposes as the production of chlorine, caustic soda, and soda ash. Additional underground storage facilities for liquefied petroleum gases are currently being made in Permian salt beds of Oklahoma. Similar caverns might be made for the underground storage of natural gas, or possibly for the storage of low-intensity radioactive waste materials. A knowledge of the distribution and thickness of salt beds also is useful in the interpretation of seismic data obtained in the exploration for petroleum.

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February 17, 1964

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"Geology and Geophysics of the Eastern Palo Duro (Hollis) Basin, Southwestern Oklahoma"

The discovery of Conley field, Hardeman County, Texas, in March of 1959 has renewed interest in the Eastern Palo Duro Basin of southwestern Oklahoma. This area, also known as the Hollis, Harmon, or Hardeman Basins, covers approximately 2,300,000 acres. It is bounded on the south by the Red River, on the east by the Waurika-Muenster Arch, on the north by the Wichita Mountains and on the west by the Texas Panhandle.

Geophysical activity in the basin started with a torsion balance survey in 1929 which resulted in the discovery of the Altus field. Since that time seismograph surveys have played a major part in the development of the basin. These surveys show a definite relationship between record quality and surface and near surface formations.

The outcrop pattern conveniently divides the basin into two distinct record quality areas. This division takes place along a N-S line roughly following the Salt Fork of the Red River. East of this line records in the Hennessey shale are good to excellent. West of the line the quality ranges from good to extremely poor in the Blaine gypsum and Dog Creek shale formations. On the latter formations record quality can be vastly improved by increased seisphone coverage and location of the charge in shale stringers. Use of the "VIBROSEIS" system resulted in data superior to that obtained from the conventional method.

Production in the basin is primarily governed by structure. In turn, the structural traps are influenced by two major orogenic movements – the Acadian at the end of Devonian time and the Wichita at the end of Morrowian time.

The basin has produced about 18 million barrels of oil from two major features in Tillman and Jackson Counties. These features are the Altus horst trend and the West Frederick – SE Frederick anticlinal trend. Anticlines at Altus, Tipton, West Frederick and SE Frederick, and a stratigraphic sand at Henderson account for 90% of the oil found along these trends. The anticlines are associated with major faults whose throws range from 500-1600′.

Development of Conley field has confirmed an anticline with 400′ of closure but so far has not established the presence of a major anticlinal trend or faulting.

While it is unlikely that structural trends comparable to that of Altus and West Frederick will be found by present or future seismic programs, it is concluded that there is ample room in the western portion of the basin for many more discoveries of the size and nature of Conley field.