Petrography Of The Basement Complex Of Maddhapara Mining (Production Level) Dinajpur District, Bangladesh

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Abstract
This research work deals with the petrography of the Palaeoproterozoic Basement Complex (production level) Maddhapara Granite mining project area, Dinajpur district, Bangladesh. Tectonically the study area is a continuation of the Central Indian Tectonic Zone (CITZ), where the Basement Complex is overlain by the Tertiary thin to moderate sediment sequence. The present study has been performed on the basis of collected samples which are taken from the production level at the elevation of about -270m. The rocks of the studied zone are mainly medium to fine grained with some occasionally coarse grained. The color of these rocks is mainly dark to light gray but some pink and white color minerals are also noticed. Both microscopic and megascopic observations suggest that the rock types of the studied zone are quartz diorite, tonalite, granite. The dominant constituent minerals are plagioclase feldspar (27-68%), alkali feldspar (1-18%), quartz (11-46%), biotite (5-6%), hornblende (8-19%) with some accessory minerals like chlorite, sericite, epidote etc. Crystallization temperatures of the dioritic rocks are 680-725˚ C. These rocks are possibly crystallized by processes of fractional crystallization.

Keywords: Petrographic analysis, Lithologic evaluation, Megascopic study

1. Introduction
General
Petrography is the study of rocks in all their aspects, including mineralogy, texture, structure and their relationship to other rocks under microscope. Petrography of the Basement Complex of the study, which is a remnant of Columbia supercontinent. In this point of view, it have been intended to feel the interest on petrography of the Basement rock.

Location, Extent and Accessibility
Maddhapara is situated at the northwestern part of Bangladesh. This area is bounded by the latitudes 25°31' to 25°34'15" N and longitudes 89°03'30" to 89°04'53" E (Fig. 1). The study area is flat one and formed more or less Tableland. The area is drained mainly by local Jamuna River in the west and the Jamuneswary River in the east. Maddhapara Granite mining area is about 13km northeast of Phulbari Thana and connected by a metallic road. Saidpur is the nearest airport. The mine site of Maddhapara is about 54 km and 450 km from Dinajpur and the capital Dhaka respectively (Fig. 1).

Previous work
Several holes were drilled in the northwestern part of Bangladesh for exploratory purpose and some of these are encountered for the Basement rocks. Petrobangla has designed a mining project to extract the Basement rock commercially. Geological Survey of Bangladesh and some other organization are also launching mineral exploration program in this area. North Korean company (NAM-NAM) is construct a hardrock mine which is now in under production of hardrock. Many authors have performed the petrography of the Basement complex including Ahamed (1970), Rahman (1973), Rahman and Sengupta (1980), Hasan (1983), Rahman (1983), Aman et al., (1998), Zaman, N., (2001) and so on. The present research is carried out the petrographical study of the Basement complex of the Production level of Maddhapara mining area, Dinajpur, Bangladesh.

Objectives Of Study
The principle objectives of the study area are as follows-

a) Detailed petrography of different rock types.
b) Mineralogical study to classify the rock types on the basis of modal composition, texture, structure, and other characteristics.
c) To ascertain the possible origin of the studied rock.
d) Evolution of the basement rock in contrast with surrounding areas.

Work Flow Sheet of the Study
General flow chart of the study procedure is given below-
Methods Of Study

Field Study
At the time of field work at Maddhapara mine area the samples are taken at different places as well as at different distances. During sample collection the variation on gross lithology, mineralogy, color, texture etc. are observed. Then the different samples are well packed and numbered. About six (6) samples are chosen for preparation of thin section slide.

Petrography
Thin section preparation
At first rock samples were prepared with 3 cm in length, 2 cm in width and 1cm thickness with adhesive glue. Adhesive glue was prepared by mixing araldite hardener in a ratio of 1:1 and was diluted with toluene to decrease viscosity (glue 30%, toluene 70%). Then the rock samples were pasting the slide with the glue and it kept 24 hours. After evaporation of toluene, the samples become hard. After impregnation, following steps were carried out for the preparation of thin section-

- Pasting rock sample was cutting by the diamond cutter approximately 2 mm in diameter and it was grinding to make less than 1 mm in diameter.
- Then it was grinding on a glass plate successively using 600, 800, 1000, 1200 grade carborandum powder. The thickness of the rock sample was checked regularly using a polarizing microscope until the required thickness (0.003 mm) was gained.
- The rock sample was polished the fine polisher Deagglomerated alumina 0.03 µ and polycrystalline Diamond solution.
- The washed and dried rockslide was then covered by a thin cover slip. Finally the slide was washed by acetone and labeled.

