

GEOLOGY AND MINERALIZATION OF BIKILAL PHOSPHATE DEPOSIT, WESTERN ETHIOPIA, IMPLICATION AND OUTLINE OF GABBRO INTRUSION TO EAST AFRICA ZONE.

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ABSTRACT

The Bikilal layered gabbro-complex is composed of zones/layers/ of olivine/ pyroxene gabbro and hornblende gabbro. Within the hornblende gabbro, repeated lenses-like thin and elongated bodies of hornblendite are found intimately associated with massive and disseminated ilmenite-magnetite bodies, in places with apatite. Petrological examination of the hornblende gabbro shows 50-55% hornblende, 40-45% plagioclase, 5-7% opaque minerals/ilmenite +

magnetite/, and 5-15% apatite and that of hornblendite shows 75% hornblende, 10-15% apatite, 10-15% ilmenite and rare sulphides, and traces of Uranium. Regardless of the type of lithological units, entirely based on phosphate (P₂O₅) assay values of chip, channel and, core samples, two main zones of phosphate mineralization, upper and lower zones, were identified and delineated.

The strike length of the upper zone is measured to be 1600m. There are two thin layers of phosphate mineralization in the upper zone, at which the average thickness of each layer to be 30m and 40m respectively. The strike length of the lower zone measured to be 3000m having a thickness within a range of 60m to 200m. The minable reserve of Soji-Bikilal phosphate deposit to be 181 million tons, at a grade of 3.5% P₂O₅. Preliminary beneficiation trial reveals merchant grade concentrate, at which the overall weight recoveries is in the range of 3-5%.

The Radioactivity of Uranium is not determined and hence reevaluation of the phosphate rock for Uranium content should be analyzed.

Similar Gabbros intrusions occur in Western Ethiopia and in East Africa which should be assessed for phosphate potential to develop the fertilizer potential of the East Africa Region.

Key words; *Phosphate; Apatite; Hornblende gabbro; Hornblendite; Soji Bikilal;*

INTRODUCTION

A project was initiated to assess and locate local phosphate resources in Ethiopia.

Investigations were made on some of the potential resources of phosphate, namely, the esozoic-Cenozoic rocks, the Precambrian metasedimentary sequences and the intrusive rocks of alkaline basic- ultrabasic rocks. Consequently, the Bikilal layered gabbro complex has been found promising and systematic exploration activities for apatite were conducted on it since 1986. Soji-Bikilal is located in western Welega zone of the Oromia National Regional State, 24-km NNE of Gimbi town. Gimbi is 440 km west of Addis Abeba. The project area is geographically bounded between 35°52'37"E - 35°53'41"E, and 9°18'30"N - 9°19'42"N.

As a result of successive geological exploration works, a target area of 4 km² was selected and 18 profile lines of 200 m. spacing were cut and a number of pits dug at an interval of 40 m. along the lines. Fifteen trenches were also excavated between the profile lines to confirm the strike continuity of the apatite bearing bodies (Wondafrash Mamo, 1997).

Drilling work was started with a Purpose to determine the strike, dip angle and direction as well as thickness of the apatite-bearing hornblende gabbro and hornblendite units on the selected upper and lower zones of the target area, along with the core sampling for chemical analysis, petrographic study and mineral separation trials.

A total of thirty boreholes were drilled to a total meterage of 7159.73Lm. and 5534 core samples were collected.

Two strategies were designed to determine the strike and dip of the lithological units, which were the bases to decide the angle and azimuth of drilling. The drilling work was conducted by truck mounted drilling rigs fit with diamond bits. As the area is covered by gabbroic complex and the dip vary from place to place within a shorter distance, so the attitudes of the lithology need to be determined prior to intensive drilling. “Three point problem method” is applied to determine the strike and dip of the lithological units of the upper zone while, “intersection angle measurement method” applied for the lower zone to determine the dipping of the lithology.

The average dip angle is calculated to be 43° towards 225° (SW) and the strike measured to be 315° – 135° (NW-SE). Accordingly 10 vertical boreholes were drilled, at an interval of 70mts following the strike and down dip of the apatite bearing lithology of the upper zone.

