Petrographic Characteristics of Rock Types in Parts of Khammam Schist Belt, A.P., India

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Abstract: The Khammam Schist Belt (KSB) is unique from other schist belts in the granite greenstone terrain of the Dharwar Craton by the presence of workable deposits of corundum in this belt. The petrographic studies on the rocks of KSB are vital and of significant value for not only demarcating the mineralized zone but also for understanding the genesis of corundum.

The KSB is predominantly composed of schistose and gneissose rocks of the Precambrian age. These rocks form the entire plain country of the KSB and occur as discontinuous deformed interlayers/bands. Hornblende schists, Schistose amphibolites and Tremolite-actinolite-talc-chlorite schists occur as dark bands, streaks and lenses within the tonalite gneisses and pelitic gneisses in the KSB, forming the basement for younger anorthosites, amphibolite dykes, mafic and felsic granulites, meta-dolerites and granitoids. All these rocks are deformed and metamorphosed under upper amphibolite to lower granulite facies conditions. (Appavadhanulu, K. et al., 1976)

A number of representative samples were collected for the close examination of various rock types in the area. As many as 100 thin sections were prepared to establish the petrographic character of the rocks. Modal Analysis were carried out for some important rock types to estimate the approximate percentage of various minerals present in them.

Keywords: Khammam Schist Belt, Corundum, Modal Analysis of Rocks

I. INTRODUCTION

1.1 GEOLOGICAL SETTING

The area is a part of KSB which mainly consists of metamorphosed felsic and mafic volcanic, now preserved as quartzo-felspathic gneisses, hornblende schists and schistose amphibolites, with or without garnet. Lithological variations include the pelitic meta-sediments manifested in sillimanite-kyanite schists, sillimanite- cordierite-orthopyroxene-corundum bearing rocks , pegmatites and banded iron formations (quart-magnetites). Garnet bearing quartzites are rare and insignificant in the KSB. The dominant lithology comprises amphibolites, which may be described as banded, foliated, garnetiferous or massive based on its field appearance and form a basement for the proterozoic pakhals and phanerozoic gondwana sediments.

1.2 STRUCTURE

The Dharwar schists and gneisses occupying the plains between Wyra lake and Gobbagurti, exhibit a general foliation along NE-SW (varying between ENE-WSW to NNE-SSW) with moderate to steep foliation dips varying from 40^{o} – 70^{o} due SE. (Apavadhanulu, K., et al. 1976)

1.3 PETROGRAPHY (GENERAL DESCRIPTION OF ROCK TYPES)

GNEISSES: Streaky biotite gneisses and tonalite gneisses are the representative rock types of the Precambrian suite. They are comprising garnetiferous quartzo-felsic gneisses, garnetiferous quartz-pyroxene-magnetite gneisses and charnockite occurs as sparsely distributed xenoliths or inliers in the form of thin bands and lenses within the Precambrian gneissic terrain.

Tonalite Gneisses are the dominant lithounits. They contain plagioclase, quartz and hornblende as dominant minerals. Garnet, epidote and sphene occur as subordinate minerals. Plagioclase (An_{30-40}) and quartz form white band, while hornblende, garnet and epidotes concentrate in dark bands of tonalite gneisses. The typical minerals present in these gneisses are quartz, felspars, pyroxenes, hornblende, biotite, perthite and epidote. Garnet, apatite, zircon, sphene, scapolite and sericite are minor accessories. These rocks show typically granular texture with equant mineral grains, and planar boundaries.

The Hornblende Plagoiclase Gneisses occur as intercalated bands with tonalite gneisses. They consist mainly of hornblende, in hornblende rich dark layer and plagioclase (with little quartz) in plagioclase rich white layer. Bent lammellae of plagioclase indicate that these rocks were deformed during or after their emplacement in the KSB

The Amphibole Gneisses occur as thin bands within the biotite gneisses. They are medium to coarse grained, melanocratic, gneissic to schistose, very often garnetiferous. The amphibole gneisses are essentially containing green hornblende and plagioclase felspars. as major constituents while actinolite-tremolite, epidote, quartz and sphene occur as accessory minerals. Plagioclase felspar, the dominant mineral and subordinate k-felspar occurs as porphyroclasts.

