Geochemistry and tectonic setting of gabbroic and pyroxenitic rocks from the southern Ashanti greenstone belt, Ghana

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The tectonic setting in which the Paleoproterozoic juvenile crust of the West African craton was formed has long been contested, with two main models emerging in recent years: plume vs. arc-related magmatism. Most of the models are explained by the volcanic rocks in the greenstone belts, with minor contributions from the sedimentary rocks and granitoids. The associated mafic-ultramafic intrusives have received little attention, though they are crucial for unraveling the geodynamic evolution of the greenstone belts.

We present geochemical data on gabbroic and pyroxenitic rocks from the Axim-Aketakyi area of the southern Ashanti greenstone belt of Ghana, and infer the tectonic setting in which they were formed. Apart from the largest mafic-ultramafic body which has been interpreted as a Paleoproterozoic supra-subduction zone ophiolitic complex, the geochemistry of the other mafic-ultramafic rocks is poorly documented.

The gabbros consist of plagioclase, pyroxene and hornblende, and accessory minerals include apatite, magnetite, ilmenite and sphene. The pyroxenites contain pyroxenes which are either partially or completely replaced by actinolite or talc. Accessory minerals include apatite and ilmenite and magnetite. Some varieties contain hornblende and plagioclase.

The analyzed gabbros have SiO2, MgO and TiO2 contents of 45.1-51.8 wt.%, 6.81-11.5 wt.% and 0.21-1.10 wt.%, respectively, Mg numbers of 45-68, Ni contents of 140-270ppm contents and Cr contents of 270-880ppm. They show slightly LREE-depleted and -enriched patterns, $(La/Sm)_N$ =0.43-2.64, $(La/Yb)_N$=0.25-5.76, with minor negative to strong positive Eu anomalies ($Eu/Eu*$=0.94-1.87). On the primitive mantle-normalized, trace element diagram, the gabbros show enrichment in LILE relative to HFSE and in LREE relative to HREE, with Th-U trough, negative Nb, Zr-Hf and Ti anomalies, and spikes in Sr (and Pb).

The pyroxenites have SiO2, TiO2 and MgO contents of 48.7-50.5 wt.%, 0.54-0.78 wt.% and 7.98-12.6 wt.%, respectively, and low Mg numbers of 63-74 with Ni contents of 170-520ppm and Cr of 630-1580ppm. The trace element geochemistry reveals two types of pyroxenites. The Type I pyroxenites show LREE enrichment patterns with $(La/Sm)_N$= 1.16-1.70, $(La/Yb)_N$=1.94-2.34, minor positive Eu anomalies of 1.09-1.17, minor Ce anomalies of 0.98-1.03 and total REE contents of 28.1-32.8ppm. The Type II pyroxenites also show fractionated REE patterns with $(La/Sm)_N$=1.20-1.47, $(La/Yb)_N$=1.06-2.55, Eu anomalies of 0.99-1.03, significant negative Ce anomalies of 0.53-0.88 and relatively higher total REE contents of 57.1-124ppm. The pyroxenites are characterized by enrichment in LILE relative to HFSE and in LREE relative to HREE. The Type I pyroxenites show Th-U and Nb-Ta troughs, positive Sr anomalies and minor negative Zr-Hf and Ti anomalies, whereas the Type II pyroxenites exhibit negative Th anomalies, pronounced negative Nb, Zr-Hf and Ti anomalies, and spikes in Sr.

The LILE and LREE enrichment and HFSE depletion indicate involvement of subduction-related components. Some of these geochemical signatures could also be exhibited by intracontinental, rift related magmas derived from a subduction-modified lithospheric mantle or reflect inherited features of crustal rocks. Nevertheless, the negative Zr-Hf anomalies are inconsistent with crustal contamination, as crustal materials are enriched in elements such as Th, Pb, Zr, Hf, etc. Also, the negative Zr-Hf and Nb (and Ta) anomalies argue against oceanic island basalt (OIB) component in the source region of the rocks, as OIB is enriched in Nb and Ta, and negative Zr-Hf anomalies are not common among intraplate basaltic magmas. Rather, the geochemical signatures of the gabbros and the pyroxenites are similar to those of island arc intrusions. We contend that the mafic to ultramafic intrusions in the studied area were not plume-generated but were derived from arc-related magmatism during the Paleoproterozoic.