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Crystal growth mechanism from pumice into zeolite via hydrothermal synthesis

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Zeolites are tectoaluminosilicate minerals and they have spatial aluminosilicate frameworks built from channels and cages with a specific pore size and large surface area, which are acted as economical industrial mineral, e.g. adsorbents, catalysts, ion exchanger, and carriers. Due to the increasing demand for different applications, the hydrothermal synthesis of zeolite from natural minerlas (rocks) has attracted great attention. Pumice are porous volcanic clastic rocks (rhyolite) and abundant distribution throughout the world. The composition of pumice is mainly consisted of 65%-75% SiO_2 and 9%-20% Al_2O_3, which makes it suitable for fabricating into zeolite due to its high silicon and aluminum content.

In this study, the pumice (received from Penghu Island) was synthesized into zeolites by hydrothermal method with different alkaline concentrations, reaction temperatures and times, and the addition of NaCl. The aim of this study is to synthesize some pure mineral-phase zeolites and to discuss the crystal growth mechanism. It was found that zeolite Na-P1, which was a GIS structure, can be stably synthesized in the condition of 0.1 or 0.5 M at 150 ˚ C. It was observed that the feldspar phase (albite) was initially occurred and then formed the zeolite phase (zeolite Na-P1). Phillipsite was an intermediate product during this synthetic process and it was unstable. According to the results, the phase transformation sequence followed the order of albite, phillipsite, and zeolite Na-P1. The possible reaction formula was as follows: 1. Pumice to albite: $6SiO_2 + Al_2O_3 + 4Na^+ + 4OH^- + 2H_2O \rightarrow 2Na(AlSi_3O_8) + 2Na^+ + 2OH^- + 3H_2O$; 2. Albite to phillipsite: $2Na(AlSi_3O_8) + Na^+ + OH^- + 5H_2O \rightarrow Na_2(Si,Al)_8O_{16}4H_2O + Na^+ + OH^- + H_2O$; 3. Phillipsite to zeolite Na-P1: $2Na_2(Si,Al)_8O_{16}4H_2O + 5H_2O + 3Na^+ + OH^- \rightarrow Na_6Al_6Si_{10}O_{32}(H_2O)_{12} + Na^+ + OH^- + H_2O$.

Keywords: pumice, zeolite, hydrothermal synthesis, crystal growth mechanism.