AMPHIBOLITES: The amphibolites are granular and streaky in nature. Based on mineralogical variations they are categorized into: Normal amphibolites, pyroxene-plagioclase amphibolites, and garnet-pyroxene-plagioclase amphibolites. The amphibolites show hornblende, plagioclase and quartz as main constituents and pyroxene and garnet as accessories. Idioblasts of garnet display sieve structure because of hornblende and quartz inclusions. The amphibolitic sections showed the presence of hornblende with good cleavage, and pleochroism, presence of biotite, plagioclase in small amounts and opaques. in accessory amounts.

The highly garnetiferous, coarse-grained rocks occurring as dykes and lenses are well exposed . They form a number of low mounds. These ramify as apophyses and tongues into the dharwarian gneisses and meta-anorthosites. They sometimes show a typical Salt and Pepper texture, made up of white felspars and black amphiboles. These rocks show coarse aggregates of greenish-brown hornblende, and abundant pink garnets together with minor amounts of alkali felspar, biotite, and quartz compared to the hornblende-granulites. These are coarse grained and lack plagioclase and pyroxene which suggest that these rock types could be meta-eclogites. Presence of porphyroblasts of garnet is reported in some sections.

ANORTHOSITES: Anorthosites are predominantly gabbroic and occasionally banded. They contain 10-20% of mafics while plagioclase accounts for 80-90%. Hornblende is an important mafic constituent and occurs as secondary mineral after the pyroxenes. Small amounts of scapolite, zircon, sphene and zoisite are present. Traces of hypersthene are noticed. Plagioclases occur as plates and as small grains. The mineral is twinned. Most of the grains show Carlsbad twinning. Zoning is observed. Inclusions of pyroxene and hornblende are observed. Hornblende is secondary and strongly pleochroic in nature. Both clinopyroxe and ortho-pyroxene occur together but clinopyroxene (augite) is dominant. It is also a domainal rock, consisting of lenticular regions dominated by **alkali feldspar** (orthoclase) with a little **quartz** and **biotite**, set in a matrix dominated by **cordierite**. The K-feldspar domains may represent veinlets of syenitic melt, either intruded into or melted out from the rock. The cordierite-rich zones with in this rock type contain **cordierite** + **K-feldspar** + **corundum** + **spinel** + **opaque** assemblage. Clear K-feldspar is interstitial to cordierite, and shows lower refractive indices. The high-relief colourless mineral is corundum. **Biotite** is concentrated along the margins of the k-feldspar. There is a little white mica (retrograde) and andalusite (not in all sections). This rock composition is somewhat depleted in silica and alkalis, and relatively enriched in Al_2O_3, FeO and MgO, compared with a typical metapelite, which is consistent with the removal from it of a partial melt fraction. Inclusions of rutile are observed along with the presence of garnet which are similar in chimalpahad area (Leelanandam, C., Reddy, M. N., 1988).

1.4 GRANULITES

Granulites are of 3 Categories, namely basic granulites, acid granulites and calc granulites. The basic granulites are mostly confined to the South-SW region. At Gobbagurti, basic granulites are emplaced in an environment of granitic gneisses with pockets of amphibolites and calc granulites. Basic granulites are observed as garnetiferous and non-garnetiferous varieties. The Gobbagurti basic granulites contain garnet in abundance at the southeast margin of the hill and slowly decreases towards the northeast border with enrichment of hornblende when a complete traverse is taken from SE-NE. The gneisses at Gobbagurti show a deep cataclastic imprint. The contact between gneisses and granulites is sharp when the outcrops are well exposed. These rocks reveal the presence of clinopyroxene, plagioclase and hornblende as essential minerals and quartz, orthopyroxene, biotite, garnet, zircon and opaques as accessory minerals. Subhedral crystals of hypersthene show feeble pleochroism from colourless to pale green. Clinopyroxenes are predominant over orthopyroxenes and are represented by diopside and augite. Rounded crystals of zircon with high relief are seen in minor amounts.

Hornblende-pyroxene-granulites, chlorite-talc-tremolite schist and amphibolites with or without corundum are younger rocks, which are medium to coarse grained, dark coloured, hard and compact. They trend along NNW-SSE to NW-SE and E-W directions. These rocks are essentially composed of hypersthene, diopside, plagioclase, brown hornblende, and actinolite-tremolite. Biotite, garnet, scapolite, zoisite and quartz occur in varying amounts. However, it is reported that the amphiboles derived almost entirely from the pyroxene show xenoblastic to granoblastic, ophitic to sub-ophitic texture are rich in hypersthene.

