Geochemistry and Mineral Chemistry of Amphibolites in Parts of the Proterozoic Ilesa Schist Belt, Southwestern Nigeria

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Abstract

We conducted a study of the amphibolites of Itagunmodi-Igun area within the Ilesa Schist Belt to determine their petrochemical affinities and pressure–temperature conditions of formation. The amphibolites of the area are massive and comprise magnesio-hornblende, actinolite, labradorite, albite, and accessory titanite. The major and trace element characteristics revealed that they are ortho-amphibolites with tholeiitic and calc-alkaline affinities, plotting in Within-Plate Basalt field of the Zr versus Zr/Y diagram. Plagioclase-hornblende thermobarometry constrained the temperature of formation of the amphibolites to 450-6870C and pressure of 0.5–4.3 kbar. Further, the average pressure of the formation corresponds to approximately 6.6–7.4 km depth of emplacement for the amphibolite.

Keywords

Itagunmodi-Igun • Ortho-amphibolite • Within-Plate Basalt • Magnesio-hornblende • Plagioclase-hornblende thermobarometry

1 Introduction

Itagunmodi and Igun areas occur within the Ilesa Schist Belt; a prominent feature of the basement geology of southwestern Nigeria believed to have been formed in a back-arc basin setting which developed after the beginning of subduction at the margin of the West African Craton ca. 1000 Ma ago. Pelitic and semi-pelitic schists, quartzites, marbles, gneisses, phyllites, banded iron formation (BIF), and amphibolites make up the geology of the Nigerian Schist Belts. The amphibolites are best exposed and most extensive in the Ilesa area (Elueze 1988); experiencing multiple deformations and metamorphism episodes. Petrographic, structural and geochemical studies have been conducted on the am-phibolites in parts of the Ilesa area. However, their petrochemical affinity and pressure–temperature (PT) conditions of formation of amphibolites of Itagunmodi-Igun area (7°30″–7°35″ N and 4°37″–4°42″ E) have not been determined. Petrographic and whole-rock chemical studies, as well as studies on the chemistry of amphibole and plagioclase in the amphibolites of Itagunmodi-Igun area, have been carried out in order to determine the origin, tectonic setting, and P–T conditions during metamorphism.

2 Methodology

Nineteen rock samples were collected and studied by petrographic methods under a transmitted light polarizing microscope at the Department of Earth Sciences, University of the Western Cape, South Africa. Seven samples mounted in polished 1″ epoxy discs at the University of Free State, South Africa, were analyzed for amphibole and plagioclase chemistry using the scanning electron microscopy-energy dispersive/wavelength dispersive X-ray (SEM-EDX/WDX) technique on a Zeiss EVO MA 15 spectrometer housed at the Central Analytical Facility of Stellenbosch University, South Africa. Whole-rock geochemical analysis of pulverized rock samples was done at Bureau Veritas Pty Ltd., Vancouver, using Lithium Metaborate digestion.

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3 Results

3.1 Geologic Setting and Petrography

The Itagunmodi-Igun area consists of amphibolite, talc-chlorite schist, quartzite, and quartz-biotite schist. Hand specimens of the amphibolites are green to greyish-green and fine-grained with plagioclase seen as aggregates in some of the outcrops.

In thin sections, rocks consist of hornblende as it is the most abundant mineral, with subordinate actinolite, plagioclase, and epidote. They also contained accessory titanite with minor opaques. The alteration was evident in some samples with amphibole and plagioclase replaced by epidote. The amphibolites contain 63–72% amphibole (hornblende plus actinolite), 11–20% plagioclase, 8–15% epidote, with quartz and opaque minerals averaging 3.45% and 3.75%, respectively.

3.2 Geochemistry

The CaO-MgO-Fe_2O_3 diagram reveals the amphibolite is an ortho-amphibolite, and all samples plotted in the field of basalt on the Cr versus Ni plot. Cr/Ni ratios range from 2.07 to 2.80; with an average of 2.30; characteristic of basaltic rocks. CaO + MgO values for the rocks range from 12.12 to 17.71; within the 12% < CaO + MgO < 20% range of Pearce rocks commonly classified as basalts (Table 1).sss

The Itagunmodi-Igun amphibolites produce a more tholeiitic than alkaline basalt trend on the Zr/P_2O_5 versus Nb/Y plot (Fig. 1). The majority of the samples plotted within the Within-Plate Basalt (WPB) field of the Zr versus TiO_2 plot of Pearce, while few plotted within the field of Mid-Oceanic Ridge Basalt.

3.3 Amphibole and Plagioclase Chemistry

Mainly of the calcic group, the amphiboles are predominantly magnesio-hornblende, with subordinate actinolite and accessory edenite, winchite, glaucophane, and barroisite. The plagioclases vary in composition from labradorite to albite, with An-content: 6.90–58.98.

