An experimental perspective on the diversity of (lower) arc crust: key role of water contents

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We present experimental results designed to better understand fundamental fractionation processes in the deep crust. While investigations of Si-rich plutons and volcanic products in the upper crust indicate that magma mixing and hybridisation are important processes, the question remains where and how this variety is produced. One way to form voluminous granitoids is island arc and continental arc magmatism. We discuss results from nominally dry and moderately hydrous experiments designed to understand fractionation processes, with an emphasis on the roots of magmatic arcs. An evaluation of the major element composition indicates that the cumulate line of descent (CLD) of hydrous systems is fundamentally different from dry systems. Cumulates derived from hydrous experiments display elevated CaO and Al_2O_3 contents at low SiO_2, producing voluminous andesitic to rhyolitic liquids, while dry systems follow plagioclase dominated, very different fractionation paths. The mineralogical and chemical composition of cumulates converges for very different hydrous primary magmas, indicating that fundamental phase equilibria under the conditions prevailing in the roots of magmatic arcs exert a strong control on the compositions of derivative andesitic to rhyolitic liquids. Oxygen fugacity increases through differentiation crystallization via efficient depletion of ferrous iron relative to ferric iron, resulting in an increase of fO_2 by about 2 log units in hydrous magmas, potentially providing an explanation for the generally more oxidized character of hydrous arc magmas. Enhanced stability of amphibole and garnet (±spinel) relative to plagioclase+pyroxene makes hydrous systems more efficient in producing Si-rich magmas. Melting experiments on amphibolite equally produce granitic – rhyolitic liquids yet their restites do not present the same variability of the cumulates of hydrous fractional crystallization experiments.