Low water content in the mantle source of the Hainan plume as a factor inhibiting the formation of a large igneous province

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Large igneous provinces (LIPs) are generally considered to be related to mantle plumes and to have a great importance to the supercontinent break-up events, climate change and biological evolution over Earth's history. The high melt production rates of LIPs can be achieved under rigorous melting conditions: an abnormally high temperature, substantial decompression, addition of fusible components, or remarkable enrichment in water. Although it has been repeatedly noticed that water enrichment has occurred in many Phanerozoic LIPs, the significance of water enrichment in the mantle source for the generation of LIPs has not been explicitly highlighted. The southeastern Asian basalt province (SABP), which is thought to have formed by the Hainan mantle plume, was emplaced over a small area of about 0.037 Mkm^2 over a long period of time from 28.5 Ma to Holocene, thus differing from a typical LIP (>0.1 Mkm^3 in volume emplaced in one or multiple pulses of less than 5 Ma). In this work, we measured H_2O contents of high-Mg# clinopyroxene phenocrysts (12–179 ppm H_2O) from Cenozoic basalts in the northern Hainan Island, which is part of the SABP. These data were utilized to estimate the water content of the mantle source of these basalts, yielding values in the range of 84–360 ppm H_2O, which are significantly lower than those obtained for many Phanerozoic LIPs (thousands of ppm). The chemical compositions of olivine phenocrysts and bulk rocks indicate involvement of pyroxenite in the generation of SABP basalts. After calculating the mantle potential temperature for the Hainan basalts about 170 °C higher than that for the MORB source mantle, we consider that the paucity of source water likely depressed the melt productivity and the velocity of plume upwelling, and induced the Hainan plume to stall at depths of 350-500 km, inhibiting the formation of a LIP by the Hainan plume, despite the occurrence of other favorable conditions. Hence, our results from the SABP provide evidence for the significance of water enrichment in the mantle source in the formation of LIPs. The low water content in the Hainan plume can be attributed to the incorporation of subducted slabs that had experienced significant dehydration.