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Self-accelerating dolomite-for-calcite replacement: dynamics of burial dolomitization and associated ore mineralization

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Attempts at understanding burial dolomitization became a comedy of errors after Weyl (1959, 1960), the first geochemical modeler, recommended ignoring petrography and assumed that replacement happens by dissolution-precipitation. This has led to models that are ad-hoc, contain wrong reactions, ignore feedbacks and petrographic insights, and avoid checking predictions against reality. Dolomitization is a beautiful case of geodynamics. The new model correctly predicts a suite of geological, textural, microstructural, rheological, paragenetic, geochemical and morphological properties of dolomites. The model assumes that the dolomitizing brine must be Mg-rich and - counterintuitively - dolomite-undersaturated. Deep brines from the Mississippi Salt Dome basin do satisfy that requirement, and happen also to be rich in Pb, Zn, Sr, Ba, and SO4, hinting at why dolostones host Mississippi-Valley-type ores. The fact that the dolomite-for-calcite replacement is self-accelerating via Ca2+ has astonishing consequences. (1) It makes dolomitization self-organized in time (in the form of many growth ‘pulses’ per ‘slice’) and space (in sequential limestone ‘slices’, each several meters thick, with dissolution porosity accumulated at the entry into each slice, thus spatially periodic - as observed). (2) Because dolostones are strain-rate-softening and replacement happens by induced-stress-driven pressure solution, the self-accelerating replacive growth must pass continuously to displacive dolomite growth - before shutting itself down abruptly. (3) The same Ca2+ involved in the self-accelerating replacement also drives increasing insertion of submicroscopic calcite slivers into the displacive dolomite crystals, deforming them. The displacive growth causes bilateral veins to form normal to the crystal growth direction. The occurrence in most dolostones of zebra veins consisting of displacive, saddle dolomite crystals and a replacive/displacive contact which is seamless stunningly confirms the new dynamics. (4) The high aqueous Ca2+ left when dolomite growth shuts down drives calcite growth and dedolomitization, and growth of other Ca-bearing minerals such as anhydrite and fluorite, and of sphalerite and galena - as observed. (5) Dolomite growing in late pulses of one slice should replace ores formed in earlier pulses, concentrating the ores downflow - as observed.