Rock Samples Collected from the Oasis Mountain Region, Antarctica

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ABSTRACT

Four rock samples from the outcrops of western part of the Oasis Mountain in the vicinity of the *Dakshin Gangoiri* station and three rock fragments from the bottom sediments from a depth of 1700 m were studied. The megascopic and microscopic studies revealed that the four rock samples are (i) hypersthene and garnet bearing gneiss (ii) garnetiferous granitoid gneiss (iii) biotite granite and (iv) amphibolite. The rock fragments are of (i) granoditoritic gneiss and (ii) sillimanite bearing granulite. This rock suite is similar to that of peninsular India and is thus related to the pre-drift positions of India and Antarctica.

INTRODUCTION

The 'Oasis Mountains' is 'Roche Moutonnee' or otherwise wide expanse of thick ice cover and can be seen from scores of kilometres off the Antarctic Coast. It is about 20 km in length. This rock outcrop is devoid of ice and dotted with melt-water lakes. The reversal of the normal phenomenon, namely, its snow/ice free higher reaches, presence of liquid water near the summit while the lower levels are ice bound and frozen, is a dramatic expression of the radiation balance of white ice surface and dark rock exposure—the reason for perpetuation of the ice sheet here. Even from the helicopter the paleo-glaciation of this outcrop is clear. At present the glacier skirts the outcrop and its morainic ridges are well developed. There is an abundance of debris scattered on the outcrops and part of these appear to be of morainic character.

The rock samples collected from the western part of this large outcrop are described below and indicate a sequence of gneisses and granulites. The presence of hypersthene bearing granite in the assemblage indicates charnockitic affinities of the suite.

The most significant rock is a hypersthene and garnet (Pyrope-Almandine) bearing gneiss which contains abundant plagioclase feldspar, quartz, frequent alkali feldspar (perthite etc.), biotite and opaques. It has obvious charnockitic affinities.

Another rock type is garnetiferous, granitoid gneiss. The garnet (Pyrope-Almandine) occurs as porphyroblasts, the alkali feldspar, more abundant than plagioclase and quartz, is one of the most abundant constituents. The rock has many characters common to the granulites and is a variant of the above mentioned suite.

The third rock is a biotite granite which too has suffered a phase of tectonism but has shown no evidence of belonging to granulite facies.

The fourth rock is an amphibolite which contains a lot of relict augite as well as plagioclase and K-feldspar. The amphibole too has partially altered to biotite. This could be either product of retrograde metamorphism of a clino-pyroxene granulite or a metamorphic product of a basic igneous rock. It is probable that the granitic phase is related genetically to either of the above two processes. That the four rock types mentioned above have been collected from the same locality is indicative of a high probability of their morainic origin.

Two rock fragments recovered from sea bottom grab samples and obviously derived from the mainland through the agency of icebergs bear mention here. One is a granulite containing garnet, sillimanite, K-feldspar, plagioclase and abundant quartz which easily finds place in the granulite facies represented by rocks mentioned above and the second is a hornblende, biotite bearing granodiorite. This generally could

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represent the second suite of rocks mentioned. Detailed petrographic descriptions of these rock samples are given below.

ROCK DESCRIPTIONS

Sample No. 1

Megascopic Description

The rock is greyish white, medium to coarse grained and consists of quartzofelspathic bands of thickness varying from 0.5 to 2 cm alternating with brownish grey layers of garnet and brown mica. The garnets are 1 to 3 mm diameter and are associated with flakes of biotite which show preferred orientation.

Microscopic Description

The rock is coarse-grained and consists of quartz, alkali feldspar and plagioclase with considerable amount of garnet and biotite as the major constituents, with minor amount of apatite, zircon, opaque oxides and chlorite as subsidiary minerals.

Quartz is one of the most predominant constituent occurring as fine equant to coarse elongate grains having a strong preferred orientation. Many of the larger elongate grains are highly strained and show wavy extinction, some are broken into smaller sub-grains distinguished by slight optical divergence. The smaller equant and inequant grains are by and large devoid of strain. Transverse fractures transect the elongate quartz grains commonly at large angle to the sub grain boundary but having an orientation generally orthogonal to the direction of gneissosity. Quartz shows intergranular relation with rest of the mineral phases.

Alkali feldspar is very common and occurs as medium-sized xenomorphic grains almost as a rule having exsolved strings and spindles of albite generally having an asymptotic morphology. Wherever the alkali feldspar has come in contact with the plagioclase feldspar, the latter is embayed or corroded by the former and a mantle of quartz albite symplectite form over the alkali feldspar-plagioclase interface. There is no discernible replacement relations between alkali feldspar and other minerals. Many of the alkali feldspars are highly strained and show strong wavy extinction.

