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**UNDERSTANDING THE MECHANISMS BEHIND THE SILICIFICATION OF
CONTINENTAL CARBONATE ROCKS: INSIGHTS FROM GEOCHEMICAL
MODELLING**

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ABSTRACT

Silicification is a diagenetic process involving the replacement of the host rock and the cementation of the pore space by Silica. It has been widely recognized in continental carbonates, resulting from either internal source of Silica (e.g., dissolution of the Mg-clay matrix constituents) or the arrival through deep-rooted faults of hot external fluids enriched in Silica. Since silicification affects the primary fabric of the rocks, and thereby their porosity and permeability, understanding its mechanism has important implications for subsurface energy applications. In this study, we focus on the internal sources of Silica, more precisely, on the chemical and physical factors controlling the Mg-clay stability based on "batch" geochemical modelling. The simulations are constrained by a large set of samples and well data from a lacustrine Mg-clay-carbonate environment, the Barra Velha Formation (Aptian in age – Santos Basin, Brazil), and take part in a larger workflow, including (1) fluid inclusion analyses and oxygen isotope microanalyses of diagenetic silica phases to constrain the salinity and temperature ranges of the diagenetic events, (2) stratigraphic forward modelling to define the Mg-clay composition of each facies and (3) advanced basin modelling computation to infer the history of CO₂ circulation and quantify its amount. The results show that conditions favouring the replacement of Mg-clays by Silica include (1) high concentrations of CO₂ to drive Mg-clay dissolution under low-pH conditions, (2) rapid flow resulting in high water-to-rock ratios to renew the DIC source more effectively, and (3) the presence of Mg-carbonates (dolomite and magnesite) to remove magnesium released in solution by Mg-clay dissolution. The Mg-clay type, pressure, salinity, and temperature do not significantly affect the Mg-clay weathering over the investigated ranges. From these findings, phenomenological laws linking the CO₂ content to the carbonate silicification intensity are derived and implemented in basin modelling to build silicification risk maps. Hence, geochemical modelling has been an invaluable tool to better understand the mechanism of carbonate rock silicification and in implementing such understanding in a quantified manner in geomodelling at a larger scale. This approach can also be used on similar diagenetic processes and help define major reservoir/aquifer plays.

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