Numerical modelling of reactive flow of mixed H_2O-CO_2 fluids and progress of calc-silicate reactions in contact aureoles

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Binary H_2O-CO_2 fluids strongly influence calc-silicate metamorphic reactions. We modelled the flow of mixed H_2O-CO_2 fluids and the progress of calc-silicate reactions in contact aureoles using a two-dimensional finite-element model. Results show that CO_2 strongly affects fluid flow patterns. Infiltration of magmatic water into an aureole with a homogeneous permeability structure and containing CO_2-H_2O pore fluid causes vigorous, upward flow of relatively CO_2-poor fluid along the side intrusion-wallrock contacts and vigorous downward flow in the outer aureole along a sharp CO_2 gradient. Reaction-produced CO_2-rich fluid tends to promote upward flow in the aureole. We also tracked the temporal evolution of P-T-X(CO_2) of metamorphic reactions. The progress of low to middle-grade, phlogopite to diopside-forming, reactions is mainly driven by heat as the CO_2 concentration and fluid pressure increase. In contrast, the progress of the high-grade, wollastonite-forming reaction is mainly driven by infiltration of disequilibrium CO_2-poor fluids during cooling of the inner aureole. CO_2-rich fluids dominate in the inner aureole during heating, whereas CO_2-poor fluids prevail at or after peak temperature is reached. Consequently, low-grade metamorphic rocks likely record the presence of CO_2-rich fluid and high-grade rocks likely reflect the presence of CO_2-poor fluid, consistent with geological observations in many calc-silicate aureoles. Infiltration of magmatic water significantly dilutes the reaction-produced CO_2 out of the aureole and enhances the progress of high-grade reactions, in particular the production of wollastonite. The distribution of mineral assemblages predicted by our simulations matches well the observed distribution in the Notch Peak aureole. The results provide new insights into the hydrologic and metamorphic evolution of the Notch Peak and other contact aureoles.

Proteoglycan diversity and aragonite crystallization patterns in coral skeletons: a reinterpretation of isotopic “biological mismatches”

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Since the assessment that "spherulitic crystallization" (Bryan and Hill, 1941) is the leading mechanism in coral calcification process, coral-based environmental studies use to consider that coral skeletons are built by variously arranged "single orthorhombic crystal of aragonite".

Numerous obervations converge to suggest that under two respects, this classical view should be modified:

1 - Coral skeletons are not exclusively built by fibres, and microstructural studies have fully confirmed the biological specificity of "centres of calcification" (Ogilvie, 1896). Up to highest resolution levels, observation of taxonomy-linked chemical and microstructural patterns indicates that crystallisation of skeletal units is under biological control (Cuif and Dauphin, 1998).

Localized measurements of isotopic ratios were carried out (Blamart *et al*, 2002), and the observed differences between skeletal components clearly support this view.

2 - Fibres are not pure aragonite crystals. Enzymatic etchings allow their stepping growth mode to be recognized. XANES mapping of sulfur in the sulfated oxidation status provides us with pictures that strictly correspond to centre of calcification and fibre growth steps.

These results fully agree with Alcian blue staining of 2D electrophoretic studies that had demonstrated the dominance of acidic sulfated sugars in the soluble organic matrices extracted from skeletons (Dauphin and Cuif, 1997). Additionally, the very high molecular weights of these compounds are shown by HPLC profiles in strongly dissociative buffers (Dauphin, 2001).

This consistent set of data suggests that unexpected properties of coral skeletons should be interpreted by taking into account the organo-mineral relationships that may influence crystallization during each step of the fibre cyclic growth process.

References

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