Petroleum hydrogeology in the thrust-fold belt, SW Alberta; Mississippian Strata

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There are few public domain references to hydrodynamic systems in thrusted and folded strata. This is principally due to the lack of public access to seismic data required for defining the complex stratigraphic/structural geometry in these regions. Without a clear understanding of the geometry, one can not even locate hydrodynamic data within the rock framework let alone sort out the flow systems.

Characterizing the nature of flow systems in the thrust-fold belt is important for two main reasons. From an academic point of view, the thrust-fold belt represents a critical part of the overall basin scale flow. It has been speculated that it could either represent a significant recharge region for many shallow and deep aquifers, or alternatively, represent a relatively closed system disconnected from deeper undisturbed aquifers to the northeast. More practically, there are large reserves of hydrocarbons trapped in these strata whose distribution and pressures are impacted by flow systems in the thrust-fold belt. We hope to begin a characterization of the flow systems in thrusted and folded strata with this paper.

Our investigation covers the region Tp. 22-33 R. 4-10W5M concentrating on Mississippian strata. This geographic area straddles undisturbed Mississippian strata to the northeast and thrusted and folded strata to the southwest. There are a number of significant pools in the region consisting of gas and condensate. Mississippian strata itself can be repeated up to four times at a particular geographic location in the study area. A combination of well logs, seismic and structural cross-sections were used to characterize the rock framework.

At a first glance the hydraulic head data in thrusted Mississippian strata appear to represent an almost chaotic set of values with extreme variation over short horizontal distances. In comparison, once in the undisturbed strata to the northeast the hydraulic gradient becomes flat where values range from 700 to 800m and can be traced some 100 km parallel and adjacent to the disturbed strata. Within individual slices in the disturbed belt flow directions tend to be parallel to the structural strike. There are large changes in hydraulic head in a northeast-southwest direction when moving across structures. When examining the flow system from a geographic perspective it is best to consider these structures as discontinuities with respect to the flow system.

The question that remains is the connection or lack thereof between individual flow systems within thrust slices. From a perspective of mass balance there must be some continuum at some scale because we can map active flow systems within thrust slices which must have a source and a sink for the moving formation water. We believe the answer to this question is related to the nature of the structures themselves. There are only a few deep seated structures which can be traced for large horizontal distances in the northwest-southeast direction. Most structures in the area of investigation have surface traces 20-30 km in length. At the ends of individual structures, deformation is taken up along parallel to sub-parallel structures either in or outboard. It is at these locations where hydraulic communication appears to exist between thrusts in both a vertical and horizontal (northeast-southwest) direction.

With this model in mind, tortuous flow paths can be defined which originate in the southwest and eventually connect to undisturbed Mississippian strata in the northeast. Having established the flow system for formation water, hydrocarbon accumulations can then be evaluated with standard petroleum hydrogeological techniques either for exploration or production purposes.

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