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Evolution of continental crust in the Paleoproterozoic Birimian-Eburnean Orogeny

FELIX AIDOO[1], SHAO-BING ZHANG[2] AND PROSPER MACKENZIE NUDE[3]

[1]University of Science and Technology of China
[2]CAS Key Laboratory of Crust-Mantle Materials and Environments, School of Earth and Space Sciences, University of Science and Technology of China
[3]University of Ghana, School of Physical and Mathematical Sciences, Department of Earth Science, Legon

Presenting Author: f.aidoo@gaecgh.org

To understand how the continental crust was formed and evolved during the assembly of the oldest known supercontinent, the Columbia, a combined petrology, geochemistry and geochronology study was conducted on Paleoproterozoic rocks from the eastern margin of the West African craton in SE Ghana. This area is postulated to have been affected by the Birimian-Eburnean Orogen which welded the African and South American continents. Samples collected consist of orthogneisses and high-K metagranites. All the rocks are calc-alkaline, metaluminous to weakly peraluminous, and display trace element patterns characterized by high LREEs and LILEs, and low HREEs and HFSE. The orthogneisses show negative to weakly positive Eu anomaly (Eu/Eu*=0.68-1.44), high Sr/Y (11-115), $(La/Yb)_N$ (10-104) and Nb/Ta (11-50). The metagranites exhibit significant positive Eu anomaly (Eu/Eu*=1.25-7.20), with higher Sr/Y (73-369) and $(La/Yb)_N$ (42-288), and lower Nb/Ta (19-42). The geochemistry of the metagranites can be compared to the transitional TTG-like potassic granitoids. Zircon U-Pb dating of the orthogneisses and metagranites yield 2.15-2.11 Ga and 2.12-2.10 Ga, respectively. Both rock suites mostly preserve subchondritic zircon Lu-Hf isotope signature with $\varepsilon_{Hf}(t)$ values of -10.6 to -1.7 and -11.1 to -1.6 for the orthogneisses and metagranites, respectively. A few inherited zircons from the metagranites yield ca. 2.6 Ga with $\varepsilon_{Hf}(t)$ of +1.5 to +1.9. In addition, all the samples preserve similar oxygen isotope compositions with $\delta^{18}O$ values of 9.0-9.9 ‰ for quartz, 5.8-7.6 ‰ for zircon, and 7.3-8.5 ‰ for whole-rock. These imply that both the orthogneisses and metagranites are Paleoproterozoic rocks derived from melting of a common Archaean source. Theoretical modelling results of partial melting suggest that the orthogneisses and metagranites derived from partial melting of metabasalt in the lower crust depth (<35 km) at a pressure <1.0 GPa, and thickened lower crust depth (>50 km) at a pressure of about 1.5 GPa, respectively. This marks significant crustal thickening as a result of collision between the Birimian arc and unknown Archaean terrane to the east possibly, now the Dahomeyide Belt. Remelting of Archaean crust in the thickened Paleoproterozoic Orogeny suggests that crustal reworking analogous to the present-day Himalayan Orogen began at least 2.1 Gyr ago.