Petrology and Geochemistry of Aketakyi Ultramafic Complex from the Paleoproterozoic Southern Ashanti Greenstone Belt of Ghana

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The Paleoproterozoic "Birimian" (ca. 2.1 Ga) ultramafic-mafic rocks and granitoids are believed to provide evidence for juvenile crust-forming events near the Archaean-Proterozoic boundary. Consequential as these ultramafic-mafic intrusives may be to our understanding of the geodynamic evolution of the Paleoproterozoic terrane of the West African craton (WAC), they have not received much attention. The Paleoproterozoic Aketakyi ultramafic-mafic rocks which are associated with the volcano-sedimentary-granitoid rocks in the Paleoproterozoic southern Ashanti greenstone belt of Ghana have been studied for their petrological, mineralogical characteristics and whole-rock geochemical compositions. The data obtained are discussed in the petrogenetic and geotectonic context.

The studied Aketakyi ultramafic complex (UMC) is made up of mainly cumulate harzburgite, dunites, pyroxenites and gabbros. Primary minerals in the rocks include olivine, pyroxene and amphibole. Olivine occurs as oval and subrounded crystals that are commonly serpentinized. Both brown and green amphiboles are present in the rocks with brown amphibole oikocrysts occurring mostly as a postcumulus phase, enclosing serpentinized olivine and sometimes pyroxene. Secondary minerals include actinolite, chlorite and tremolite. Chromite and magnetite commonly occur in the rocks, and ilmenite occurs as anhedral minerals in some of the rocks. Representative olivine grains from the cumulate peridotites are compositionally unzoned and show a limited compositional range of Fo_{84}-Fo_{82} at grain centers.

The clinopyoxene in the serpentinized peridotites is mostly diopside. The brown primary amphibole is mostly tschermakitic hornblende in composition. The analyzed serpentine minerals are mainly antigorite, suggesting that the parent minerals of the serpentines were first retrogressed to form lizardite and chrysotile, followed by progressive metamorphism.

The analyzed rocks have SiO2, K2O, TiO2, MgO, Al2O3 and CaO contents of 42.3-53.7 wt.%, 0.0-0.07 wt.%, 0.09-0.61 wt.%, 15.1-36.5 wt.%, 2.75-11.8 wt.% and 2.20-13.5 wt.%, respectively. The ultramafic-mafic rocks are characterized by moderate to high Mg numbers ranging from 72 to 84 with Ni contents of 710-1650 ppm, and Cr of 1590-3940 ppm. The Al2O3-CaO-MgO compositions of the analyzed rocks suggest that they are ophiolitic cumulates. The ultramafic-mafic rocks display LREE-depleted to flat, chondrite-normalized REE patterns [$(La/Sm)_N$= 0.32-1.16; $(La/Yb)_N$= 0.16-1.16] with no to minor positive Eu anomalies and with total REE contents ranging from 1.71 to 22.3 ppm. The positive Eu anomalies observed in some of the rocks suggest that plagioclase was a cumulative phase in the formation of those rocks. On the primitive mantle-normalized, trace element diagram, they show enrichment in Cs, slightly negative Th and Nb anomalies, and variable but minor positive and negative Sr, Hf and Ti anomalies.

The early crystallization of pyroxenes and the low TiO2 content of the clinopyroxenes (0.01-0.14 wt.%) indicate that their parental magma was generated by a moderate to high degree of partial melting. Also, the occurrence of primary magmatic amphibole suggests the involvement of relatively high water contents in the parental magma and is indicative of hydrous partial melting of a mantle source which had previously been metasomatized. The parent magma of the Aketakyi UMC is a high magnesian (mafic) magma, probably juvenile lithospheric mantle-derived basalt, which has undergone extensive crystal fractionation.

In conclusion, petrological and mineralogical characteristics, and the trace element signatures as well as the field relations of the Aketakyi UMC show that the rocks were formed in a supra-subduction zone environment. This is consistent with the island arc complex model that the Paleoproterozoic terranes of West Africa evolved through subduction-accretion processes.