SCHISTS: Quartz-chlorite schists, felspathised quartz-chlorite schists, and quartz-chlorite biotite schists occur in small patches in association with the gneisses described earlier. They are highly puckered, schistose, very often garnetiferous and at places sericite bearing. These Schists are essentially constituted of quartz, felspars, biotite, chlorite and sericite. Undulose extinction in quartz is seen which indicates strain effect.

The Quartz Musconite Schists occur as thin bands within the biotite gneisses. These are leucocratic, gneissose and at places garnetiferous. They are seen as xenoliths within the meta-anorthosites. These schists are essentially constituted of quartz and muscovite as essential minerals while biotite, felspar, kyanite and garnet are the accessory minerals. Muscovite occurs as elongated flakes with basal cleavage. The cleavages are bent and show wavy extinction, with incipient alteration.

The Garnetiferous Muscovite Schists occur as small pockets within the biotite gneisses and schists. These schists are essentially constituted of quartz, muscovite, biotite and garnet as the major constituents while kyanite and felspar as accessory minerals. Most of the thin sections revealed the presence of sillimanite, with characteristic sugarcane structure and straight extinction, schistose texture wherein; foliation planes are aligned by the linear orientation of sillimanite and micaceous minerals Plagioclase exhibits polysynthetic twinning. Sections showed admixture of sillimanite and plagioclase.

II Analysis and Results

Table 1.1 Modal analysis of Gneisses

Mineral	Sample1	Sample2	Sample3	Sample4	Sample5
Plag	11.59	11.35	11.65	11.5	11.68
Hbl	0	0.05	0.06	0.04	0.05
Cpx	1.82	1.6	1.75	1.75	1.66
Qtz	64.33	65.8	64.8	65.7	66.3
Zircon	0.33	0.28	0.22	0.3	0.26
Bt	3.7	3.5	3.8	3.94	3.77
Orthoclase	10.05	9.7	9.85	9	8.48
Opx	7.07	6.9	6.76	6.82	6.8
Apatite	0.66	0.5	0.68	0.55	0.55
Sphene	0	0	0	0	0
Epidote	0	0	0	0	0
Opaques	0.44	0.4	0.42	0.4	0.45
Garnet	0	0	0	0	0
Muscovite	0	0	0	0	0
Total	99.99	99.98	99.99	100.00	100.00

No. 1 Gneiss**,** Gobbagurti Hills, Near Pangidi. No. 2 Gneiss, Tallada area.
No. 3 Gneiss, Lakshmipuram area. No.4 Gneiss, Pangidi area
No. 5 Gneiss, Lakshmipuram area. No. 6 Gneiss, Irlapudi area.

Table 1.2: Modal analysis of Normal Amphibolites:

Minerals	**Sample1**	**Sample2**	**Sample3**	**Sample4**	**Sample5**
Cpx	4.26	3.08	3.5	3.8	3.8
Opx	0.31	0	0.2	0.3	0.3
Plag	17.3	23.55	23	22	22
Qtz	3.14	10.97	8.5	7.5	8
Opaques	0.52	0.98	0.7	0.8	0.6
Garnet	0	0.23	0.1	0.2	0.1
Hbl	72.1	61.2	68	66	66
Zoisite	-	-	-	-	-
Scapolite	2.41	-	-	-	-
Total	100	100	100	100	100

No. 1 Amphibolite, Gobbagurti area. No. 2 Amphibolite, Donabanda area.
No. 3 Amphibolite, Lakshmipuram area. No. 4 Amphibolite, Mekalkunta area.
No. 5 Amphibolite, Pallipadu area.

Table 1.3: Modal analysis of Pyroxene-Plagioclase Amphibolites:

Minerals	**Sample1**	**Sample2**	**Sample3**	**Sample4**	**Sample5**
Cpx	6.07	8.18	17.20	9.89	12.00
Opx	0.00	0.92	1.12	1.28	0.80
Plag	27.45	21.15	37.70	36.21	30.55
Qtz	4.94	3.53	1.01	3.02	3.30
Opaques	1.00	0.51	0.39	1.92	0.75
Hbl	60.54	65.72	42.58	47.66	52.60
Total	100.00	99.98	100.00	99.98	100.00

No. 1 Pyx -Plag amphibolite, Gobbagurti area. No. 2 Pyx - Plag amphibolite, Donabanda area. No. 3 Pyx - Plag amphibolite, Lakshmipuram area. No. 4 Pyx - Plag amphibolite, Mekalkunta area. No. 5 Pyx - Plag amphibolite, Pallipadu area.

