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Experimental investigations on the decarbonation reaction under sedimentary basin temperature and pressure conditions

LEI SONG, HAOKUN LIAN AND XIAOLIN WANG
Nanjing University

Carbon dioxide (CO_2) is a crucial acidic component in sedimentary basins, significantly influencing the formation and evolution of dissolution-type reservoirs. While carbonate decarbonation represents a critical pathway for substantial CO_2 generation within Earth's deep subduction zones and metamorphic regimes, its occurrence under sedimentary basin environments remains debated. To address this, we conducted high-temperature (100~350 ℃), high-pressure (0~70 MPa) *in situ* and *ex situ* experiments, integrated with scanning electron microscopy and Raman spectroscopic analyses, to elucidate the conditions and mechanisms governing decarbonation within the $CaCO_3$-SiO_2-H_2O, $CaMg(CO_3)_2$-SiO_2-H_2O, and $CaCO_3$-SiO_2-H_2O-$MgCl_2$ systems. The results indicate that temperature is the dominant controlling factor: calcite decarbonation occurs above 275 ℃, a thermal regime rarely reached in sedimentary basins. However, magnesium-rich diagenetic systems enable this reaction to initiate at temperatures as low as 100°C, with reaction rates exhibiting a pronounced temperature dependence—progressively accelerating at elevated temperatures. Pressure inhibits decarbonation, and system openness determines the solid-phase products. In nearly closed systems, kerolite forms and dehydrates into talc, while calcite undergoes dolomitization in the presence of magnesium-rich fluids. In open systems, talc is the dominated solid product, with less dolomitization, and the release of CO_2 promotes decarbonation. Based on these results and previous case studies of silica- and magnesium-rich hydrothermal fluids interacting with carbonate strata, we propose that carbonate decarbonation is a significant source of CO_2 in sedimentary basins, facilitating the generation of secondary pores and the development of dissolution-type reservoirs. Further research should explore the implications of these mechanisms for hydrocarbon reservoir formation.