Late Permian basalts in the northwestern Sichuan Basin, SW China: Implications for the geodynamics and thermal effect of the Emeishan mantle plume

Xiaoyu Liu and Nansheng Qiu
College of Geosciences, China University of Petroleum-Beijing, Beijing, China (liuxiaoyucup@163.com)

The Middle-Late Permian Emeishan large igneous province (ELIP), located in the western margin of Yangtze craton, SW China, is regarded as the result of the impingement of a mantle plume onto the lithosphere. However, little is known about the petrogenesis of Late Permian basalts in Sichuan Basin, which were previously considered to be located outside the ELIP. Here we report new petrographic, major elements, trace elements and isotopic data (Sr-Nd-Pb) for Late Permian basalts in the boreholes from the northwestern Sichuan Basin. These basaltic rocks are characterized by low SiO$_2$ contents (47.17-49.40 wt.%), high TiO$_2$ contents (3.38-4.11 wt.%) and Ti/Y ratio (539-639), moderate total alkalis contents (Na$_2$O+K$_2$O, 3.36-6.01 wt.%) and Mg$^#$ values (40.93-46.04), which geochemically resemble the Emeishan high-Ti basalts. These rocks are enriched in large ion lithophile elements (LILEs) and light rare earth elements (LREE), and have (La/Yb)$_N$ ranging from 9.95 to 11.78, showing that typical oceanic island basalt (OIB)-like normalized patterns. The fractionation of MREE to HREE suggests that the basalts were generated by low degree of partial melting within the garnet stability field. Low initial $^{87}$Sr/$^{86}$Sr ratios (0.70572-0.70676; t=260 Ma), Pb isotopic ratios [$^{206}$Pb/$^{204}$Pb$_i$ (18.062-18.637), $^{207}$Pb/$^{204}$Pb$_i$ (15.574-15.641), $^{208}$Pb/$^{204}$Pb$_i$ (38.33-38.98)], and slightly high εNd(t) values (-0.03 to +1.34) indicate that the magma formed from a deep mantle source that may possibly be a mantle plume and have negligibly been affected by crustal contamination. This inference is further supported by high Nb/U ratios (20.56-25.70), low Th/Nb (0.17-0.19) and Th/Ta ratios (2.77-3.14), and no visible Nb and Ta anomalies. In addition, thermal history reconstruction using paleogeothermal indicators in the study area shows that the Lower Paleozoic to Middle Permian formations experienced an intensive thermal event and abnormal high heat flow value reached 118.0 mW/m$^2$ at the Late Permian, which may be due to the mantle plume magma upwelling. The geochemical and geothermal characteristics all demonstrate that these basalts were probably generated in response to the Emeishan mantle plume. Thus, we conclude that the ELIP may have larger areal extent and has been played an important role on the thermal evolution of source rocks in the Sichuan basin.