Microscopic Study
Using Research Petrographic Microscope (MEIJI) model ML-PLO-T carried out detail qualitative and quantitative analysis. The presence of different individual minerals and their relative abundance and prominent characteristics were carefully examined from the prepared thin sections.

Lithologic Evaluation
The sedimentary sequence is a function of the geotectonic pulse over long period of time. That is why, the sedimentary sequence of Bogra Slope and Rangpur Saddle differs from one another. Thick continental Gondwana coal bearing sedimentary sequence of mostly Permian age consisting of cross bedded arkosic sandstone, conglomerates, carbonaceous shale with locally coal horizons were deposited in graben type basin on Palaeoproterozoic Basement in fluvio-lacustrine environment in cool, humid climates far as the shelf area of Bengal Basin but are discontinuous in the half graben basin on Bogra Slope. During the time of breaking of East Gondwana from the rest of Gondwana. The basaltic and andesitic Rajmahal lava of Late Jurassic to Early Cretaceous over lays the Permian Gondwana sediments. After the phase of erosional events, the area was marked by extensive transgression of sea caused by a very distinct basin wide subsidence during Middle to Late Eocene time; the Tura sandstone, Sylhet limestone and Kopili formation were deposited. A significant regression caused by global drop of the sea levels and epeirogenic movements caused the deposition of Oligocene sediments in the deeper part of the basin and were deposited under shallow marine condition. The sedimentary sequence of the Rangpur Saddle appears to be different from that of the Bogra Slope the stratigraphic succession of the boreholes in the Saddle suggest that the area remained landmass till Late Tertiary where gradual slow subsidence caused continental Dupi Tila Formation over basement except for the area old graben basin of Permian age where Permian coal Bering Gondwana sequence were deposited. At Maddhapara, however like much of the Rangpur Saddle, Palaeoproterozoic basement is overlain only by upper Tertiary Dupi Tila formation.

Petrographic Analysis
The present study discusses the petrography of the Palaeoproterozoic basement rocks in the studied area. Both megascopic and microscopic observations have been performed to petrographical characterizes the rocks. Megascopic study includes physical appearance and visual composition while microscopic study includes texture and mineralogy of the rocks samples. Unaided eyes have done visual composition of the rocks. Point counting carried out model analyses and percentage of minerals varies calculated a percentage (Table1).

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Quartz (%)</th>
<th>Plagioclase Feldspar (%)</th>
<th>Alkali Feldspar (%)</th>
<th>Hornblende (%)</th>
<th>Biotite (%)</th>
<th>Epidote (%)</th>
<th>Rock type</th>
</tr>
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<td>Tonalite</td>
</tr>
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</table>

Table: 1 Modal composition (volume %) of the Basement complex of production level, Maddhapara.
Petrography
A total of 6 thin sections were prepared from collected samples taken from production level occur at the elevation -269 m. The rocks types of production level includes quartz diorite, tonalite, granite.

Megascopic Study
Megascopic study is the necked eye observation of rock. The present observation includes physical characteristics of the rocks and visual composition of the rocks. Various colors of rocks, different mosaics created by arrangement of rock constituents and textural variations have been studied.

Physical Appearance
Based on color, texture and structural characteristics as seen in unaided eyes visual grouping of the studied rocks have been done.

Structure:
According to the structure, the studied rocks are classified as massive. Massive rocks are structureless, hard and compact. Dark colored minerals are evenly and sparsely distributed without any preferred orientation the rocks are fractured and fractured surface. Several crises-cross veinlets are present within the rock.

Texture:
The grain size of the Palaeoproterozoic basement varies from very coarse to very fine 0.32% of the studied rocks are medium grained 0.32% are medium to fine grained, 6% are fine to medium, 10% are fine grained and 13% are fine to very fine grained 0.3% of the studied rocks are very coarse to coarse.

Color:
The Palaeoproterozoic basement varies color from dark to light. Color the function of mineralogy. Higher concentration of dark colored minerals results into dark colored appearance. Their lower concentration gives lighter appearance. The major colors of the rocks are dark gray to light gray and light gray. Some pink and some are dirt white in color.

Microscopic Study
Microscopic study deals with the identification of minerals present into the rock and investigation of the textural relation. A detail qualitative and quantitative observation has been performed under polarizing microscope to petrographically characterize the rocks. Texture is the geometrical relationship among the component crystals of a rock. Textural properties include crystalline, i.e. the relative proportions of glass and crystals, granularity, i.e. the absolute and relative size of crystals, crystal shape and mutual relation of crystals and any amorphous materials if present.

In the present research textural behavior and mineralogical composition of different types of rocks have been studied and based on these studies the detail petrography of individual rock types have been made.