'Plagioclase feldspar is common, occurs in small subequant to elongate imperfect prismatic grains showing multiple twining which is commonly bent, faulted or partially obliterated. The plagioclase appears to be oligoclasic. Most of the plagioclase grains are fresh and free from alteration. ;

Biotite is common and occurs as short flakes confined generally to certain planes dominated by mafic minerals. Most of the biotite flakes are aligned parallel to apparent foliation in the rock. The foliation is weakly folded and many of biotite flakes buckled. The biotite flakes go around the garnet porphyroblasts. Biotite is strongly pleochroic from straw yellow to deep brown with the following absorption formula X = straw yellow, YZ = dark brown. Inclusion of biotite are very common within garnet porphyro-blasts where the Si is parallel to Se.

Garnet is common and occurs as medium to coarse porphyroblasts subsequant to elongate in habit. The elongate porphyroblasts are oriented parallel to the external foliation and commonly show a transverse fracture confined only to garnet grains. Inclusions of quartz, biotite and rarely plagioclase are noticed.

The grains are light pink in colour, isotropic and at places highly fractured, intimately associated with biotite and iron oxide.

: Chlorite occurs as an alteration product of biotite. Small euhedral grains of apatite are seen in quartzofeldspathic mosaic. Rare grains of zircon are seen as inclusion in garnet. The morphological and.

textural features of the rock shows a granoblastic to porphyroblastic texture and gneissose structures and may be termed as garnetiferous granitoid gneiss,

Name of the rock : *Garnetiferous granitoid gneiss.*

Sample No. 2

Megascopic Description

The rock is greyish white medium to coarse grained and show preferred orientation marked by greyish to brownish biotite and garnets. The coloured constituents alternate with greyish white feldspar and quartz and thus give rise to gneissose structure. The micaceous minerals studded with pinkish to brownish garnet form fine streaks and lenticles. The size of garnet varies from pin head to 4 mm. These are mostly rounded in shape but lenticular forms are not uncommon. The staining by the ferruginous material has given rise to yellowish stains on the sample.

Microscopic Description

The rock is coarse-grained and mainly composed of plagioclase, alkali feldspar, quartz, biotite hypersthene and garnet. Quartz occurs in medium to coarse xenoblastic grains commonly showing high degree of strain. A few grains are elongate, apparently flattened parallel to the foliation. A few smaller grains are devoid of strain and appear to be post tectonic. Plagioclase feldspar is the most abundant constituent and occurs as small hypidioblastic to xenoblastic grains generally strongly deformed and showing arched and obliterated twin lamellae. The phase seems to be andesinic in composition. Patchy exsolution of K-feldspar give rise to mosaic of a large antiperthite grain. The exsolution apparently proceeding along the prominent twin planes. Some of the plagioclase grains are contiguous with K-feldspar and at the contact preferred development of quartz-plagioclase symplectite is observed.

Alkali feldspar is common and occurs as medium to coarse xenoblastic grains invariably having strings and spindles of albite within a groundmass of K-feldspar, oriented along certain crystallographic plane. The contact between K-feldspar and plagioclase is highly irregular, sutured and embayed, while that between quartz, garnet and hypersthene are planar. Perthitic intergrowth between potash feldspar and albite is common in most of the grains. Where the perthite comes in contact with antiperthite development of quartz-alkali feldspar symplectic inter-growth is seen.

Garnet is common and occurs in fine to coarse semiequant to equant hypidioblastic to xenoblastic grains. A few grains are elongate. Inclusions of quartz, biotite and opaques (not showing any discernible pattern) are fairly common. Most of the grains are fractured along which deeply iron-stained chlorite is seen. Deposition of iron oxides/hydroxide is common along the fracture planes. The elongate grains have fractures orthogonal to the direction of elongation.

Hypersthene is fairly common, occurs exclusively in garnet and opaque rich bands as elongate plates and coarse hypidioblastic grains, strongly pleochroic; Y = brown pink, Z = greenish grey. Most of the grains are sheared and fractured with infillings of opaques. At places garnet porphyroblasts occurring in contact with hypersthene show a polyhedral character wherein each hedra is planar, suggesting a complete textural equilibriation between the two.

Biotite is common and occurs as small flakes, large plates and sheafs having a strong preferred orientation, commonly confined to definite planes. Wherever garnet porphyroblasts grow, the biotite flakes wrap around them. A few inclusions of biotite caught within garnet seem to be optically continuous with biotite flakes lying outside the crystals. Biotite is frequently intimately intergrown with garnet and opaque oxides. Most of the quartz grains around are generally fine-grained. There is no evidence of post-

crystalline deformation in biotite. Opaques are fairly common, occur as xenomorphic tine to medium grains. A few crystals are skeletal in form and are intimately associated with garnet.