Concerning the lower zone, a vertical test borehole designated as BK 603, and an inclined test borehole, BK604, were drilled to determine the dipping of the lithology of the lower zone by an intersection angle measurement method. Shallow angle of intersection (15°- 20°) were measured from the core samples of the vertical test borehole, while an 4

intersection angle ranging from 45°-50° were measured from the core samples of the inclined test borehole. This implies that the dipping of the lithology in the lower zone to be steep (70°-75°).

Therefore, it is decided to drill the successive boreholes at 60° inclination, so as to intersect different lithological units, with a minimum depth of drilling.

Accordingly, 15 inclined boreholes were drilled at 60° inclination towards N and NE azimuth, following the strike of the apatite bearing lithology of the lower zone, at a spacing of 200m.

Description of each lithological units supported by petrological examination are described as follows; Pegmatites, Olivine/pyroxene Gabbro, Hornblende Gabbro (Apatite Bearing Gabbro and Apatite bearing Hornblendite), Anorthosite and Metasediment.

Apatite bearing hornblende Gabbro

The major apatite-bearing hornblende gabbro bodies are distributed at the southwestern and northern part of the project area, with an E-W, NW-SE and N-S strike and southerly and south westerly dip at 40°-45°, on the southwestern part and at 70°-75° on the central northern and northeastern part of the target area.

The unit is generally greenish grey with an average grain-size of 2-3 mm /mediumgrained/.

It varies from mesocratic to melanocratic with an average mineral composition of 50-55 % hornblende, 40-45 % plagioclase, 5-15 % apatite, 5-7 % ilmenite+magnetite, and rare sulphides. The melanocratic variety is the dominant lithological unit in the lower zone and is the chief host for apatite mineralization, where the apatite content reaches up to 15%. The mesocratic variety is more common on the upper zone and with relatively less content of apatite, usually not exceeding 5-7 % (Gallon, 1997)

Plate-1 Excavation of Trenching on Phosphate Rock Area

Apatite bearing hornblendite

The major apatite bearing hornblendite bodies are distributed at the central and southeastern part of the target area.

The apatite-bearing hornblendite is dark-greenishgrey, and is very fine grained < 1 mm/.

It generally shows orientation of minerals and banding but is rarely massive. It occurs as concordant, elongated, subparallel lenticular bodies of variable dimension separated by 5 meso-melanocratic hornblende gabbro. Contacts are usually abrupt but gradational composition is also known. The mineral contents are identified as 75 % hornblende, 10- 15 % apatite, with 10-15 % ilmenite and rare sulphides.

Gray colour and fine-grained apatite-magnetite-ilmenite-trimolite-actinolite-disseminated ore assemblage is restricted in the lower-zone in association with the apatite-bearing hornblendite. In some places such variety is slightly Chloritized in which the chlorite and hornblende intermix together.

Petrological examination of the samples also shows mineral compositions of 70-75 % tremolite-actinolite, 15-18 % ilmenite + magnetite and 5-12 % apatite with hypidioblastic texture (Mineral Science Ltd, 1997).

