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Migration Pathways in the Colville Basin, Northern Alaska: Geochemical Constraints on Fluid Flow Simulations

The Colville basin, Northern Alaska, is an east-west asymmetrical trough-shaped foreland basin, adjacent to the Brooks Range fold-thrust mountain belt. Lower Cretaceous age rocks make up much of the sediment fill including flyschlike marine turbidites and shales of the Torok and Fortress Mountain formations and marine and delatic sandstones, shales, and conglomerates of the overlying Nanushuk group. Lower Cretaceous age rocks were deposited on top of a Paleozoic age passive margin sequence. We have conducted numerical simulations of fluid flow driven by topographic recharge in the Colville basin. These simulations are constrained by salinity estimates from well logs, isotopic composition of ground waters, location of oil and gas fields, vitrinite reflectance, and heat flow measurements. Our results indicate that there are two separate pathways for fluid migration. In the east, fluid movement is downward through the Fortress Mountain formation, then upwards along the interface between the Fortress Mountain and Torok Formation and finally northward through the permeable Nanushuk group. Very little meteoric water enters the underlying Paleozoic rocks as evidenced by the presence of saline pore waters. In the west, fluid movement is downward through the Fortress Mountain formation into the Paleozoic rocks and then northward. Our results also show that permafrost is a primary control on the pathway and rate of fluid flow by controlling the distribution of surface recharge and discharge. For example, areas of low saline waters along the arctic coast may represent upward groundwater discharge due to the absence of permafrost.