Classification Scheme
Most igneous rock classifications are based on one or combination of mineral content, texture and geological environment of formation. But for the nomenclature of rocks the most widely used classification is the quantitative or semi-quantitative mineralogical classification. Mineralogical solidifications of igneous rocks are normally based on one or more important variables, i.e., percent and type of feldspar, presence or absence of quartz, feldspathoid or olivine, percent and type of dark minerals (ferromagnesian minerals), grain size and texture. These classifications use different criteria and have different limits for the standard rock names. These are used by different authors in different countries has given rise to international attempts as standardization. The International Union of Geological Sciences (IUGS) commission of petrology, through a broadly based international working group on rock nomenclature, has recently published a final version of its igneous rock classification (Streckeisen 1973, 1976, 1979). In the present study IUGS classification scheme has been applied for rock classification. The IUGS classification use Quartz-Alkali Feldspar-Plagioclase (QAP) triangle diagram to classify the igneous rock into different categories (Fig. 1). The proportions of the three minerals are plotted with quartz (Q), alkali feldspar (A) and plagioclase (P) occupying the apices of the equilateral triangle. The relative amount of quartz, alkali feldspar and plagioclase should be calculated from the light colored constituents only the value of Q is derived from the amount of quartz by dividing the figure by the sum of the total felsic minerals (Q+A+P) and multiplying by 100. In the triangle, the value determines the main horizontal boundaries. The values chosen are 14.84 to 50.54% of quartz by contrast the Q=20 line is of great significance. The acid and quartz bearing intermediate rocks separated by the Q=20 boundary are each further divided into different categories bedded. Note that the lower limit of granite at Q=20 has been chosen because the large majority of granitic rocks fall with in the limits Q=20 to 40. Most of the older classifications placed lower limits at Q=5, 10, or 18 but Q=20 better satisfies the natural relationship (Chayes, 1957).
Figure 1. Modal APQ diagram for the basement rocks in Maddhapara Fields: 1. Tonalite, 2. Quartz diorite, 3. Granite, 4. Quartz diorite, 5. Quartz diorite, 6. Tonalite.

Figure 2. IUGS classification of plutonic and volcanic rocks in the triangle Q-A-P. (Source: Streckeisen, 1973, 1976, 1979)

Petrography
According to IUGS classification scheme, the rock type of the production level includes quartz diorite, tonalite, and granite. The detailed petrography of different rock types have been described based on microscopic study. The rocks are described according to their abundance.

Tonalite:
The textural characteristics of tonalites are holocrystalline, hypidiomorphic granular, fine to medium grained, having an interlocking arrangement of the mineral constituents. Plagioclase feldspar is dominant all over minerals and constitutes 51 to 56 %, anhedral to subhedral shows polysynthetic twining according to the albite-carlsbad twin law. A few grains of plagioclase feldspar show normal zoning. Myrmekitic intergrowths are observed along the quartz and plagioclase feldspar show normal zoning. Hornblende constitutes 16 to 18 %, fine to medium, low relief, anhedral to subhedral. Some quartz grains show high interference color blue and yellow. Some of the grains are fractured and shows wavy extinction and the fractures in the quartz grains indicate strain effect. Hornblende constitutes 12 to 16 %, green in color, moderate relief, pleochorism is common ranges from light to dark green. Inclusions ofapatite and garnet are sparsely scattered in some hornblende grains. Biotites (4 to 7%) are anhedral to subhedral, light to dark brown in color. Twisted and banded biotite grains also present which indicate strain effect. Epidote is a secondary mineral resulted from hornblende and dark brown in color. Shaped and as inclusions in some feldspar grains: Other minerals are sphene, garnet, rutile and some opaque varieties.

Figure 3. Modal APQ (Alkali, Plagioclase and Quartz) diagram for sample-1.

Qtz=21.53%, Pl=78.47% and AF=0%

Figure 4. Modal APQ (Alkali, Plagioclase and Quartz) diagram for sample-2.

Qtz=18.15%, Pl=81.84%, AF=0%

Figure 5. Modal APQ (Alkali, Plagioclase and Quartz) diagram for sample-3.