Name of the rock: *Garnetiferous hypersthene gneiss.*

Garnet: a= 11.484 Å, Pyrope-Almandine group.

Sample No. 3

Megascopic Description

The rock is greyish in colour composed of medium sized laths of amphibole and mica showing preferred orientation. These are associated with greyish white feldspar. The rock is layered, the middle portion rich in amphibole is greenish grey whereas the marginal part rich in biotite and feldspar is greyish in colour.

Microscopic Description

The rock is medium grained. The middle part of the rock is characterised by abundance of amphibole and pyroxene. Pyroxene is represented by augite and amphibole is represented by hornblende and tremolite showing preferred orientation. These are associated with plagioclase, biotite, zoisite, clino-zoisite, apatite, ilmenite, magnetite and rutile. The pyroxene show alteration into hornblende and biotite is alteration product of hornblende. The feldspars are represented by plagioclase and potash feldspars. The calcic plagioclase show albite and combined carlsbad albite twin. These are mostly calcic oligoclase to andesine in composition. Colourless prismatic crystals of apatite are seen as inclusion in plagioclase. Pale greenish to grey crystals of epidote are seen in plagioclase as well as in amphibole. Sericitization is not common but can be seen where feldspars show alteration. The marginal mesocratic part of the rock is characterised by tremolite, actinolite, calcic plagioclase, biotite, chlorite and opaques, besides, relic of pyroxene is seen in amphibole. The amphiboles are colourless to pale greenish, tabular and needle shaped. Tremolite actinolite are by far the most predominent constituent containing inclusions of pale green pyroxene. The amphiboles contain pale yellow highly pleochroic to dark reddish brown-flakes of biotite along the cleavage traces. The size of biotite varies from small shreds to lath-shape flakes. The amphiboles together with mica flakes show tectonic deformation and exhibit lamellar undulose extinction. These are often accompanied with pale greenish chlorite. The opaques are xenqblastic dark grey often associated with amphibole and brown mica. The uncoloured mineral represented by calcic plagioclase show corroded margin with amphibole, biotite and potash feldspars. Potash feldspars occur in very small amount and without any sign of alteration. The rock showing layering and recrystallisation of mineral constituents indicate it to be amphibolite derived perhaps from metamorphism of basic igneous rock. The alteration of amphibole into biotite and presence of K-feldspar in the rock may show the rock to have undergone potash metasomatism.

Name of the rock : *Amphibolite*

Sample No. 4

Megascopic Description

The rock is leucocratic coarse-grained very hard and composed of greyish white feldspar, smoky to purplish quartz and biotite. The biotite flakes are segregated into irregular bodies and sometimes show banding with the quartzofeldspathic material. The crystal outlines of feldspars are well defined in the quartz-rich portions of the rock and sometimes micrographic intergrowth of quartz and feldspars are seen. The weathered portions of the rock are highly pitted due to removal of micaceous constituents.

Microscopic Description

The rock is holocrystalline mainly composed of K-feldspars and plagioclase together with quartz showing allotriomorphic texture. The plagioclase is most common and occurs as colourless turbid

anhedral to subhedral grains of oligoclase of composition Ab86 An_{12} The turbidity is due to alteration into fine earthy coloured kaolinite and minute shreads of sericite. The outer margins of the crystals are never straight, mostly crenulated by quartz and K-feldspar. The K-feldspar is less turbid, colourless, generally contain plagioclase showing fine albite twinning. The perthite display optically continuous twin lamellae of oligoclase and sometimes micrographic intergrowth with quartz. The bending of the oligoclase twin lamellae and also the granulation of feldspars into equidimensional grains indicate deformation of the rock. The shearing of feldspars into smaller grains give rise to granular texture in which fresh-crystals of microcline and albite are seen. These minerals have crystallised at a much later part in the sequence of . magmatic crystallisation. Quartz occur as anhedral grains. The coloured minerals present in the rock is pale brown to greenish brown, highly pleochroic flakes of biotite. These are mostly seen at the outer margins of quartz and feldspar and sometimes from lenticular shaped bodies with a few flakes of muscovite. The other minor accessories are colourless apatite, pinkish grey sphene, tiny prismatic crystals of zircon and opaques.

Name of the rock: ***Biotite-granite***

PETROGRAPHIC DESCRIPTION OF ROCK FRAGMENTS FROM ANTARCTIC OCEAN BOTTOM SAMPLES

Three pieces of dark brown-stained rocks of following dimensions were available.

