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Petrographicand Geochemistry Studies of Kudrekonda Gold-Sulfide Mineralized Zones andAssociated Lithologis, Shimoga Schist Belt, Western Dharwar Craton.

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ABSTRACT
Kudrekonda area is situated in the southeastern part of Shimoga schist belt. Kudrekonda area is known for placer gold since over a century and there are records of gold nuggets found in the streams.Kudrekonda gold deposit is located 0.5 Km west of Kudrekonda village and 16 Kms SW of Honnali town. Lithologically the area consists of metamorphosed volcano-sedimentary sequence and belongs to Chitradurga group.It is the northern extension of the Palavanahlli and Kodikoppa prospects.The major litho units of study area are namely, amphibolite, chlorite schist, quartz sericite schist, acid volcanic, conglomerate and auriferous quartz veins Extant of old workings viz., adit, shaft and old pits indicatingthat there was intensive mining activity during ancient times.Rama Rao (1963) has given the description of the old working for gold in Kudrekonda. Recently, Lingadevru et al., (2007) have recognized three NNW-NW trending discontinuous parallel auriferous quartz veins. These veins occur within the highly deformed amphibolite and exhibit pinch and swelling structure. The mineralized zone essentially consists of sulphide minerals viz., chalcopyrite, pyrite, arsenopyrite, sphalerite, magnetite, and covellite besides very fine specks of native gold.

Keywords: *Amphibolite, Chlorite schist, Kudrekonda gold deposit, Western Dharwar craton.*

Introduction

The Archean Dharwar craton lies between longitudes 72^{o} 45' – 80^{o} and latitudes (Fig .1), covering an area of 4.5 lakh km^{2}. Dharwar craton of southern India is one of the oldest terrains of the world and exposes large section of continental Archean crust. It preserves within it, the geological history of one of the earliest continental crusts, covering a time span of over 3.3 Ga of earth history. It is bounded to the south by Pan-African Pandyan mobile belt (Ramakrishna 1990, 1991); to the north by the by Purana (Middle to upper Proterozoic) sedimentary basins of Kaladgi, Bhima and Tertiary volcanic province of Deccan, to the NE by the by Palkal-Purana basin which is overlain by the Gondwana sediments of Godavari graben; to the east by Proterozoic EaternGhatmolbile belt and to the west by Arabian sea. Dharwar craton is divided into western and eastern blocks (Swaminath et. al., 1976: Swaminath and Ramakrishna, 1981, Rollinson et. al., 1981) primarily based on broad difference on the lithogical assemblage of the schistose rocks, the abundance of intrusive granites and the type of metamorphism.The strong N-S trending fabric of the Dharwar craton is partly a

result of late Archean transcurrent shearing episode (Drury and Holt, 1980; Chadwick et al., 1989) and is contemporaneous with the emplacement of the Clospet granite by seismic profiling further north in the craton by Kaila et al. (1979). This shear deformation slightly postdates the regional diapiric event in the craton (Bouhallier et al.,

EasternDharwar Craton (EDC) by Rogers (1986). It is now interpreted that the western block forms an older Archean peninsular gneissic nucleus, older than 3.0Ga and the eastern block consisting mainly of granitoides is a mobile belt made up largely of younger more potassium-rich granites and reactivated gneisses ranging in

(Jayananda and Mahabaleshwar, 1991). The boundary between the two blocks may be one of the profound N-S shear zones located

1993; Peucat et al., 1993). The western and the eastern blocks were renamed respectively as the Western Dharwar Craton (WDC) and
age from 2.5 to 2.6Ga (Jayananda et al 2006) known as Dharwar batholith (Chadwick et al. 2000). The study area belongs to the Kudrekonda formation of Shimoga schist belt of western Dharwar craton and a preliminary review of this belt has been carried out by HarnadhaBabu et al., (1981) and Chadwick et al., (1989, 1991).

