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Sedimentary Processes and Deposits of Saline Lakes, Saline Pans, and Playas in Early Mesozoic Rocks of Subtropical Pangea

Joseph P. Smoot
U.S. Geological Survey, M.S. 926A, National Center, Reston, VA 20192 U.S.A.

The early Mesozoic sedimentary rocks of the Pangean rift basins in Morocco and eastern North America accumulated in continental settings for over 35 million years. During this extended time span, many of the basins experienced periods of aridity resulting in the formation of saline or desert facies. Comparisons of fabrics in the early Mesozoic rocks to modern environments provide the building blocks to reconstruct the geometry of basin facies and predict the distribution of lithologies in the subsurface. By understanding the processes that produce assemblages of sedimentary fabrics, we can reconstruct the distribution of environments that may have no direct analog in the modern world.

Four major lacustrine desert facies are found in the early Mesozoic of the study area: Perennial saline lakes, saline pans, saline mudflats, and dry playa mudflats. Perennial saline lakes may accumulate hundreds of meters of sediment without reaching supersaturation with evaporite minerals. The controls on include the chemistry of the inflow waters, the depth of the lake, and the residence time of water within the basin.
Evaporite mineral precipitation includes cumulus crystals formed at the water-air interface, crusts formed at the sediment-water interface, and intrasediment crystals formed from brines sinking into the sediments. Crystals formed in perennial lakes are often reworked by waves or turbidites, particularly in shallow lakes. Saline pans are ephemeral lakes in which evaporite crusts develop during wet stages that are disrupted by efflorescent crusts during dry stages and partially dissolved during intermittent transgressions. The evaporate chemistry is controlled by the dissolution of efflorescent crusts in a process called chemical focusing. Sinking brines form intrasediment crystals beneath the surface. Saline mudflats are subaerial plains with groundwater brines near the sediment surface. Evaporation of pore water causes minerals to form within the sediment. In general, the largest crystals form in the wettest areas and smaller crystals form in areas that are only intermittently wet. Efflorescent crusts form at the sediment-air interface by the complete evaporation of pore water. Salt crystals and brine spray may be blown into areas with deeper groundwater tables, even in different basins. In these situations, the solutes may be cycled downward into the sediment by rainfall then concentrated by evaporation into intrasediment evaporites or efflorescent salt crusts. Dry mudflats are areas with deep groundwater tables. Saline minerals only form if they are introduced by the wind.
Sedimentation by sheet-flooding or ponding is punctuated by prolonged periods of desiccation. A complex array of crosscutting mudcracks act as sediment traps and air-filled vesicles commonly develop during flooding stages.

Sedimentary features produced in these different settings include: 1) Perennial Saline Lakes, laminated to thin-bedded mudstones with laminae consisting of fine evaporite crystals or beds of crystals with mudstone or carbonate partings, crystal beds in which crystals are subhedral to rounded and distributed into lenticular beds or graded beds, crystals with long axes vertically or radially oriented to the bedding plane and crystal terminations preserved, irregular bedding thicknesses with angular boundaries and projections, euhedral crystals randomly distributed in mudstone with upward-coarsening successions; 2) Saline Pans, flat-beds of evaporate crystals with long axes vertically or radially oriented to mudstone or carbonate bedding planes, crystal terminations are planed off and vertical solution voids are common, randomly distributed euhedral crystals in partings between crystal layers show no size distribution; 3) Saline mudflats, mudstones or carbonates contain randomly distributed euhedral crystals that may produce upward-fining sequences to more anhedral crystals that are restricted to cracks or lenses, massive mudstones with irregular patches of silt or sand, massive mudstones comprised of poorly sorted rounded mud intraclasts that fill crack patterns or surround angular mudstone fragments; 4) Dry mudflat, massive mudstone with abundant ovate to flattened cement-filled voids (vesicles) and irregular sinuous to jagged cracks which may be partially filled with cement, laminated to thin-bedded mudstone with abundant mudstone-filled cracks that are filled with vesicles - evaporite soils may form in areas with fresh groundwater if the upper areas are dry enough – and plants may grow at the surface while rain reworks solutes downward to produce an upward-coarsening crystal profile.

Outcrops of the Argana basin in Morocco and the Fundy basin in Nova Scotia show abundant evidence of saline mudflats that were covered with halite efflorescent crusts. Subsurface equivalents probably contain perennial saline lake deposits of mixed halite and gypsum and saline pan deposits dominated by halite. The Newark basin in the eastern U.S. contains a variety of deposits including perennial saline lakes with calcite pseudomorphs after possible sodium carbonates, saline mudflats with upward-fining crystal sequences and fabrics indicating powdery efflorescent salt crusts. There is no evidence of saline pan deposits equivalent to these deposits. Dry playa mudflats dominated by vesicular fabrics produce continuous beds in the central basin indicating conditions with deep groundwater tables. Root-disrupted mudstones with gypsum soil features indicate wetter conditions that support surface vegetation but dry enough for windblown solutes to be preserved in the upper soil profile.