Delaware Mountain sandstone. The Lower Castile formation is younger than the Capitan, which it overlaps.

In the vicinity of Carlsbad the Rustler rests directly on the Carlsbad limestone. Evidence of the Pleistocene age of the Pierce Canyon beds is presented.

13. GEORGE A. KROENLEIN, geologist, Lovington, New Mexico: Salt, Potash, and Anhydrite in the Castile Formation of Southeast New Mexico.

Continual accumulation of concentrated saline water beneath the surface water in the Delaware basin raised the level of the highly concentrated water to the point where it caused two epoch-making events to occur in Upper Permian history. First, it stopped Capitan reef building and associated petroleum deposition. Second, it diminished the inflow of marine water and started deposition of evaporites in the Delaware basin. This point marks the close of Capitan time and the beginning of Castile time.

Subsurface study of the lower Castile formation discloses many hundred feet of depositional relief on the basin floor. This condition is responsible for unsuccessful attempts to run a structural correlation across the Delaware Basin on the base of the upper Castile (Main Salt).

At present, potash is the mineral with greatest economic importance in the Castile formation. Two mines are producing from one of the finest potash deposits in the world.

Two subsurface cross sections show many interesting features about the deposition and occurrence of evaporites.

14. PHILIP B. KING, associate geologist, Geological Survey, U. S. Department of Interior, Washington, D. C.: Relation of Permian Sedimentation to Tectonics in Guadalupe Mountain Region.

This paper is based on observations in the areas of Permian outcrop of northern trans-Pecos Texas, and especially in the Guadalupe Mountains and the Sierra Diablo. The two regions are mutually supplementary in that the first exposes the higher Permian and the second the Lower Permian and pre-Permian rocks.

The stratigraphy of the Permian series is complex, for it is characterized by great and abrupt changes in faunal and lithologic facies and in thickness of beds. The most striking features are limestone reefs, of which one of the largest is formed by the Capitan limestone. These are thicker and less elastic than adjacent contemporaneous deposits. Other less striking but no less significant changes are common, including lateral gradation of limestone into clastic rocks or evaporites, and of one variety of limestone into another.

These complex relations were produced by variations from place to place of physical-chemical and ecological environments at the inner end of an embayment of the sea. The variations resulted from many causes, the relative importance of which is not easy to evaluate. Some barriers, such as the reef masses, produced largely by sedimentation, restricted the inwash of clastic sediments and caused differences in depth and salinity on opposing sides. Similar effects have been caused by buried hills that are erosional relics of pre-Permian disturbances. The author believes, however, that some structural features arising on the sea floor during Permian sedimentation were also the direct cause of variations in environment and that they were an indirect cause of variations by their effect on the placing of the reefs and hills. The fundamental control of the complex Permian deposits thus appears to be tectonic.

Tectonic control has been imparted in a broad way by differences in subsidence in different areas and, on a smaller scale, by monoclinal flexures that were in movement during the time of Permian deposition.

Control by differential subsidence is illustrated by the relation of the Permian rocks of the Delaware basin to those in adjacent areas. The northwest corner of the former basin extends into the now upraised mountain area, and was bordered on the west by an area that may be termed the Diablo platform, a part of which forms the present Sierra Diablo. The platform has a substructure of deformed and deeply eroded pre-Permian Paleozoic and of pre-Paleozoic rocks, but the basin may have been a region of little disturbance during pre-Permian time, for the few deep wells that have gone beneath the Permian in the basin show that it rests on little disturbed later Pennsylvanian rocks.

That the basin was a region of greater subsidence than the platform during early Permian time is suggested by the thinning of the Bone Spring and other early Permian formations from the basin toward the platform. In later Permian time, greater subsidence of the basin may have continued, but, if so, it was now complicated by other factors. The upper Delaware Mountain deposits of the basin are thinner than equivalent beds outside the basin. Evidence indicates that they were deposited in water of great depth (1,000 feet or more). Since at this time the basin was encircled by limestone reef barriers, the inwash of clastics from outside was slow, perhaps too slow to keep pace with sinking, thus allowing the bottom to be deepened.

