Significance of salt diapirs, magmatism, and tectonics on the thermal history of Axel Heiberg Island, Nunavut

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Only one in ten hydrocarbon exploration wells in the Sverdrup Basin in the Canadian Arctic Archipelago in the 1960s and 1970s led to discoveries (18), all but one of these fields in Mesozoic clastic strata on the crests of anticlinal structures, many of which are salt cored. Previous fission track (FT) studies by our group combined with organic maturation data suggest that a better understanding of the timing of hydrocarbon generation, migration and trap formation could have significantly decreased the exploration risk. It has been proposed that the thermal effects of Cretaceous and early Tertiary magmatism and salt/anhydrite diapirs on potential source rocks, and the possible breaching of reservoirs by Tertiary faulting may be key factors to be considered in hydrocarbon exploration models for this region. This project was developed with the primary aim of better understanding the thermal and timing aspects of the petroleum system using low-temperature FT and (U-Th)/He thermochronology, fluid inclusions, and organic geochemistry.

Field work on Axel Heiberg Island during the 2003 field season consisted of reconnaissance and sampling traverses mainly in the following areas: Geodetic Hills – Stolz Thrust (Lat. 79°50' N; Long. 89°35' W); Eureka Pass (Lat. 79°35' N; Long. 89°15' W), the south shore of Strand Fiord (Lat. 79° 10' N; Long. 90° 10' W) and Colour Peak, Expedition Fiord (Lat. 79° 23' N; Long. 91° 15' W). Over 100 diapirs are superbly exposed in 3D on Axel Heiberg Island, close to the Mesozoic depocentre of the Sverdrup Basin. They consist of Pennsylvanian gypsum-anhydrite with limestone interbeds and locally halite. Diapirs pierce Mesozoic strata and locally Paleogene sediments. Strata are folded into synclines and anticlines in brain-like patterns. The diapirs often form dikes and sills along, or near reverse faults. Because of the prevalence of anhydrite (S.G. 2.9) at the exposed level, some authors ruled out buoyancy as the main mechanism of emplacement, favouring horizontal compression as driving diapir intrusion during the Paleogene Eurekan orogeny.

Many large rafts of basaltic rocks (sills and lavas) of Cretaceous age are embedded in the diapirs. In a large diapir east of Eureka pass we sampled extrusive (pahoehoe and pillowed) basalts showing evidence of high-temperature interaction with evaporite, suggesting that the diapir was rising and exposed during the Cretaceous - extensional - tectonic phase. At Expedition Fiord, we observed perennial warm (<10°C) salt springs associated with two diapirs previously described by McGill University researchers, in an area where permafrost is otherwise 600 m deep. Salt, which undoubtedly cores the anhydrite diapirs, has a far higher thermal conductivity than most sedimentary rocks. If the thermal effect of the diapir has raised the isotherms in this area, it must have affected the petroleum system in the past. Our observations lead us to believe that the diapirs are actively rising, a hypothesis that we plan to test using geodesic tools in future. The timing of thrust fault movements, their relationships with Paleogene sediments and contained fossil forests, and the level of exhumation of various salt diapirs are being investigated using low-temperature thermochronology.