Thermobaric Dolomitization: Transient Fault-Controlled Pressure-Driven Processes and the Role of Boiling/Effervescence

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The designation “thermobaric” rather than “hydrothermal” to describe the process of dolomitization by subsurface hot brines at temperatures and pressures greater than the ambient temperature and pressure of the host limestone places emphasis on the role of pressure in the dolomitization process. Pressure and the associated stress regime interact to influence the direction of fluid flow, formation of dolomite-limestone “fronts”, hydrofracturing, the formation of dilational breccias, zebra fabrics, rimmed microfractures and other fabrics. Pore fluid pressure and stress field orientation proximal to a periodically-active fault undergo transient changes related to pre-seismic, co-seismic and post-seismic stages of fault activation/evolution. Resulting fluid movement within the fault or fault/fracture network will be episodic, but also may be very dynamic, with high flow rates, resulting in remobilization of internal dolomite fragments/crystals and redeposition as cross-bedded, scoured and graded laminae of internal sediments. Abrupt drop in confining stress may result in geologically-instantaneous hydrofracturing to form dilational breccias and/or zebra fabrics and may trigger boiling of water or effervescence of CO_2, methane and/or other gases, in turn driving instantaneous and probably massive precipitation of cement.

Dilational cement-filled sheet fractures and pore space in thermobaric dolomite rock fabrics may be a product of dilation on extensional or strike-slip faults. Seismically-recognizable ‘sags’ above thermobaric dolomite intervals (a major exploration target for these reservoirs in the Michigan and Appalachian Basins, the WCSB and elsewhere) may reflect subsidence above a transtensional negative flower structure on a strike-slip fault, although there is emerging evidence that other factors may also play a role in sag formation.