Control of Permian sedimentation by tectonic features is illustrated on a smaller scale by the relations near monoclinal flexures, such as the Bone Spring flexure in the Guadalupe Mountains and the Victorio flexure (named for Victorio Peak, south of which it extends) in the Sierra Diablo. On each, Permian rocks are bent down, away from the marginal area and toward the Delaware basin area, the total displacement amounting to 1,000 feet or more. The Bone Spring flexure trends north-northeast, whereas the Victorio flexure and some similar features of the Sierra Diablo trend west-northwest. Both run across the more northerly and younger Cordilleran fault and fold trends, and in the Guadalupe Mountains no faults or joints trend parallel with the Bone Spring flexure. In the Sierra Diablo, however, the Victorio flexure is paralleled by the dominant joint set of the area and by a system of faults which moved in Cenozoic and several older times. As shown by exposures, the Victorio flexure involves not only the Permian but also the pre-Permian rocks. Along it, in places, the pre-Permian rocks rise into buried hills.

The Victorio flexure is beveled by and is older than Cretaceous rocks. Movement on it during Bone Spring time is suggested by the occurrence on it in that formation of intraformational pebble conglomerates of considerable thickness. Movement on the Bone Spring flexure during Permian time is suggested by the coarse conglomerate which locally rests on the Bone Spring limestone and forms the base of the Delaware Mountain formation, and by the overlapping out of 1,000 feet of Delaware Mountain strata against the surface of the Bone Spring limestone as upraised along the flexure. The two flexures and other related features seem to have been narrow zones of interplay between the more rapidly subsiding Delaware basin area and the less rapidly subsiding platform areas.

The region of the flexures is marked by great changes in facies in the Permian rocks. The facies of the Delaware basin (black shaly limestone in the Bone Spring, sandstone in the Delaware Mountain formation) gives place up the flexures to thick bedded limestones, and to massive reefs such as the Capitan limestone. It is believed that movements on the flexures aided in creating physical-chemical and ecological conditions on the sea bottom which were more favorable for lime deposition on the upper part of the flexures than the lower. Such conditions include shallower, warmer, and more agitated water, in which the solubility of calcium carbonate was reduced, and in which reef-dwelling organisms could thrive.

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15. E. RUSSELL LLOYD, consulting geologist, Midland: Theory of Reef Barriers.

Studies of the organic reefs of the Permian basin and their relationships to rocks of contemporaneous age show a pronounced threefold facies, which the writer proposes to call the reef facies, the lagoonal facies and the "pontic" facies, the latter being a new name proposed for the facies group of which the Delaware Mountain formation, the black shales of the Black Shale basin, the Bone Spring formation of the Delaware basin, and the type Leonard formation (not including the Hess facies) of the Glass Mountains are good examples. The reefs form natural barriers, separating the rocks of pontic facies from the sharply contrasted lagoonal facies which, in the Permian basin, consist of dolomitic limestones grading laterally into anhydrite and rock salt.

By analogy, the reef barriers may serve as adequate explanation of the origin of all thick salt and anhydrite (or gypsum) deposits such as the New York salt and gypsum deposits, the thick salt deposits of western Colorado, the Stassfurt salt deposits of Germany, and many others. In each case we should expect a lateral gradation from the salt and gypsum (or anhydrite) into dolomitic limestone.

Likewise, reef barriers may be the explanation for such contrasts as the early Paleozoic Ouachita facies (pontic facies) of the Ouachita Mountains with the contemporaneous, dominantly limestone facies (lagoonal) of the Arbuckle Mountains. In like manner, the Ordovician Marathon facies (pontic) may be separated by a reef barrier from the contemporaneous foreland (lagoonal) facies.

Similarly, a reef barrier rather than a permanent land barrier may account for the contrast between deposits of the Chazy trough (lagoonal facies) and the Levis trough (pontic facies) of the Appalachian geosyncline.

16. LINCOLN R. PAGE, associate professor, Department of Geology, University of Colorado, Boulder, Colorado, and JOHN EMERY ADAMS, geologist, Standard Oil Company of Texas, Midland: Stratigraphy, Eastern Midland Basin, Texas.

The thick series of Red-beds along the eastern edge of the Southern Permian basin is divided into groups and formations that can be recognized both on the outcrops and in the subsurface. Gradations between near-shore, marine and restricted sea deposits are recognized and described, and unconformities in the section are traced out into the basin. The Triassic-Permian boundary line is redefined as occurring between the top of the newly defined Dewey Lake Red-beds and the base of the overlying Tecovas silts.