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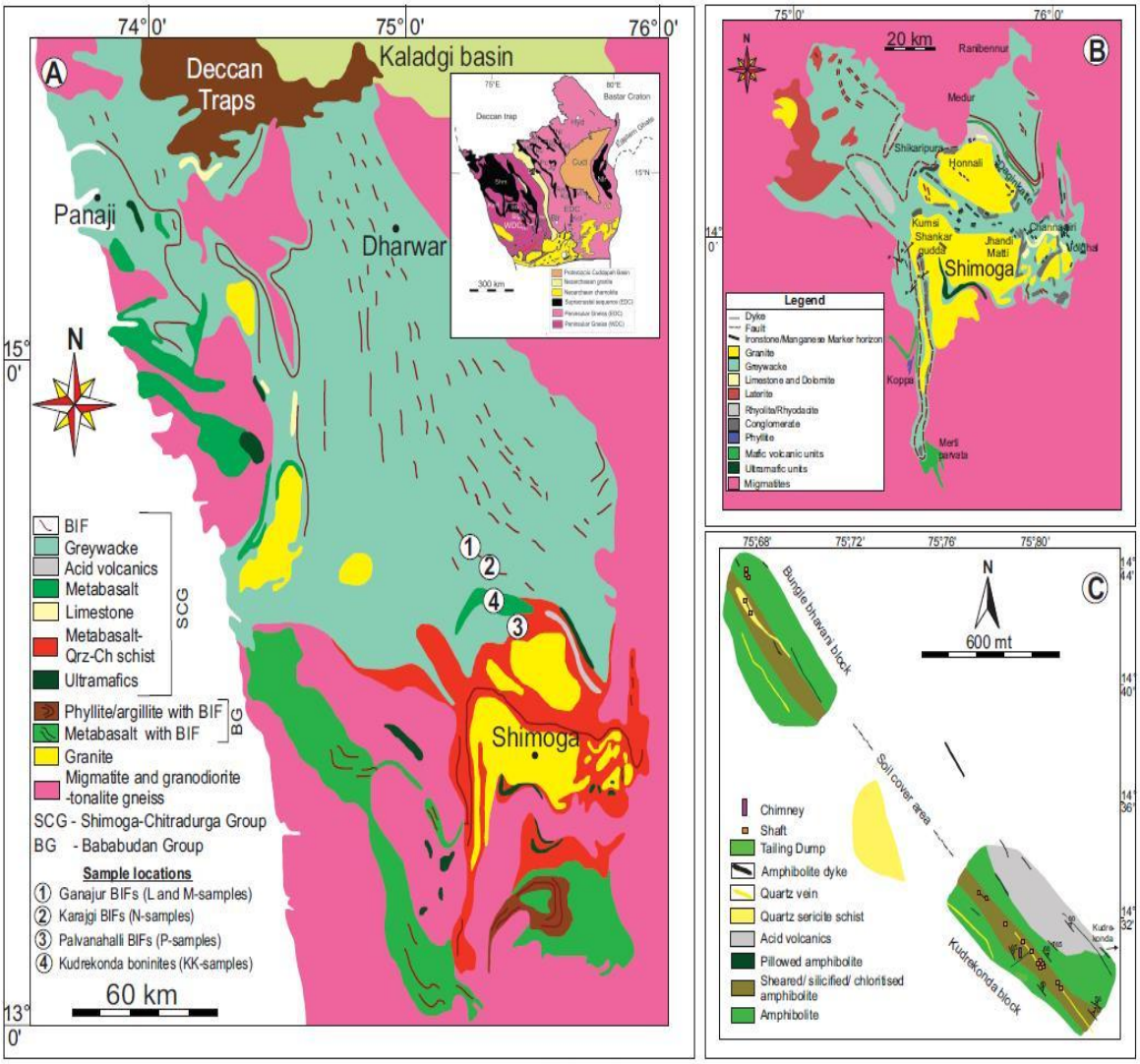

Fig.1

Source:SohiniGanguly et al., 2015

Field relations and petrography

In this paper an attempt has been made to understand the field relations and petrography description of different litho units occurring in the study area with an emphasis on gold mineralization. Detailed mineralogical and textural description of different litho units has given below.