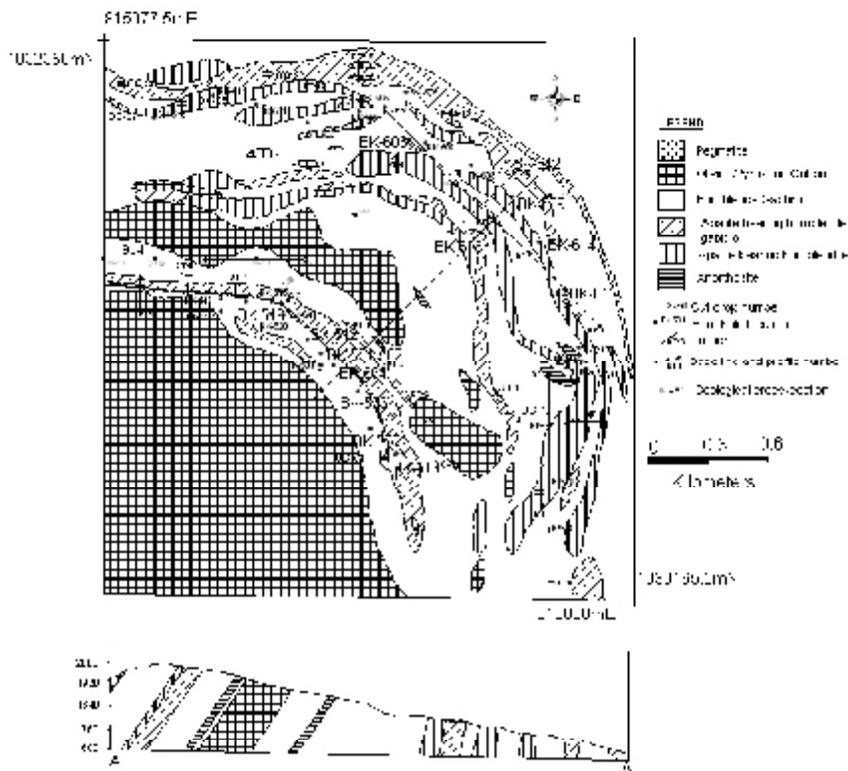


Fig. 1 Geological and Mineralogical Map of phosphate rock area - Dehghani

RESULT AND INTERPRETATION

Geochemistry

The geochemical anomalous zones correspond with the major apatite bearing lithological units of upper and lower zones and the relatively elevated values of P₂O₅, represent patches of

anomalies corresponding with the lenticular apatite-bearing lenses of hornblendite and hornblende gabbro.

Geological mapping has shown that the igneous banding is inward towards the center of the intrusion, and corresponds closely with the swing of the geochemical anomaly. The inference from this is that the apatite mineralization is strata bound (Gallon, 1997).

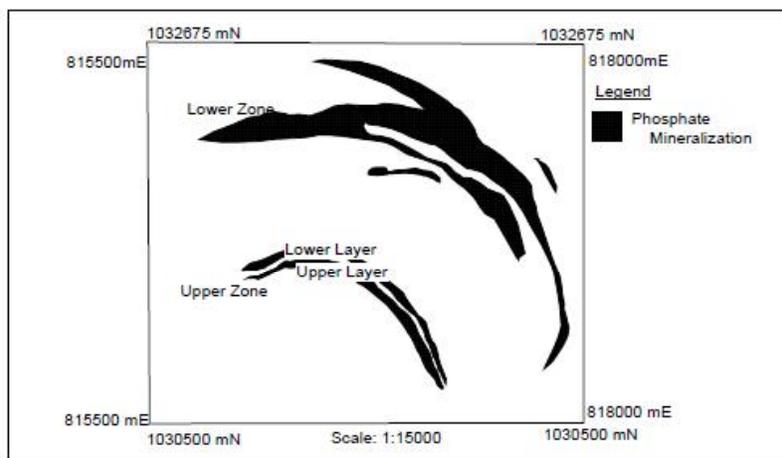


Fig. 2 Zones of phosphate mineralization of Soji-Bikilal. (Extracted from report no.2. Consult 4 int., October 2001)

Considering combined sections of boreholes and trenches, regardless of the lithotype of the lithological units, the P₂O₅ assay values of channel and core samples enabled to delineate two main zones of phosphate mineralization (Fig. 2). The 3D-wire frame of the mineralized layers of both zones is outlined, by applying “Gemcom” software as processed by the consultant.

The P₂O₅ assay values were considered and plotted on each section of boreholes and trenches. The subsurface anomalous values of P₂O₅ were extrapolated and showed two main and one minor layers of phosphate mineralization on the upper zone. The lower layer of the upper zone is identified only on the boreholes sections. Based on surfacial projection of the layer with the calculated dip angle 43° of the upper zone lithology, trench DT2, DT3, DT4 and DT8 were recommended to be extended 60m towards NE and N. The P₂O₅ assay values of channel samples from these trenches have therefore confirmed the surfacial extension of the lower layer. Accordingly the geological and mineralization map is refined.

The strike length of upper zone is measured to be 1600 mt. The thickness of the upper and lower layers of phosphate mineralization is 30m and 40m respectively, separated by a 35m barren zone.

