Geochemical modeling of fluid-fluid and fluid-rock interaction in areas of cross-formational flow in southern Alberta

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Equilibrium thermodynamic models were used to determine the effect of fluid chemical composition on mineral stability in two areas of mixing and cross-formational flow in southern Alberta. Fluids (water and gas) of known composition were used to produce geochemical models of fluid-fluid interactions. The fluid compositions were also plotted on computer generated mineral stability diagrams in order to evaluate possible water-rock interactions. If correctly parameterized the models can be used to predict precipitation and dissolution of cements and mineral grains, which will affect porosity reduction and enhancement. The parameters that were found to be of critical importance were temperature and pH. Difficulties in obtaining reliable thermodynamic data for clay minerals and the occurrence of metastable equilibrium between reaction components hinders interpretation of mineral phase stabilities.

pH and temperature, although directly measurable from water samples, often do not accurately represent reservoir conditions and must be calculated through other means. Temperatures were determined through correlating bottom hole temperatures with average geothermal gradients for the region. pH was determined using two methods: setting pH according to temperature and equilibrium with calcite; and setting pH at a specified temperature according to equilibrium between the partial pressure of CO_2 and dissolved HCO_3. Water compositional analyses come from various sources but all were carefully collected and analyzed to give only the highest quality results.
The waters used in this study occur within Paleozoic carbonates of Mississippian age and Lower Mannville siliclastics. The study area includes Townships 10-20, Ranges 9-20. Flow is into the Mannville at the Mississippian subcrop. Cross-formational flow can be recognized through variations in the chemical composition of fluids found in the Mannville. Zones of mixing are found to occur within the Mannville. Displacement of Mannville waters by Mississippian waters is also observed to occur.

The Mississippian waters can be characterized by two end member types consisting of a Na-HCO3-Cl water and a Na-Cl water, with considerable mixing in varying proportions of the two. The waters from the Lower Mannville are made up of Mississippian bicarbonate waters, Mississippian Na-Cl waters, Mannville Na-Cl waters and various mixtures of these. Mixing typically occurs along well defined fronts radiating away from areas of incursion of Mississippian waters. Potential reactions during mixing and between fluid and rock include dissolution and precipitation of the cements calcite, dolomite, anhydrite and quartz and dissolution, precipitation and exchange reactions between feldspars, clays and micas.

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