Amphibolite

Dark green colored amphibolite forms the dominant litho unit of the study area. Fine to medium grained schistose amphibolite is largely found in the Kudrekonda area with perfect schistose texture and coarse grained amphibolite is the miner phase and occurs in the form pod. The amphibolites are commonly amegdular and

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occasionally they are pillowed. The general trend of the schistose amphibolite is N40^{o}W with dip of 65^{o} due east (plate.1). The amphibolites are highly silicified, carbonatised, chloritised and sericitsed which is indicated by the presence of quartz carbonate veins and stringers.

Plate.1. Field photograph of amphibolite

In thin section amphibolite exhibits schistose texture and mineralogically consists of chlorite, quartz, plagioclase feldspar, hornblende and calcite as essential minerals.Opaques are the usual accessories. Chlorite occurs in the form of small scaly aggregates with perfect cleavages. It is dark green in color and exhibits feeble pleochroism from green to pale yellow color. It shows anomalous dusky blue interference. Unhedral grains of quartz found in the matrix exhibits undulose extinction. Quartz more often associated with carbonates indicating silicification might be associated with carbonatization. Plagioclase occurs as laths exhibiting multiple twining bent lamellae and is filled with lot of sericitic dust. Hornblende occurs as prismatic with well-developed amphibole cleavages (plate2&3). It is unstable and braking down to biotite and chlorite along the margins and fracture planes. Calcite is identified by its rhombhedral cleavages, twinkling property and symmetrical extinction. It often associated with undeformed quartz grains.

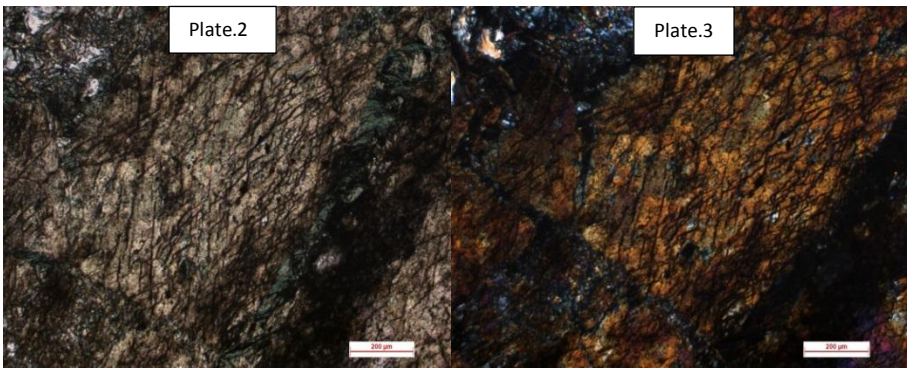

Plate.2&3. Photomicrographs of amphibolite

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Chlorite schist

Fine grained chlorite schist is one of the important litho unit in the study area. It exhibit dark green color, well developed schistosity and strike about N45^{o} W and dipping 65^{o} easterly. Network of quartz-carbonate veins traverses the chlorite schist (plate 4).

Plate.4. Field photograph of Chlorite Schist

The petrographic study of chlorite schist exhibits fine grained nature and schistose texture. Locally, this schistose fabric is crenulated and pokiloblats of FE carbonate seen to be grown within the crenulation cleavages. Chlorite schist essentially consists of chlorite, mica and quartzo-feldspathic minerals (plate5&6).

The light green colored flake of chlorite is the dominant mineral in the chlorite schist. It is pleochroic in shades of green to pale yellow and exhibits anomalous dusky blue color. Flakes of sericite and biotite are closely occurring in association with chlorite. Plagioclase occurs as laths with imperfect twinning and often sericitised. Quartz occurs as subhedral to unhedral and exhibits undulose extinction.

