Thermal effects of salt and brines in sedimentary basins

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The thermal conductivity of salt is up to four times greater than other sedimentary rocks; thus salt diapirs funnel geothermal heat and cause a high-temperature anomaly in the basinal sediments above. Depending on the shape of the salt body and its depth, the surface heat flow over the salt can be 2 to 3 times greater than away from the salt, and thus have drastic effects on hydrocarbon maturation; deeply rooted diapirs cause the

greatest thermal disturbance. In addition to heat conduction, advection of warm fluids (brines, oil, and gas) produces highly localized heat anomalies on top of diapirs. Long distance fluid movement in the basin may be driven by hydraulic gradients due to overpressures under the relatively impermeable salt, particularly during times of high sedimentation, dehydration of gypsum to anhydrite, or in zones of tectonic compression; mineralized veins and brecciated systems may form, aided by hydrofracturing. Later on in the basin history, large scale circulation of heavy brines (with salt dissolved from evaporites) may be driven to the surface by hydrostatic forces from surrounding highlands. Localized heat such as that provided by salt diapirs can drive convective flow and contribute to the formation of salt springs and pools. The above processes have the potential of contaminating freshwater resources, yet diaper- related geothermal anomalies may provide renewable energy through the use of heat exchangers.

In the Maritimes Basin, a large number of (100°–200°C hydrothermal) metallic mineral deposits were formed in sub-evaporite environments by maximum burial at ca. 300 Ma. Salt is being mined underground at Mines Seleine, Magdalen Islands, Quebec, where Lower Carboniferous salt of the Windsor Group has diapirically risen to the surface from a depth of ca. 8 km. Apatite fission track data indicate that the basin was inverted and rocks now at surface were cooled below ca. 100°C during the Triassic-Jurassic Atlantic margin break-up, whereas apatite within the salt mine yields Cretaceous apparent ages; the temperature-sensitive fission-track lengths have been significantly shortened (equivalent to >3 km depth in a well). Time-temperature modelling of the data requires re-burial of the salt structure in post Early Cretaceous times and heating of the diapir to higher temperatures than the regional background, confirming the focused thermal effects of the salt diapir. Salt springs are common in many diapir areas in Atlantic Canada.

In Axel Heiberg Island, part of the Sverdrup Basin, Nunavut, Upper Carboniferous evaporites have risen to the surface from a depth of ca. 8 km and intrude post-glacial sediments. Mineralized breccias and veins occur in many near-salt structures largely developed during Eocene Eurekan compression (ca. 60–50 Ma). Apatite fission track data on surface samples along a >80 km transect demonstrate that whereas the region was exhumed and cooled to ca. 100°C during the Eocene basin inversion, data from an area with active gypsum-anhydrite diapirs indicate that rocks now at the surface remained warm (to temperatures equivalent to ~5 km depth elsewhere) well into the Neogene. We suggest that the thermal effect of the diapir is also responsible for the existence of perennial salt springs in this permafrost area.