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Salt Diapirism in Central Utah

In central Utah, many complex structures in the transition zone between the Colorado Plateau Province and the Great Basin can be explained by salt diapirism. Flowage of rock salt (halite) in the Arapien Shale (Middle Jurassic) has forced up the enveloping mudstones, which in turn have bowed up younger consolidated strata to form elongate, linear diapiric folds, fan-shaped in cross section. Removal of salt, by extrusion, solution, or lateral flowage, has resulted in partial destruction of these folds, either by collapse along faults or by general subsidence. Field evidence suggests that these diapiric folds grew and failed repeatedly, presumably as a result of sporadic, rapid, upward movements of the salt and its subsequent removal. These surges were separated by longer periods of much slower upwelling of the salt. Continuous, nearly imperceptible upwelling of the salt after collapse and erosion of each fold is suggested by sedimentary thinning near the flanks of the diapiric folds. The salt has been moving probably since it was deposited; it is probably moving today. As a result of this episodic diapirism, younger daughter folds occupy the same structural zones as the older parental folds. At least three diapiric episodes are reflected in the country rocks.

Although autonomous isostatic movement of the salt (halokinesis) may explain some aspects in the development of the diapiric folds, external tectonic stresses (halotectonism) seem a more reasonable explanation for the uniform distribution and the unusual length (as much as 125 km, 75 mi) and straightness of the folds. Movement along deep-seated fundamental normal faults in the pre-salt rocks provides a plausible mechanism for controlling the timing and location of the folds.

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Utility of Microfossils in Rocky Mountain Exploration

Prior to 1960, exploration geologists in the Rocky Mountain area primarily used lithology, E-logs, geophysics, and a few microfossil groups (fusulinids, invertebrates) for stratigraphic correlations. From 1960 to about 1968, these exploration geologists added several additional groups of microfossils (spores, pollen, and foraminifers) to their tools for correlation. During the past 15 yrs, there has been an "explosion" in the scientific study of icrofossils ranging in age from Cambrian to Holocene.

CENOZOIC	PLANKTONIC	BENTHIC	MARINE	NON-MARINE	AGE-DATING	PALEOENVIRONMENT
Diatoms, freshwater	●	●		●	●	●
Ostracods		●	●	●	●	●
Micromollusks		●	●	●	●	●
Palynology						
Angiosperm pollen	●			●	●	
Gymnosperm pollen	●			●	●	●
Fungal spores	●			●	●	●
Dinoflagellates	●		●		●	
Spores, lower plants	●			●	●	●
MESOZOIC						
Radiolarians	●		●		●	
Calcareous nannofossils	●		●		●	
Foraminifers						
Planktonic	●		●		●	
Benthic		●	●		●	●
Larger		●	●		●	●
Palynology						
Angiosperm pollen	●			●	●	●
Gymnosperm pollen	●			●	●	●
Dinoflagellates	●		●		●	
Spores, lower plants	●			●	●	●
Conodonts	●		●		●	
LATE PALEOZOIC						
Radiolarians	●		●		●	
Foraminifers						
Fusulinids		●	●		●	●
Endothyrids		●	●		●	●
Palynology						
Gymnosperm pollen	●			●	●	●
Spores, lower plants	●			●	●	●
Acritarchs	●		●		●	
Calcareous algae		●	●		●	●
Conodonts	●		●		●	
EARLY PALEOZOIC						
Palynology						
Acritarchs	●		●		●	
Chitinozoans	●	●	●		●	●
Calcareous algae		●	●		●	●
Conodonts	●		●		●	
Graptolites	●	●	●		●	●
Invertebrate shells		●	●		●	●
EO-CAMBRIAN						
Bacterial-Spores	●		●	●	●	●

Currently, oil finders are integrating the age-dates and paleoenvironmental information obtained from analyzing 20 different groups of microfossils with the stratigraphy, sedimentology, structure, and geophysical data to create a synergistic exploration program. The addition of micropaleontology and paleoenvironmental data into an exploration program has helped managers make better management decisions, save millions of dollars for the company, and find economical pools of hydrocarbons. The following chart will give the exploration geologist an appreciation for the number of groups of microfossils presently available and how they are used to interpret the age and paleoenvironment to make oil finding more cost effective.

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Geology of North End of East Pioneer Mountains, Beaverhead County, Montana

The north end of the Pioneer Mountains is underlain by the following rocks: lower Proterozoic gneiss and amphibolite; middle proterozoic clastic rocks of the Missoula Group (Mount Shields Formation?); basal Cambrian clastic unit; Cambrian-Devonian-Carboniferous shelf sequence; Permian Phosphoria Formation; and Lower Triassic Dinwoody Formation. Jurassic rocks are missing. The Lower Cretaceous Kootenai Formation is of lagoonal to fluviatile facies, overlain by a thick (≈ 2 km, 1 mi) section of fluviatile Colorado Group. An upper member of the Colorado Group has yielded a Campanian-to-Maestrichtian pollen flora. The sedimentary rocks are cut by calc-alkalic plutonic rocks (80 to 65 m.y.B.P.), the oldest of which are synchronous with upper Colorado sedimentation. The youngest pre-Quaternary rocks are Eocene and Oligocene calc-alkalic lavas and Oligocene pumiceous tuff. The Missoula Group is entirely in thrust sheets that postdate the Colorado, so the thrusting is no older than Campanian, but the thrusts are cut by 72 to 74 m.y.B.P. plutons. The Johnson thrust of Fraser and Waldrop, on the 1972 U.S. Geological Survey Geologic Quadrangle Map 988, is part of this thrust system. A klippe of Missoula Group on Morrison Hill is an erosional remnant, but most of the overthrust rocks are west of the Wise River valley and probably overlie Phanerozoic strata.

In addition to the thrust sheets, two families of high-angle faults dominate. One family trends west-northwest and displacements along these faults can be measured in kilometers. The Johnson thrust is interpreted to have been displaced by a sinistral fault of this system along the straight valley of Big Hole River between Seymour Creek and Dewey. The eastward projection of the mountain front at Maiden Rock, just south of Divide, resulted from block displacement along two strands of this fault. This particular fault is of major significance because it marks an abrupt jump in the initial strontium ratios of intrusive rocks, from values typical of the Boulder batholith (0.706 to 0.709) to those of the Pioneer batholith (0.711 to 0.716), indicating that different crustal blocks were juxtaposed. The second family of high-angle faults trends north-northeast. Wise River valley is interpreted to be a graben in this system. One important fault in the system is the Fourth of July fault, with downdrop (to west) of several kilometers; the fault may be continuous with the Comet Mountain fault. The west-northwest fault system began at least before the Eocene lava flows, but complex field relations between the two high-angle fault systems indicate their growth must have overlapped in age, possibly through the late Tertiary.