Petrographic and geochemical study of Birimian mafic and ultramafic complexes of the Mako super-group (eastern Senegal)

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The Birimian magmatic formations (except granitoids) of the Mako super-group (Eastern Senegal) were analyzed in the Mako village sector, a key sector where ultramafic series are notably exposed. These magmatic formations are represented by: i) mafic series, the most abundant, consisting of pillow basalts, massive basalts and gabbros which form either homogeneous masses sometimes associated with basalts, or bodies bordering ultramafic rocks, or veins intersecting the other facies; these mafic series are found in enclaves within the granitoids; ii) differentiated ultramafic rocks composed of several types of rocks (lherzolite, harzburgite, clinopyroxenite) in plurikilometric massifs (Lamé massif) where they appear as monocrystalline bodies (wehrlite or lherzolite) as in Mako, Lamé, Koulountou and Sofia ; ultrabasic rocks form scales within the mafic series; (iii) mafic to differentiated volcanic rocks (basalts, andesites, dacites, rhyolites) outcropping in the form of metamorphic to decametric veins intersecting previous mafic and ultramafic rocks. These veins with the exception of rhyolites contain centimetric enclaves at decametric of gabbros. The different series are affected by a schistosity underlined through a paragenesis of greenschist facies marked by the development of sericite, chlorite, epidote, amphibole of actinote type, quartz and albite.

The geochemical study of magmatic minerals (chromites, olivines, clinopyroxenes, orthopyroxenes, amphiboles) and rocks made it possible to distinguish two magmatic series: i) a tholeiitic series and ii) a calc-alkaline series. The tholeiitic series is double with two sub-series called tholeiites 1 and tholeiites 2 each consisting of ultramafic rocks, gabbros and basalts. These three lines (tholeiites 1, tholeiites 2 and calco-alkaline) are evidenced from the rare earth spectra of rocks. Tholeiites 1 have an almost flat rare earth spectrum (LaN/SmN=0.74-1.14 and LaN/YbN=0.82-2.05), whereas tholeiites 2 are more enriched in light TR (LaN/SmN=1.25-1.75) and show a more pronounced light/heavy TR fractionation (LaN/YbN=2.04-3.71). The calc-alkaline series, clearly identified in the field by its veinic volcanic nature intersecting tholeiitic rocks, is more enriched in light TR (LaN/SmN=2.06-3.51) and poorer in heavy TR with more sloping spectra (LaN/YbN=4.70-13.97). These geochemical characteristics are confirmed by the isotopic data. The tholeiitic series 1 (n=22) has a mean initial isotopic composition characterized by 87Sr / 86Sr=0.701736 ± 10 and εNd (2.1 Ga)=3.51 ± 0.01. The tholeiitic series 2 (n=14) has a mean initial isotopic composition characterized by $^{87}Sr/^{86}Sr$=0.702601 ± 19 and εNd (2.1 Ga)=3.05 ± 0.01. Finally, the calc-alkaline series (n=7) has a calculated mean initial isotopic signature of $^{87}Sr/^{86}Sr$=0.702090 ± 9 and εNd (2.1 Ga)=2.70 ± 0.02. The isotopic and trace elements data show a magmatic evolution from a depressed source (tholeiites 1) to a more enriched source represented by tholeiites 2 and calc-alkalis, respectively.

The analysis of the tholeiitic and calc-alkaline magmatism in the Mako sector makes it possible to envisage for the Birimian series an evolution from a geodynamic context of frank oceanic type or back-arc type towards a subduction environment.

Keywords: Birimian, Mako supergroup, isotopes, trace elements, calc-alkaline, oceanic basin, subduction