



Isotope Geochemistry of Fault Zone Samples from the Livingstone Range Anticlinorium and their Significance to the Thermal and Fluid History of the Southern Canadian Foreland Fold and Thrust Belt

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Abstract

Pre-deformation fluid-flow in the Livingstone Range anticlinorium of southern Alberta is represented by quartz/dolomite/calcite+/-fluorite+/-sphalerite veins that cut perpendicular to and parallel with bedding. Dolomite in alteration haloes has radiogenic strontium isotopic ratios and enriched oxygen isotopic compositions that suggests a basement-derived fluid source. Dolomitized Paleozoic carbonates throughout the Foothills of the southern Canadian Cordillera show a trend of increasing radiogenic Sr and ^{18}O -depletion that indicates regional dolomitization may have been caused by the infiltration of similar basement fluids.

During the early stages of Cretaceous/Tertiary deformation, the undeformed Upper Paleozoic strata became buried by a >4km-thick succession of shale-dominated foreland basin deposits (Figure A). The insulating effect of the sediment raised temperatures in the underlying strata at a geothermal gradient of $\sim 33^\circ\text{C}/\text{km}$. The increased temperatures likely caused hydrocarbon maturation, the possible recrystallization of magnetic minerals that reset paleomagnetic signatures, and increased vitrinite reflectance values of coal. The eastward-migrating blanket of foreland basin sediments was systematically deposited ahead of the deformation front, which caused an eastward-migrating hot thermal anomaly to pass through the foreland basin ahead of the deformation.

The initial stage of fault-propagation folding in the Livingstone Range anticlinorium caused extensive fracture dilation in the Paleozoic rocks, which caused hot basement fluids to be drawn into the anticlines along folding-related faults (Figure C). The hot fluids migrated into the anticlinorium when the Livingstone thrust cut through steep ENE-trending reactivated faults that were conduits for the basement fluids. Isotopic compositions of fault-related veins and host rocks indicate that cross faults were the primary conduits for the infiltrating fluids. Isotope geothermometry of calcite, dolomite +/- quartz in veins in one cross fault and two thrust fault samples indicate that these early veins precipitated at temperatures of $>250^\circ\text{C}$, which is $60\text{-}80^\circ\text{C}$ higher than that expected from temperatures extrapolated from overlying coal.

As thrusting continued, the Livingstone Range anticlinorium underwent eastward translation and became elevated and affected by erosion, allowing deep infiltration of meteoric water that cooled the rocks to a geothermal gradient of $12\text{ - }17^\circ\text{C}/\text{km}$ (Figure D). The presence of meteoric water in

the Livingstone Range anticlinorium is recorded by late fault-related veins with strongly-depleted $\delta^{18}\text{O}$ values ($< -10\text{‰PDB}$).

The widespread occurrence of strongly $\delta^{18}\text{O}$ -depleted veins in thrust faults in the Front Ranges and Foothills of the southern Canadian Foreland Fold and Thrust Belt is attributed to regional infiltration of meteoric fluids, which swept through the deformed rock from west to east along with the deformation.

