American Mineralogist, Volume 100, pages 2509–2517, 2015

The magma plumbing system of the Emeishan large igneous province and its role in basaltic magma differentiation in a continental setting

Yan Tao[1,*], Keith Putirka[2], Rui-Zhong Hu[1] and Chusi Li[3]

[1]State Key Laboratory of Ore Deposit Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, Guiyang, 550002, China
[2]California State University, Fresno, Department of Earth and Environmental Sciences, 2576 E. San Ramon Avenue, MS/ST25, Fresno, California 93740, U.S.A.
[3]Department of Geological Sciences, Indiana University, Bloomington, Indiana 47405, U.S.A.

Abstract

Magmatic activity of the Emeishan large igneous province (ELIP) of SW China is one of the most significant geological events of the late Paleozoic. The large volume flood basalts plus rare picrites were erupted in Late Permian. Previous studies indicate that the basalts are the derivatives of primary mantle-derived magma by fractional crystallization, but the depths at which this process took place remain unknown. To answer this question, we use phenocryst compositions and mineral-liquid thermobarometers to determine the *P-T* conditions of the magma reservoirs where crystallization occurred, then use these data to reconstruct the magma plumbing system of the igneous province. Thermobarometric calculations show that most picrite-hosted clinopyroxene phenocrysts crystallized at ~25 km and 1200–1280 °C, whereas most basalt-hosted clinopyroxene phenocrysts crystallized at depths <20 km and temperatures <1200 °C. Some picrites containing primitive olivine with Fo up to Fo92 likely formed by eruption of the most primitive magma with composition similar to the primary magma from the deepest reservoir possibly at the Moho. Parental magmas yield mantle potential temperatures of 1740–1810 °C, which are the highest such temperatures yet recorded for terrestrial magmas of any age. Less primitive picrites containing both olivine and clinopyroxene phenocrysts formed by eruption of moderately fractionated magma from a reservoir in the middle crust. Basalts and basaltic andesites formed by eruption of the most fractionated magmas from the reservoirs in the upper crust, coinciding with the depths of coeval sulfide ore-bearing and Fe-Ti-V oxide ore-bearing mafic-ultramafic intrusions. The reason that the Emeishan volcanic sequence is dominated by basalts is because most of the mantle-derived magma was trapped in the middle and upper crusts, undergoing variable degrees of crystal fractionation plus crustal contamination before eruption. Primitive picrites are rare because their eruption requires a trans-lithosphere conduit, which is difficult to create and maintain due to increasing lithospheric pressure with depth. The results from this study reveal that magma reservoirs at the crustal levels play a critical role in magma differentiation in a continental setting.

Keywords: Magma plumbing system, flood basalt province, clinopyroxene phenocrysts, thermobarometer, magma differentiation, Emeishan