Metamorphic CO_2-source rocks in collisional orogens: a petrographic journey through not-(always) obvious CO_2-producing lithologies in central Himalaya

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Decarbonation reactions during regional metamorphism in "large-hot" collisional orogens are an important source of atmospheric CO_2, able to influence global climate through geologic time (Gaillardet & Galy, 2008). The petrologic study of the CO_2-source rocks is consequently the key to successfully investigate the metamorphic CO_2 flux in the past.

This contribution focuses on the distribution and petrographic description of different types of CO_2-source rocks (i.e. calc-silicate rocks) in the archetype of "large-hot" collisional orogens, the Himalaya. Fieldwork performed in central and eastern Nepal highlighted that calc-silicate rocks are widespread in the Greater Himalayan Sequence (GHS) and occur as: dm- to m- thick layers or boudins within medium- to high-grade metapelites in the lower portion of the GHS, vs. tens to hundreds of meter thick layers within anatectic gneisses in the structurally upper GHS.

Three different groups of calc-silicate rocks have been recognized, corresponding to different protolith compositions, and they can be described in terms of relatively complex chemical systems: (i) CFMAS-HC (CaO-FeO-MgO-Al_2O_3-SiO_2-H_2O-CO_2) system, significantly more abundant in the lower GHS; (ii) NCFMAS-HC (Na_2O-CaO-FeO-MgO-Al_2O_3-SiO_2-H_2O-CO_2) and (iii) NKCFMAS-HC (Na_2O-CaO-FeO-MgO-Al_2O_3-SiO_2-H_2O-CO_2) systems, widespread in both the lower and the upper GHS.

In all groups, mineral assemblages vary with increasing metamorphic grade from lower to upper structural levels. The CFMAS-HC assemblages are represented by: (a) Cc+Tr±Qtz±Pl in impure marbles and by (b) Grt+Amp+Qtz+Pl±Zo±Cc (Cpx-absent), (c) Grt+Cpx+Qtz+Pl±Zo±Cc and (d) Cpx+Qtz+Pl±Zo±Cc (Grt-absent) in calc-silicate rocks. The NCFMAS-HC assemblages consist of: (a) Grt+Cpx+Qtz+Scp+Zo±Pl and (b) Cpx+Scp+Zo+Qtz+Pl+Cc (Grt-absent). In the NKCFMAS-HC group the following mineral assemblages can be observed: (a) Cc+Mu+Phl+Qtz±Pl±Tr impure marbles; (b) Mu±Bt+Cc+Qtz+Pl (Kfs, Cpx and Grt-absent) phylladic micaschists; (c) Mu+Bt+Zo+Scp+Grt+Qtz+Pl (Kfs and Cpx-absent) micaschist; (d) Bt±Mu+Kfs+Scp+Qtz+Pl±Zo (Cpx and Grt-absent), (e) Bt±Kfs±Scp+Qtz+Pl+Czo±Amp±Cpx±Cc (Grt-absent) and (f) Kfs±Bt±Scp+Qtz+Cpx±Zo±Cc (Grt-absent) calc-silicate gneisses and granofelses.

Many of these assemblages, especially those equilibrated at lower temperatures and still containing abundant phyllosilicates, are not easy to be recognized in the field and have been probably considerably overlooked in the past. Most of them do not contain calcite anymore, because it was completely consumed during prograde metamorphism: nevertheless, their role in the orogenic-CO_2 cycle should be considered. Detailed fieldwork and petrographic analysis are therefore indispensable tools to estimate the volumes of potential CO_2-source rocks in collisional orogens.

Gaillardet J. & Galy A. 2008. Himalaya-carbon sink or source? Science, 320, 1727-1728.