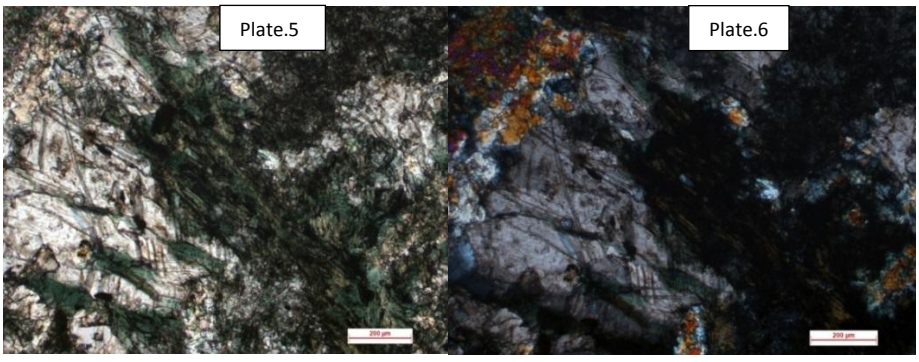

Plate.5&6. Photomicrographs of Chlorite Schist

Quartz-sericite schist

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Out crops of the quartz-sericite schist occurs in adjacent to the quartz. It is white in color with occasional black spots. Quartz sericite schist exhibits schistose texture and often it is mylonitic and characterized by the presence of sericite, fuchsite and quartz. It has the strike of N35^{o}W and dip of 70^{o}E.

In thin section quartz sericite schist reveals the presence of sericite, fuchsite, quartz, calcite and chlorite. The Sericite mica is color less and exhibits high order bluish green color. The grains of which are highly altered, probably to clay. The quartz mineral occurs as aggregate mass characterized by undeformed nature and wavy extinction this quartz occurs in the form of porphyoblast. The calcite grains have also been observed as aggregates characterized by anhedral nature, high alteration and symmetric extinction. In addition to this minerals some chlorite flakes were also been observed in quartz sericite schist, which imparts schistose texture to the rock (plate 7&8).

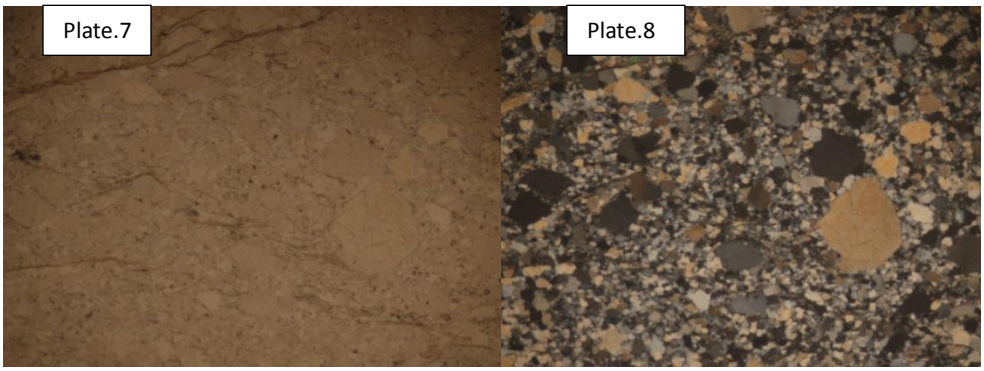

Plate.7& 8. Photomicrographs of Quartz-sericite Schist

Acid volcanic

The rock is light to pale gray in color, intensely sheared, schistose and fine grained, mineralogically consists of quartz, chlorite and carbonate minerals. The trend

broken grains of plagioclase and quartz as essential mineral in the matrix of quartz, sericite and carbonate with a variably

of this litho unit is N45^{o}W and dip is 65^{o} towards east. The outcrops of acid volcanic are located to the east of the study area.

Petrographic study of acid volcanic of the study area indicates that they are dominated by coarse, angular to rounded, intense non-penetrative fabric (plate. 9 & 10). This fabric is locally crenulated.

