RMS-SEPM Luncheon Talk, December 1st, 2015

Subsurface and surface stratigraphic evidence for surface extrusions of Pennsylvanian Paradox salt beginning in the Early Permian and still happening, Paradox Basin, SE Utah and SW Colorado

Speaker: Donald Rasmussen, PhD

Paradox Basin Data

1450 Kay Street, Longmont, CO 80501-2427

303 682 2615 (office)

ABSTRACT: Regional tectonism in the Ancestral Rocky Mountains, beginning in the Pennsylvanian, ultimately initiated and led to deformation and diapirism of the autochthonous salt-bearing strata of the Paradox Basin and the subsequent development of a regional unconformity in the Early Permian that breached the diapirs and allowed the first extrusion of subaerial salt fountains and namakiers (salt glaciers). Namakiers in the Deep Fold and Fault Belt of the Paradox Basin in southeastern Utah and southwestern Colorado first appeared after salt walls and diapirs formed during the Pennsylvanian Desmoinesian through the Permian Wolfcampian (Moscovian through Artinskian), and during and after initiation of a regional erosional event in the Permian Leonardian (Kungurian). Only after the overburden of a diapir was removed at the surface was Pennsylvanian salt and associated strata in the diapir forced upward as an extrusive dome (salt fountain) into the breach and then, by gravity collapse, away from the resulting dome of extruded salt as a namakier. Namakiers are recognized in the subsurface of the Paradox Basin on seismic and well logs, and borehole samples and cores and local surface exposures contain stratum and rock fragments from the extruded salt and associated strata, which have distinct "out-of-the-ordinary" lithologies with respect to their host stratigraphic formations. Preservation of namakiers within fluvial and eolian strata in the Paradox Basin was perhaps due to the respective arid climate and rapid burial in the adjacent sinking minibasins. The Paradox Basin namakiers have dimensions and compositions very similar to Neogene and active namakiers in the Iranian Zagros Fold Belt.

Multiple namakiers first flowed out upon the Early Permian Leonardian unconformity and were coeval with the deposition of the Leonardian Organ Rock Formation redbeds on the northeast flank of the Gypsum Valley Diapir, and subsurface data indicate other extrusive domes and namakiers may have existed at the same time on the Paradox Valley, Castle Valley and Salt Valley diapirs. Extrusion of salt likely continued on some of the diapirs during deposition of the Leonardian White Rim Sandstone, and during the Permian Guadalupian and Ochoan (evidence removed by erosion). Triassic namakiers first flowed out upon the Early Triassic unconformity and were coeval with Moenkopi Formation redbeds during the Induan, Olenekian and Anisian. Moenkopi namakiers are in the subsurface on the Pine Ridge, Moab Valley and Salt Valley diapirs, and outcrop data suggest extrusive domes and namakiers may have existed at the same time on the Castle Valley, Onion Creek, Sinbad Valley and Paradox Valley diapirs. Extrusion of salt continued in the Paradox Basin during the Late Triassic, Jurassic and Early Cretaceous as seen in the subsurface on the Salt Valley diapir.

Starting in the Late Jurassic or Early Cretaceous, all of the diapirs and other salt structures in the Paradox Basin at that time were buried with the overburden thickness reaching several thousands of feet (1.6 km

or more) by the end of the Cretaceous. Burial continued into the Paleogene (until ca. 35 Ma), about 5 million years after the Laramide Orogeny (ca. 80-40 Ma) had ended. During the Laramide Orogeny, there was regional west-east shortening (compression) that folded all of the diapirs and anticlines. The Laramide event was important because the salt in the diapirs and other salt structures freely responded to the lateral shortening, and shortening accounts for much of their present structural shapes at and near the surface. Widespread incision seen in the Rocky Mountains and Colorado Plateau during the Neogene exhumed many of the buried diapirs in the Paradox Basin. As the crest of each of the buried diapirs was uncovered during the Neogene, there apparently was an extrusion of the re-pressurized diapir rocks into the breach, the formation of a topographic dome of extruded diapir rocks and perhaps even a namakier, followed by slow dissolution and erosion of the extruded diapir rocks and any namakiers. The extrusions may have been strong enough to widen the breach and hasten the exhumation of each of the diapirs. Renewed lateral convergence of the diapir walls would have pushed additional salt-bearing diapir rocks into the breach. Continued erosion of the diapirs during the Neogene would have allowed more extrusion of diapir rocks, while the wetter climate during the Pleistocene would have caused increased erosion, dissolution and subsequent collapse of the roof rocks. As very large blocks of roof rocks collapsed into the breached diapirs, some would founder deep into the diapir rocks, thereby causing additional diapir rock to be extruded elsewhere in the breach as the collapsing blocks sank or tipped into the diapir. This process apparently continues today, as seen in the diapir badlands (extruded diapir rocks) adjacent to foundering fault blocks in some of the breached diapirs.

Speaker Biography:

B.A and M.A in geology at University of Montana, and Ph.D. in geology at University of Kansas.

Experience: Geological assistant to USGS mapping coal in eastern Montana and western North Dakota; exploration/development geologist with Pan American Petroleum Corporation in New Orleans; exploration geologist with Amoco Production Company and Davis Oil Company in Denver; and geological consultant, database vendor (Paradox Basin Data), and exploration geologist (Plateau Exploration) in Denver/Longmont.

Interests: Geology and paleontology of Cenozoic of western Montana; paleontology, stratigraphy and salt tectonics of the Paradox Basin and Four Corners region; and fossil mammals and dinosaurs of Montana. Currently active in consulting, field work, field trips and publications, and fly fishing whenever I can.

[RMS-SEPM Main Page]

[RMS-SEPM Luncheon Page]

[RMS-SEPM Luncheon Abstract Archive]