Kinematics of fibrous vein growth: insights from stable isotopes and trace elemental data*

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Veins are important recorders of thermal, hydrological, structural, and geochemical conditions during deformation. Fibrous or bladed veins are particularly useful, because the mineral fibers are believed to grow continuously or episodically over what may be a significant geologic time period. Thus, individual mineral fibers document the complex, dynamic changes occurring coeval with vein growth and mineral precipitation.

Geochemical and structural analyses have been used to constrain the kinematic history of a bed-parallel fibrous calcite vein from the Upper Jurassic La Casita Formation, Sierra Madre Oriental, Mexico. The La Casita Formation, correlative with the Smackover Formation of the northern US Gulf Coast, consists of shale and is part of a sedimentary succession that unconformably overlies evaporites of the Minas Viejas Formation. The fibrous vein used in this study was taken from the backlimb of the frontal fold of the Monterrey salient near Saltillo.

Optical petrographic observation reveals that the fibers have blade or tapering lath shapes with widths from 0.1-1.0 mm. Other minerals present in the vein are pyrite, gypsum, bitumen, and iron oxides. High-resolution, closely spaced stable isotope and elemental analyses were carried out along five traverses across the vein width. The $\delta^{18}O$ values vary in a narrow range, with an average value of +20.8 ± 0.2‰ (VSMOW). The $\delta^{13}C$ values increase systematically along the fibers, from the walls of the vein toward the suture plane. In all five traverses, the $\delta^{13}C$ increase is relatively constant, with lower values next to the vein wall (+1.2 to +1.6‰ PDB) and higher values along the suture line (+3.6 to +4.1‰ PDB).

The vein minerals, fibrous calcite and accessory pyrite, are interpreted to be the products of high temperature (190 to 260ºC, as estimated by fluid inclusion data) reactions between light hydrocarbons and dissolved sulfate, known as thermochemical sulfate reduction (TSR). Reactants such as light hydrocarbons and products such as CO_2, H_2S, and H_2O contributed to what are interpreted to have been high fluid pressures during vein growth. The origin of vein minerals is probably related to: (1) methanogenesis and decarbonation reactions within the shale, and (2) high-temperature, high-salinity brine migration during late stages of folding.

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