Similar interpretation of the data collected from boreholes and trenches of the lower zone reveals that the southeastern part of the zone reaches a thickness of 60m. In the middle of the strike extent, the zone splits into two with the inner layer being up to 100m thick and the outer layer up to 200m thick, separated by 60m barren zone. In the northwestern end the deposit is over 100m thick. The strike length of the lower zone has been measured to be 3000m (Consult 4 International, interim report No2, 2001) (Fig. 2).

In the upper zone layers, the phosphate grade over the thickness of the layers is fairly consistent with occasional high grade patches and low grade patches. Overall, the upper and lower layers mean grades of the upper zone are 2.35% P₂O₅ and 2.62% P₂O₅ respectively.

In the lower zone, the phosphate grades are generally higher. The northern part of the lower zone is the best mineralized part of the deposit with phosphate grades averaging 3.7% over a width of 160m (Consult 4 international, interim report No.2, 2001). The main phosphate distribution is normal with an excess of low values. The mean grade of this zone is 2.78% P₂O₅.

Magnetite-ilmenite, Sulphide and Calcite are encountered within the different lithological units.

CONCLUSIONS AND RECOMMENDATIONS

As part of the Bikilal layered gabbro-complex, the Soji-Bikilal apatite-bearing zones, in the hornblende gabbro and hornblendite are considered to be promising for igneous phosphate resources.

Apatite concentrations in igneous complexes are mainly confined to carbonatites, some nepheline – syenite complexes and small alkaline ultramafic intrusive complexes.

Buddington and Lindsley, 1964, Lister, 1966, Philpotts, 1967, and Kolker, 1982, have studied the association of apatite with Fe – Ti oxides among others. All researchers studying the association of Fe – Ti oxides and apatite stated that there seems to be a genetic link between the Fe – Ti oxides and apatite mineralization.

Many of the Fe – Ti oxide – apatite mineralization are associated with intrusions of anorthosite, gabbro, pyroxenites, and alkaline rocks. The Soji – Bikilal Fe – Ti – apatite mineralization appears to have many similarities with the known igneous phosphate deposits around the world. For the purpose of comparison, the phalaborwa and schiel igneous complexes of south- Africa are considered and described accordingly.

The Soji-Bikilal phosphate deposit is a low-grade and a high tonnage deposit, at which the average grade of phosphate is within a range of 3.0% - 4.0% P₂O₅.

Regardless of the type of lithological units, entirely based on P₂O₅ assay values of chip, channel and core samples, two main zones of phosphate mineralization are delineated, namely upper and lower zones.

The mineable reserve of Soji Bikilal Phosphate deposit is to be 181 MT, at a grade of 3.5% P₂O₅.

The phalaborwa igneous phosphate deposit is known to be mined since 1930. Apatite has been mined continuously since 1955 by Foskor Ltd. The phosphate ore is extracted from the Loolekop area. The Loolekop body has a carbonatite core which grades outwards into a zone of magnetite – olivine – apatite rich rock called foskorite and then into pyroxenite. The ore reserve exceed 300 Mt at an average grade of 7.45% P₂O₅ (Notholt et. al., 1990, in Wilson, not dated).

The Schiel complex is the largest alkaline plutonic occurrence known in the Northern province of South – Africa. A large deposit of apatite, associated with magnetite and vermiculite, was discovered at Schiel in 1953, and prospected by Foskor between 1965 and 1968. An ore reserve of 36 Mt at 5.1% P₂O₅ was estimated for the weathered zone to a depth of 39.6m. The average phosphate contents found in the diamond – drill cores found to be 7.4% in the Foskorite, 4% in the Pyroxenite, 4.2% in the carbonatite and 1.6% in the syenite within the ore body, (Wilson not dated).

Moreover, the Sukulu (Uganda) carbonatite and the Villa-Nora (South - Africa) basic – layered – gabbro complexes are known similar igneous phosphate deposits, at an average grade of 13.1% P₂O₅ and 6.00% P₂O₅, with reserves of 130 Mt and 25Mt, respectively (Consult 4 international, 2001).

Therefore, the aforementioned information can give a clue about the exploitable grade of phosphate from igneous sources, so that it can be compared with that of Soji – Bikilal phosphate deposit.

Similar Gabbros intrusions occur in Western Ethiopia and in East Africa which should be assessed for phosphate potential to develop the fertilizer potential of the East Africa Region.

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