A complex magmatic system beneath the middle and northern Okinawa Trough: evidence from pyroxene characteristics

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The analysis of the variation of magmatic physical conditions is an important part of the study of magmatic evolution. Here we present a comparative study on pyroxenes in white and black pumice from the Okinawa Trough, an initial back-arc basin, to explore the magmatic evolution of the region and the characteristics of the magmatic system. The results show two species of pyroxene in the white pumice (clinopyroxene and orthopyroxene) but only one in the black pumice (orthopyroxene). Many isomorphic replacements among the cations occurred during clinopyroxene crystallization. Clinopyroxene-melt thermobarometry yielded a temperature of 847–988°C and a pressure of 2.73–7.42 kbar, which vary considerably and correspond to a maximum depth of approximately 24 km. All of the orthopyroxenes in both the white and black pumice crystallized at similarly varied pressures ranging from 0.67 to 4.59 kbar, which correspond to a maximum depth of approximately 15 km. According to the seimic velocity data, clinopyroxenes crystallized mainly in the lower crust, whereas orthopyroxenes formed at the boundary depth between the upper crust and the lower crust. The similarities in the pyroxene chemical compositions and the whole-rock characteristics between the two types of pumice indicate that both types of pumice are linked to the same magmatic system at depth. The pyroxenes crystallized from genetically related melts within a magmatic system that had undergone various degrees of differentiation. The physicochemical characteristics of the pyroxenes show that the magma chamber module changed during the crystallization process from clinopyroxenes to orthopyroxenes. This change most likely resulted from local characteristics of the nearsurface structure. These observations support the model of a ‘two-layered magma chamber’ in the northern Okinawa Trough.