

The Oquirrh basin contains Pennsylvanian and Early Permian sedimentary rocks as much as 26,000 feet thick; the area of maximum sedimentation was in west-central Utah. Three principal units are recognized: a lower unit of cyclically bedded bioclastic limestone and sandy limestone, a middle unit of interbedded limestone and quartzite, and an upper unit of quartzite. The lower and middle units were mostly deposited in an offshore shallow water environment; the upper unit in offshore moderately deep water; these grade laterally both eastward and westward into shallow nearshore facies.

The Middle Permian Phosphoria basin was partly coextensive with the Oquirrh basin, but the area of maximum sedimentation was in northeastern Nevada and southern Idaho, where locally 3,500 feet of shale, cherty shale, chert, dolomite, and limestone accumulated. This facies was deposited in an offshore deep-water environment, favoring formation of thick sponge-spicule chert and cherty shale units; these grade southward and eastward into carbonates and shales that were deposited in shallow nearshore environment.

In Cretaceous time the Paleozoic and early Mesozoic rocks of northeastern Nevada and western Utah moved eastward on great thrust plates that extended from southern Utah into Idaho. Movement took place on the Willard-Charleston-Nebo thrust belt in the Wasatch Mountains. Westward continuations of these thrusts crop out in northwestern Utah and eastern Nevada. Imbricate thrusts and tear faults within the upper plate have resulted in complex distribution of late Paleozoic facies.

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#### INDUSTRIAL BASIS OF STRATIGRAPHICAL GEOLOGY

An unprecedented need for a new source of mechanical power in 18th century England, capable of functioning at rates beyond horse-power capacity, was met by coal-fuelled atmospheric engines. They propelled the country into an industrial revolution. Economic force exerted by big population changes greatly altered husbandry, industry, and transportation. Acts of Parliament relating to surveying and draining of lands, mines, and construction of roads and canals multiplied six-fold in the second half of the century.

A land drainer and mineral surveyor, in the course of canal-building in the east Somersetshire coal-field, discovered and then exploited the stratigraphical principle of natural order and regularity in fossil occurrence—each Class assigned to its peculiar Stratum (William Smith, 1796). He had employed the prime stratigraphical principle of order and regularity among the strata (drawing on colliers' lore and probably a published record), during underground surveys of the mines (1791-93). Seventy-two years earlier a wide-ranging account of the same coal-field had illustrated a definitive succession, strike, dip, subcrop, outcrop, concealed faulting and unconformity (John Strachey, 1719), and established by direct measurement underground that "the *Strata* lie shelving and regular, and observe a regular course." It codified the colliers' tradition. A century later this knowledge, unchanged in principle but enlarged in scope, achieved generality in the academic realm.

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SEDIMENTARY BASINS OF CENTRAL AND SOUTHWESTERN NEW MEXICO

Major sedimentary basins in this, the eastern part of the Basin and Range province, are the Orogrande and Pedregosa basins of Mississippian, Pennsylvanian, and

Wolfcampian age, the San Mateo-Lucero and Estancia basins of Pennsylvanian age, the Carrizozo and Quemado-Cuchillo (Foster, 1957) evaporite basins of Leonardian age, the Early Cretaceous basin near the Hatchet Mountains, and the continental basins of volcanic piles of Late Cretaceous age near Elephant Butte and Steeple Rock. Numerous Cenozoic intermontane graben basins dot the region, with the southern part of a long north-south string of interconnected grabens now followed by the Rio Grande and called the Rio Grande structural depression. Sediments filling the Cenozoic basins are mainly of Late Miocene, Pliocene, and Pleistocene in age.

Pre-Mississippian Paleozoic rocks remain only south of about 33°45' N. Lat. The basal Paleozoic unit, the Cambrian-Ordovician Bliss Sandstone, thickens positionally southward and southwestward. The Early Ordovician El Paso Limestone thins northward due to intra-Ordovician erosion whereas the Middle and Late Ordovician Montoya Dolomite is relatively uniform in thickness where overlain by Silurian rocks. The Silurian Fusselman Dolomite thins northward partly due to erosion during Late Silurian and Early Devonian time. The Devonian shaly strata are relatively uniform in thickness, although marking the first large scale influx of clay and silt; as with all older Paleozoic rocks they appear to have been deposited in shallow epicontinental seas.

The Pedregosa basin was autogeosynclinal, receiving thick deposits of Middle Mississippian crinoidal limestones, Late Mississippian arenaceous calcarenites, Pennsylvanian limestones, and Wolfcampian interbeds of limestone, black shale, and redbeds. The Orogrande basin began as a poorly defined autogeosyncline in which siliceous Middle Mississippian limestones and Late Mississippian arenaceous calcarenites were deposited, then became zeugogeosynclinal during Late Pennsylvanian time as detritus was swept westward from the Pedernal landmass, and during Wolfcampian time was filled by limestones and shales that grade northward into redbeds. The Estancia basin was a small Pennsylvanian zeugogeosyncline, and the San Mateo-Lucero basins were autogeosynclines connecting the Pennsylvanian seas northward toward the San Juan and Paradox basins.

19. JOHN EMERY ADAMS, Consultant, Midland, Texas  
STRATIGRAPHIC-TECTONIC DEVELOPMENT OF DELAWARE BASIN

The Delaware basin of west Texas and southeast New Mexico is the most negative structural unit of the southern Permian basin. It occupies an upper Paleozoic intermontane trough between the Central Basin Platform Mountains and the Ancestral Rockies. Before the development of these ranges, this area formed part of the broad Tabosa sag which accumulated shelf deposits from Lower Ordovician through Mississippian. These sediments consisted largely of carbonates and shallow water shales. The Delaware basin, as a structural and stratigraphic unit, began developing in Early Pennsylvanian. Extensive subsidence coupled with compressive faulting converted the axial portion of the Tabosa sag into the Central Basin Platform Mountains and raised the Diablo arch to the west. An east dipping half graben, the Delaware basin, developed between these uplifts. Water depths in the southern and eastern portions of this basin probably exceeded 2,000 feet throughout the Pennsylvanian. The deep areas are characterized by starved shale sections. Pennsylvanian shelf limestones cover the shallows along the north and northwest margins. Permian tectonism deepened the basin and elevated the marginal mountains. Fault displacements