An estimation of PT of formation (plagioclase-hornblende thermobarometer) yielded a temperature of 450–687 °C (Holland and Blundy 1994) and 561–666 °C (Blundy and Holland 1990), using an arbitrary pressure of 2 kbar. With the Holland and Blundy (1994) calibration, a temperature range of 456–683 °C with pressure 0.7–4.3 kbar were obtained. Blundy and Holland (1990) calibrations yielded temperature and pressure ranges of 578–642 °C and 0.5–4.3 kbar, respectively.

4 Discussion

It is believed that Basaltic suites spanning the MORB and WPB fields on the Zr versus TiO_2 plot were formed in environments transitional between the two settings. The amphiboles fall within the biotite zone and lower garnet zone, and are also of the medium pressure amphibole class. The An7—59 content of the plagioclases is suggestive of the temperature of formation $\geq 500^0$C. The calculated PT values

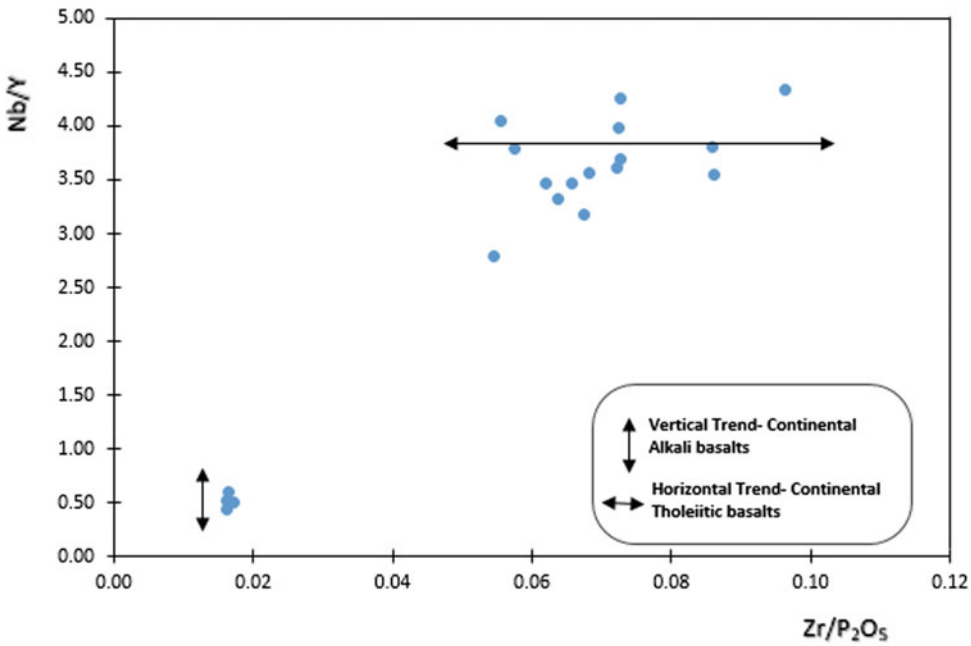

Fig. 1 Vertical and horizontal trends of Continental alkali and tholeiitic basalts on the Nb/Y–Zr/P_2O_5 plot

Table 1 Summary of major and trace element composition of Itagunmodi-Igun amphibolites

Oxide (%)	Range	Average
SiO_2	49.67–55.66	53.27
Al_2O_3	12.13–14.74	13.08
Fe_2O_3	7.75–11.15	10.13
MgO	6.42–7.24	6.70
CaO	5.70–10.96	8.90
Na_2O	***1.00–2.33***	***1.34***
K_2O	***0.66–6.66***	***2.22***
CaO + MgO	12.12–17.71	14.68
Trace elements (ppm)		
Rb	20–242	71.76
Sr	482–916	609.22
Y	21–31	26.83
Nb	10–115	83.15
Y/Nb	0.23–2.30	0.63
Rb/Sr	0.03–0.27	0.10

fall within the range of estimated values associated with the formation of rocks of the Amphibolite Facies. The average pressure of formation (i.e. 1.8kbar [Holland and Blundy 1994; Blundy and Holland 1990]) corresponds to an approximately 6.6–7.4 km depth of emplacement for the amphibolites.

5 Conclusions

The amphibolites contain magnesio-hornblende, actinolite, epidote, labradorite, albite with accessory titanite and opaques. They are ortho-amphibolites of tholeiitic and calc-alkalic affinities, likely derived from different source magmas and plotted in Within-Plate-Basalt tectonic field. Thermobarometric calculations constrained the temperature of their formation to 450-6870C and pressure 0.5–4.3 kbar, within the range of estimated values associated with the Amphibolite Facies.

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