

## The Occurrence of Dolomite in Carbonate Organofacies and its Relationship to Diagenesis and Catagenesis as Revealed by Mineral Maps Developed Using Energy Dispersive Spectroscopy and Back Scatter Electron

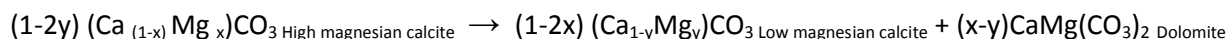
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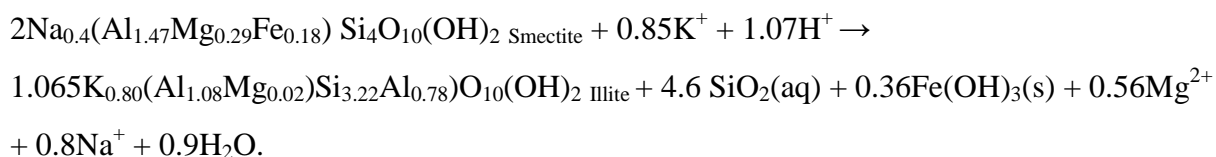
Dolomite is an authigenic mineral that often incongruently replaces calcite in conventional carbonate reservoirs. However, the provenance and pore fluid chemistry fingerprinting its geochemical origin is seldom traceable within the dominant calcite mineral fabric of limestones which is often relatively homogenous on a scale of meters. Moreover, the inability to reproduce dolomite in controlled laboratory experiments, as predicted from solution equilibria and thermodynamics, has posed uncertainty over the numerous theories that have been proposed to explain its occurrence. Recent research into developing nanoscale mapping methods for resolving the mineral fabric of source rocks has revealed that the mechanisms responsible for formation of dolomite may not be spatially evident at the scale of a conventional carbonate reservoir, but they are detectable at the nanoscale scale fabric of organic chinks or marls. The complex mineral fabric of carbonate source rocks from 2D-scanning electron images using energy dispersive spectroscopy (EDS) and back scatter electron (BSE) suggests the genesis of dolomite and its nucleation in carbonate lithofacies may occur at different temperatures related to both diagenesis and catagenesis. The software [1], designed to use EDS elemental maps and BSE intensities to map the mineralogy with nanoscale pixel resolution, differentiates between the magnesium associated with clays versus dolomite and the carbon associated with organic matter versus calcite, which also shows the two different occurrences and associations of dolomite within the mineral maps generated.

The mineral maps reveal diagenetic dolomite occurs as anhedral masses, sparsely distributed throughout the rock surface as evidence of localized changes of pore water chemistry due to the dissolution of high magnesian calcite and aragonite during initial stages of burial (Fig.1). The instability of these phases thermodynamically drives its conversion to the more stable polymorph, calcite, and in the process, magnesium is released, and dolomite is formed [2]:

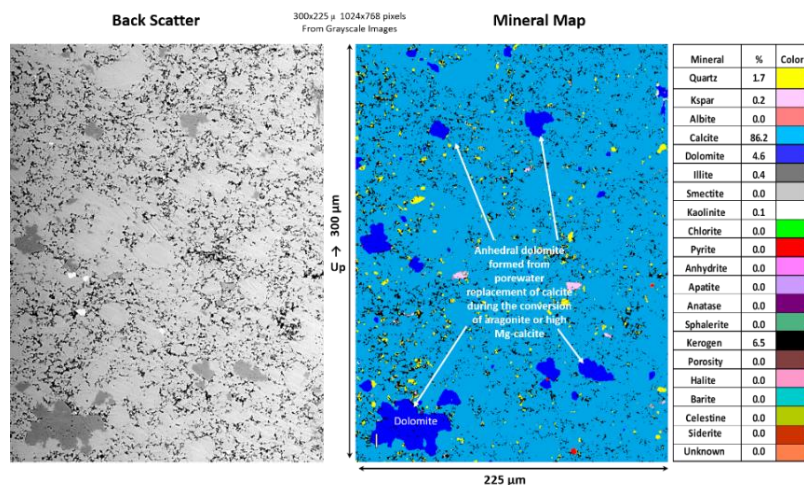


Where  $x > y$   $\Delta G = -516.83 \text{ kcal/mol}$ .

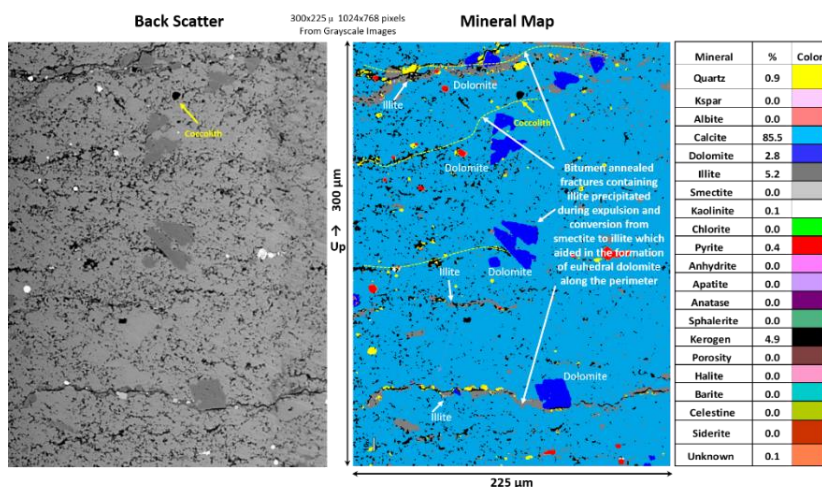
Other morphologies of euhedral, rhombohedral, dolomite is also shown to occur with illite at the interface of bitumen annealed expulsion fractures which form as the result of hydrocarbon generation (Fig.2). The conversion of smectite to illite has been predicted to occur at higher temperatures, congruent with the catagenesis stage of the transformation of kerogen into hydrocarbons [3]. This conversion also is postulated to release free magnesium which can lead to the nucleation of dolomite in calcite according to the following reaction [4]:



The association of euhedral dolomite with illite occurring at expulsion fractures, and also precipitated as anhedral masses as revealed from the mineral maps provides evidence that dolomites genesis may occur in different stages of burial during the lithification of carbonates. Its occurrence may result from multiple processes related to both temperature and provenance during burial. The mineral maps reveal why some theories proposed for dolomites occurrence could be applicable, but not easily reproduced in laboratory studies because the geochemistry surrounding their formation is rather complex.



**Figure 1.** Mineral map showing sparse occurrence of dolomite due to diffusion and pore water chemistry equilibria.



**Figure 2.** Mineral map showing the occurrence of dolomite along bitumen annealed fractures

#### References:

- [1] Jacobi D. et al., *Microscopy and Microanalysis* **25**, (2019), p. 2422.
- [2] Berner R.A., "Principles of Chemical Sedimentology", (McGraw Hill, 1971), p. 1.
- [3] Hunt J.M., "Petroleum Geochemistry and Geology". (WH Freeman and Company, San Francisco, 1979), p. 1.
- [4] Langmuir D., "Aqueous Environmental Geochemistry", (Prentice Hall, New Jersey, 1997), p. 1