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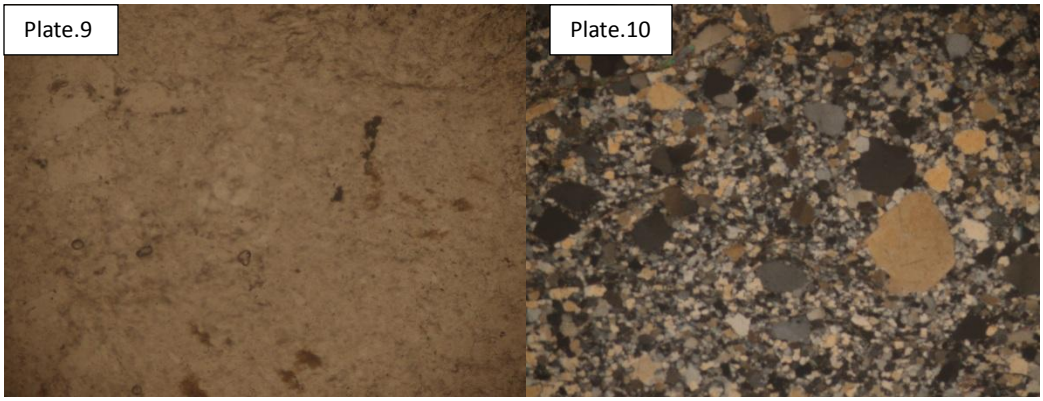

Plate.9 & 10. Photomicrographs of Acid volcanic

Conglomerate

Dull white to buff colored, N60^{o}W trending conglomerate bands has been observed on the slopes of Kudrekonda hill ranges. It consists of rounded, oval and semi oval shaped pebbles of various sizes. The pebbles found in conglomerates are polymictic in nature. However in some parts the conglomerate is essentially made up of quartz pebbles has been noticed. Rounded clasts of quartz up to 20cm in size, smaller pebbles of vein quartz, and flatclasts of black phyllite occurs crowded in matrix of coarse detrital quartz grains.

Quartz veins

Two generations of quartz vein, appear to have been traversing the lithological sequence of Kudrekonda area. prominent ones they are auriferous and occur within the schistose metabasalt (amphibolite). Number of old shafts/winzes and pits are present along these auriferous veins. Bluish gray quartz veins found to occur as vein system cross cutting the quartzites.

They are bluish quartz vein and white quartz vein. Parallel veins of white quartz are the addition to host rock. Important sulphide minerals identified in the present study are described below.

Ore petrography

Detailed pre microscopic study has been carried out in order to know the nature of ore mineral occurrences and their relation with the host rock. The ore microscopic studies reveal that the pre minerals are mainly sulphides and their occurrence is noticed mainly in bluish gray quartz in

Pyrite

Medium to coarse grained pyrite grains occur within the quartz veins, amphibolite. It is being characterized by yellow color, spongy appeareance with euhedral habit and isotropic character (plate11). This mineral is commonly associated with chalcopyrite and exhibit mutual boundary texture.

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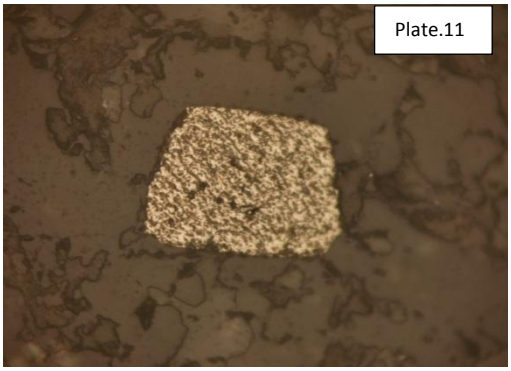

Plate.11.Photomicrograph of pyrite, Note the euhedral habit.

Chalcopyrite

Fine to medium grained grains of chalcopyrite occur as disseminated grains within the quartz veins and amphibole. It is brass yellow in color and characterized by smooth suface, unhedral habit, high reflectance and anisotropic nature (plate 12). It is commonly associated with pyrite, arsenopyrite, covellite and sphalerite and exhibit mutual boundary, colloform and replacement texture (plate 14).

