Stability of chlorite in subducted ultramafic schists

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Hydrous minerals subducted at convergent margins are the major water contributors to arc magmas. However, the stability of chlorite, one of the main water-bearing minerals, is not well constrained at sub-arc pressures and temperatures. Three key chlorite reactions were experimentally investigated in this study: Reaction 1: chlorite + clinopyroxene = garnet + olivine + H_2O ±spinel; Reaction 2: chlorite + orthopyroxene = garnet + olivine + H_2O ±spinel; Reaction 3: chlorite = garnet + olivine + H_2O ±spinel. In subducted serpentinites, chlorite will disappear along Reaction 1 and 2 whilst in metasomatically formed chlorite schists, it will persist until the terminal breakdown Reaction 3.

The study involved a series of high pressure (1.0 GPa to 6.0 GPa) and high temperature (600°C to 900°C) piston cylinder experiments conducted at the Australian National University, Canberra. Starting materials comprised 80-99% Mg-chlorite (Mg#=0.95) in order to observe all three reactions, and minor amounts of antigorite, tremolite and seed garnet.

Using 3.0 GPa as a typical sub-arc pressure, it was found that garnet first appeared at 730°C and clinopyroxene had disappeared by 750°C, showing that Reaction 1 occurs over a temperature interval of ~20°C. Orthopyroxene had reacted-out by 800°C, marking the upper limit of Reaction 2. At 850°C, chlorite had decomposed indicating the upper limit of Reaction 3. Collectively, Reactions 1-3 release water via smeared pulses over a temperature range of more than 100°C. All dehydration reactions have a moderate backbend in P-T space between 2-6 GPa.

The water release from chlorite breakdown occurs in a temperature range where associated sediments undergo wet melting and agrees well with estimated top slab temperatures at sub-arc pressures. After the terminal breakdown of chlorite at 840°C, the residual rocks are very dense garnet-spinel-olivine rocks, and so diapiric rise of chlorite schists through the mantle wedge seems unlikely.