Qtz=50.54%, Pl=29.85%, AF=19.61%
Quartz Diorite:
Most of them are free from inclusion. All the quartz diorites studied are holocrystalline, fine to medium grained ranges in diameter from 0.3 mm to 1 mm. Most of the crystals are subhedral to anhedral in shape. Quartz diorites are mainly composed of quartz, plagioclase feldspar, biotite and hornblende (Fig. 4, 6 and 7). Epidote are the main accessory mineral. Among the felsic constituents often quartz diorite, plagioclase the most abundant minerals and the volume percentage lies between 25% to 60% of the total minerals. The most important feature of plagioclase is that most of them contain small prism of hornblende, flakes of biotite, epidote, diopsite, needle like tourmaline and parthite. In general, inclusions common were the alteration common. Apart from altered products, plagioclases are free from inclusion. Most of the plagioclases show clear lamellar and pericline twining (Fig. 6). Quartz is one of the most common minerals of quartz diorite. Most of the quartz are fine grained, diameter ranging from 0.2 to 0.7 mm and show corroded boundaries. only few contain inclusions of feldspar. Biotite is common mineral in the rock. It is present 4% to 20% of the total rock components. The size of the biotite ranges from 0.1 mm to 0.3 mm. Tabular and lath form show perfectly develop one set of cleavage. Hornblende is commonly found in the rock and is medium to fine grained ranging in size between 0.3 to 0.7 mm. It is subhedral to anhedral. Parting is common in hornblende. Some hornblende crystals show polysynthetic twining Traceable rutile and opaque minerals found in the rock as minor accessories.

Granite:
Textures of the granites are inequigranular, fine grained, holocrystalline and hypidiomorphic granular. Alkali feldspars constitute a major portion of the granites about 46 to 52 % and represented by microcline, microcline-perthite and orthoclase. The grains are commonly occur as subhedral megacrysts and the microcline shows perfect hatched twining (Fig. 5). Orthoclase is colorless, shows low relief and birefringence. Graphic textures are common. Quartz is an essential mineral of the granites, subhedral to anhedral, constitutes 25 to 28 % and most of the grains are free from inclusions. Plagioclase feldspars constitute 18 to 22 %, medium to coarse, subhedral, shows lamellar twining and untwined plagioclases are also common.

Biotite is the dominant mafic mineral (2 to 3 %) and the grains are anhedral to subhedral, light to dark brown in color. Some of the biotite grains are twisted indicate strain effect. A few of hornblende grains are also present, anhedral to subhedral, green to greenish brown in color. Among the accessory minerals zircon, sphene and some opaque varieties are common.
List of Plates


Plate: 5. Photomicrograph showing typical mineral assemblage of analyzed Quartz diorite (sample-5). Crossed polars. HB: hornblende, Pl: plagioclase, Bt: biotite, Qtz: quartz.

Figure: 9. Showing the relative abundance of different minerals in the Tonalite for Sample-1.

Figure: 10. Showing the relative abundance of different minerals in the Quartz diorite for sample-2.

Figure: 11. Showing the relative abundance of different minerals in the Granite for sample-3.
Figure: 12. Showing the relative abundance of different minerals in the Quartz diorite for sample-4.

Figure: 13. Showing the relative abundance of different minerals in the Quartz diorite for sample-5.

Figure: 14. Showing the relative abundance of different minerals in the Tonalite for sample-6.
Petrogenesis

Palaeoproterozoic (1.73 Ga) Basement rocks, a remnant of Columbia supercontinent, crystallized at a depth of ~17-22 km, NW of Bangladesh (Hossain et al., 2009). The basement rocks are predominantly diorite and quartz diorite with a mineral assemblage of plagioclase (42-61%), hornblende (19-53%), biotite (1-8%), quartz (1-7%), K-feldspar (1-10%) and secondary epidote (Hossain et al., 2009). On the basis of hornblende geothermobarometry, pressure-temperature conditions of the dioritic rocks are 680 - 725 ˚C and 4.9-6.4 kbar, which probably correspond to crystallization conditions (Hossain et al., 2009). On the basis of zircon geothermobarometry, temperature condition of granitic rocks are 660-670 ˚C (Hossain et al., 2008). According to IUGS classification scheme, present study suggest (from quartz (Qtz)-alkali feldspar (AF)-(plagioclase (Pl) diagram), the rock types are granite, quartz diorite, tonalite with a mineral assemblage of plagioclase, alkali feldspar, hornblende, quartz, biotite, epidote. Petrogenesis according to Hossain et al., (2009) more or less consistent of the present studied rocks.

Conclusions

Palaeoproterozoic Basement Complex of Production level of Maddhapara mine site comprises the rock types of quartz diorite, tonalite, granite. The constituent minerals are plagioclase feldspar (27-68%), alkali feldspar (1-18%), quartz (11-46%), biotite (5-6%), hornblende (8-19%) with some accessory minerals like epidote, zircon. Most of the minerals are fine to medium grained, inequigranular, holocrystalline, hypidiomorphic in texture. Quartz diorite, tonalite are intermediate igneous rocks while granite are acidic. The petrography along with the tectonic history of the surrounding areas of the study area suggest that the granitoid body. Crystallization temperature of dioritic rock is 680˚ to 725˚ C and granitic rocks are 660˚ to 670˚ C. These rocks are possibly crystallized by fractional crystallization processes.

REFERENCES