Table 1.4: Modal analysis of Anorthosites

Minerals	**Sample1**	**Sample2**	**Sample3**	**Sample4**	**Sample5**
Plag	66.86	88.36	93.89	83.04	84.00
Hbl	29.82	5.54	3.09	12.82	10.70
Cpx	3.31	3.89	0.39	2.53	2.50
Scapolite and Sericite	0.00	2.03	2.10	1.38	1.50
Zircon	0.00	0.16	0.00	0.05	0.08
Zoisite	0.00	0.00	0.26	0.09	0.12

Sphene	0.00	0.00	0.26	0.09	0.10
Total	99.99	99.98	99.99	100.00	99.00

No. 1 Anorthosite, Jannaram area. No. 2 Anorthosite, Kodaratimetta area. No. 3 Anorthosite, Lakshmipuram area. No. 4 Anorthosite, Mekalkunta area. No. 5 Anorthosite, Pallipadu area.

Table 1.5: Modal analysis of Granulites (Gobbagurti)

Minerals	**Sample1**	**Sample2**	**Sample3**	**Sample4**	**Sample5**	**Sample6**	**Sample7**
Cpx	40.03	47.16	29.57	33.04	27.45	32.70	29.53
Opx	1.64	5.75	1.43	3.38	3.29	2.86	1.74
Plag	31.86	39.81	41.27	34.74	46.96	37.96	41.60
Qtz	5.31	3.38	3.71	5.26	2.26	3.16	4.89
Opaques	1.31	0.08	2.47	1.93	0.97	1.65	2.23
Garnet	0.00	0.00	0.00	10.11	0.38	8.74	3.23
Hbl	19.86	3.81	20.13	11.58	18.69	12.93	16.77
Biotite	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Zircon	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	100.00	99.99	98.58	99.99	100.00	100.00	99.99

No. 1 Granulite, Gobbagurti Complex. No. 2 Granulite, West of Anjanapuram area.
No. 3 Granulite, Lakshmipuram area. No. 4 Granulite, Mekalkunta area.No. 5 Granulite, Lakshmipuram area. No. 6 Granulite, Pallipadu area.No. 7 Granulite, Pallipadu area.

Table 1.6: Modal analysis of Hornblende- Schists:

Minerals	**Sample1**	**Sample2**	**Sample3**	**Sample4**	**Sample5**
Quartz	27.86	21.81	24.84	25.60	25.75
Hbl	58.56	61.20	59.88	59.75	59.50
Plag	13.17	16.99	15.08	14.70	14.57
Apatite	0.14	0.00	0.07	0.05	0.08
Opaques	0.27	0.00	0.03	0.00	0.10
Total	100.00	100.00	100.00	100.00	100.00

No.1 Hbl- Schist, Gobbagurti area. No.2 Hbl- Schist, Tallada area. No.3 Hbl-Schist, Lakshmipuram area. No.4 Hbl-Schist, Mekalkunta area. No.5 Hbl- Schist, Lakshmipuram area.

III. CONCLUSIONS

The petrography of the rock types is predominantly characterised by varieties of gneisses and schists of distinct mineralogy. The ortho-gneisses include amphibole gneisses and metamorphosed pelitic rocks which are represented by garnetiferous biotite- muscovite- kyanite-chlorite- schists, kyanite and sillimanite bearing meta-pelitic schists, calc-silicate rocks, quartzites, fuchsite quartzite, and magnetite quartzite. (Narayan Sangam and R.Pavanaguru, 2012)

The petrographic characteristics of garnet-kyanite bearing schists, hornblende schists, actinolite-tremolite schists, sillimanite schists, normal amphibolites, garnetiferous amphibolites, basic granulites and quartzo-felspathic gneissic rocks have been studied for evaluating corundum mineralisation in the KSB**.**

Petrographically, the tonalitic gneisses possess primary corundum and the reconstituted metamorphic assemblages also enclose corundum in schistose rocks.

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