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Experimental time constraints on the kinetic and chemistry of amphibole at deep crustal levels

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Aiming to improve the current knowledge about amphibole growth kinetics at deep crustal levels, new amphibole growth rate data are provided. Our findings, indeed, may be useful to correctly interpret the textural features of amphibole-bearing mafic cumulates and rocks, and for a better constraining of the timescales of magmatic processes at upper mantle-lower crustal depths. Experiments were performed to determine the amphibole growth rates in a primitive alkaline basalt from Procida island (Campi Flegrei Volcanic District, southern Italy) at the following conditions: temperature of 1030 and 1080 °C, pressure of 0.8 GPa, water content in the range 3.3-4.2 wt%, and variable dwell time from 0.25 to 9 h. Amphibole growth rates range from $1.5 \cdot 10^{-7}$ to $2.9 \cdot 10^{-8}$ cm·s^{-1} with increasing the duration of the experiments. It is observed that, keeping a constant dwell time, an increase of the experimental temperature or of the water content results in comparable growth rate increase. Coexisting synthetic amphibole and clinopyroxene show a faster growth rates in favour of amphibole regardless of the dwell time, since the chemical and structural similarities of these minerals cause kinetic competition. Moreover, the chemical composition of amphibole is influenced mainly by the experimental time; in detail, in the shortest (≤3 h) and low temperature runs edenite is the prevailing composition whereas the magnesiohastingsitic term becomes dominant at higher temperature and longer run duration. Based on the interpretation of the Fe-Mg exchange coefficient values between amphibole and coexisting liquid, the magnesiohastingsitic amphibole is considered to be the stable term at the investigated run conditions. Finally, the resulting growth rates have been applied to constrain the crystallization time of natural amphiboles and clinopyroxenes from the Oligo-Miocene cumulates of north-western Sardinia (i.e., Capo Marargiu Volcanic District, Italy), yielding crystallization times in the range 1.46-3.12 yr.