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Evaluation of metasomatic changes in an interlayered blueschist-greenschist sequence (Coastal Cordillera, Chile) by combining geochemical data with equilibrium assemblage diagrams

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In the Coastal Cordillera of Central Chile, a spectacular sequence of interlayered blueschists and greenschists occurs in coastal outcrops near Pichilemu. Three explanations are generally proposed to interpret the interlayering of metamorphic rocks that represent distinct metamorphic facies: 1. Differences in the pressure-temperature (P-T) conditions of equilibration and late-stage tectonic juxtaposition, 2. Chemical differences between the layers inherited from the protolith, and 3. Differences in the degree of metasomatic overprint during metamorphism. Investigations of such interlayered sequences can shed light on the mobility of elements and fluid-rock interaction during metamorphism. To identify the processes responsible for interlayering, geochemical analyses were combined with petrologic investigations involving the calculation of isothermal and isobaric binary phase diagrams using the THERIAK-DOMINO [1] software.

Major mineral phases in blueschist and greenschist layers are amphibole, white mica, chlorite, and albite with subordinate amounts of titanite, epidote, hematite and apatite. The mineralogy of blueschist and greenschist layers is similar, albeit the modal proportions differ, causing the distinct colouring. Peak P-T conditions of blueschists reach 370 ± 20 °C at 10 ± 1 kbar [2]. The layering on a cm-to-dm scale and the similar mineralogy suggest that both blueschist and greenschist layers experienced a similar P-T evolution. For adjacent blueschist-greenschist pairs, blueschists have consistently higher Si and Na contents, whereas greenschists are relatively enriched in Al, Mg and total Fe. However, the observed major element geochemical trends are inconsistent with magmatic differentiation. For several blueschist-greenschist pairs, ratios of incompatible trace elements, which are indicative of the protolith composition and considered as relatively immobile during low-T metamorphism (Th/Yb, Nb/Yb), are near identical. These features point to metasomatic changes during the metamorphic evolution as the main cause for the chemical heterogeneities rather than inherited compositional differences from the protolith. Mobilization of fluid-mobile elements (Cs, Rb, Ba, K) and relationships between these elements that are consistent with a metasomatic overprint suggest fluid-induced transport.

To evaluate the effects of compositional changes on phase stabilities, isothermal and isobaric phase diagrams were calculated using a compositionally representative blueschist-greenschist pair. The calculations indicate that glaucophane stability is favoured by relatively Si- and Na-rich compositions, i.e. those typical for the blueschists, which is consistent with the restricted occurrence of glaucophane in greenschist layers. Moreover, chlorite abundance continuously decreases towards the blueschist composition. This study demonstrates that the combination of geochemical data with phase equilibrium constraints provides further insights into the effects of metasomatic processes during metamorphism.

References:

[1] De Capitani, C. & Petrakakis, K. (2010), Am. Mineral. 95:1006-1016.
[2] Willner, A.P. (2005), J. Petrol. 46:1805-1833.