(i) 2.5 x 1.8x 0.3 cm.
(ii) 1.2 x 1.0x 0.25 cm.
(iii) 1 x 1 x 0.1cm.

(i) Medium to coarse-grained, dark brown-stained quartzo-feldspathic rock with vitreous to resinous lustre, superficial colloform structure in the ferruginous coating.
(ii) Medium to fine-grained quartzitic rock with light to deep brown ferruginous stain, a few glimmering specks.
(iii) Same as sample No. (i) but with deeper stain

Sample No. 5

Microscopic Description

Quartz is very common (V. E. 15%). Occurs as coarse xenomorphic grains, generally intergranular with respect to other minerals. Commonly deformed into smaller sub-grains and bands. Embayments of quartz grains into feldspar are seen.

Plagioclase is abundant (V. E. 20%). Occurs as medium sized hypidiomorphic to xenomorphic grains. Oligoclasic in composition. Most of the grains are strongly deformed and show wedged, bent and obliterated twin lamellae, generally free from inclusions. Alterations to sericite and carbonates are common.

Microcline is the most abundant constituent (40%). Occurs as coarse, xenoblastic grains showing M-twin, developed in various degrees of perfections. Few grains of microcline perthite are seen, Alkali feldspar very commonly replaces plagioclase and at the interface between the two development of quartz-plagioclase simplectite is very common. Large number of grains show strong deformation. Neomineralisation of muscovite at the expense of microcline is seen at places..

Hornblende is the commonest mafic mineral (V. E. 15%). It occurs as medium to coarse, hypidiomorphic to xenomorphic grains having rare inclusions of plagioclase. Generally weakly strained.

showing deformation bands, strongly pleochroic from greenish yellow to deep green. Flakes of biotite develop along the periphery of hornblende grains, along cleavage planes and fractures and show very irregular contact. Optically continuous islands of hornblende within biotite are seen. Commonly such alteration is seen where the potash feldspar comes in contact with hornblende. Few idiomorphic grains of zoisite are seen clustered around these altered grains of hornblende.

Biotite is common (10%), occurs in two forms (i) coarse flakes intimately associated with hornblende and having a sharp, planar contact (ii) fine to medium sized flakes, intimately associated with hornblende but showing definite evidences of replacement, pleochroic from straw yellow to light brown.

Magnetite is very common, occurring generally along the grain margins of gangue grains. Sub-idioblastic to hypidioblastic, sub-equant to elongate grains commonly having rounded edges. The grains are generally highly strained, fractured and rarely showing anomalous anisotropism. Alteration to goethite common.

Texture : Granoblastic

Name of the rock: *Granodioritic gneiss.*

Sample No. 6

Quartz is the most abundant (V. E. 40%) constituent. It occurs as fine to coarse xenomorphic grains frequently elongate. Generally strongly deformed showing wavy extinction and sub-grain formation. Most grains are fractured, the fracture planes being filled with iron oxide and micaceous minerals.

Plagioclase is common (10%). Occurs as fine to medium xenomorphic grains in the intergranular space of quartz. Deformed grains with partially obliterate multiple twin lamellae; albitic in composition, few grains are antiperthitic.

Alkali feldspar is very common (20%). Occurs as medium to coarse-grains in the quartzofeldspathic mosaic. All grains are untwinned and most grains show perthitic intergrowth with potash feldspar.

Garnet is abundant (25%). Occurs in coarse xenoblastic, irregular grains, frequently following the grain margins of quartz. Inclusions of quartz, opaque minerals and plagioclase very common and frequently give rise to sieve texture. Most grains are irregular, few are elongate and none equant. Alteration into colourless chlorite is common.

Sillimanite is fairly common (2%). Occurs as short prismatic grains. Occurs dispersed in the quartzofeldspathic mosaic.

Few plates of zoisite, rare grains of sphene and allanite at the core of zoisite grains are seen. Rare interstial flakes of goethite in quartz are seen.

Texture : Granoblastic, Gneissose structure.

Name of the rock: *Sillimanite bearing granulite.*

CONCLUSIONS

From the data collected so far from the rock samples obtained from near the station *Dakshin Gangotri,* the following inferences could be drawn:

(i) presence of a charnokitic granulite suite and (ii) a granitic (perhaps younger) suite with associated granitised or altered (including retrogressive metamorphism) granulites etc. in this general area. The

0charnokites, of course reminds one of the Eastern Ghats of India and its linkage propounded in the Gondwanaland concept.

More systematic geological work in this interesting field is recommended.

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