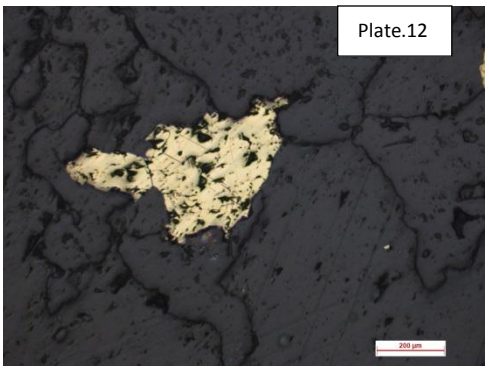

Plate.12. Photomicrograph of chalcopyrite

Arsenopyrite

This sulphide mineral is megascopically lead gray to silver white in color whereas under microscope it exhibit creamy white color, wear bireflectance, strong anisotropic (plate13). It is often, medium to coarse, euhedral to subhedral in nature and found to occur within the fractured quartz grains and also in the host rock.

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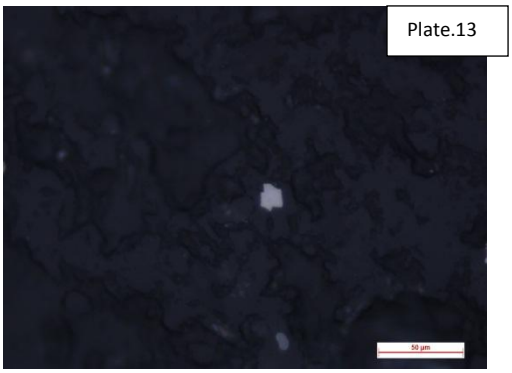

Plate.13. Photomicrograph of Arsenopyrite

Covellite

The mineral covellite is characterized by its indigo blue color, distinguishable bireflectance property. It is commonly found to associate with chalcopyrite and sphalerite and occurs as idiomorphic crystals and also replaces chalcopyrite along grain boundaries exhibiting replacement texture (plate 14).

Plate.14.Photomicrograph showing the replacement of chalocopyrite to covellite along grain boundary.

Magnetite

The mineral magnetite is characterized by its gray color with brownish tint, distinguishable bireflectance property and isotropic in nature. It occurs as anhedral grains (plate 15).

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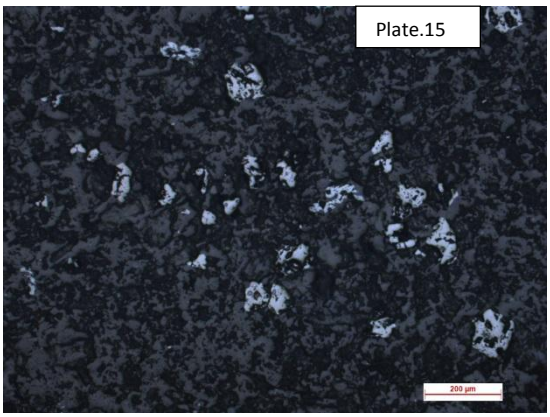

Plate.15. Photomicrograph showing the anhedral grains of magnetite.

Gold

Gold has been noticed in a sample (plate 16), it occurs as small specks and confined to fracture within the quartz and also as small globules within arsenopyrite. It is distinguished by electrum rich gold. The occurrences of gold along the fractures indicate that the mineralization is probably structurally controlled.

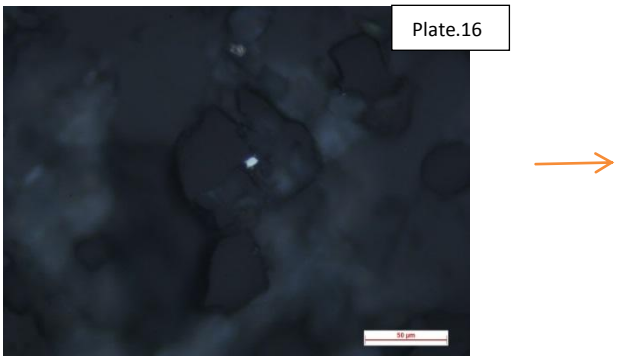

Plate.16.Photomicrograph showing a speck of electrum rich gold within the quartz grain.

Geochemistry

The major oxide data obtained for all the litho units of the study area were determined by X-ray fluorescence lab, CESS at Trivandrum. The overall average major elemental compositions of litho units of studyare presented in table 1,well comparable with the composition of tholeiitic basalts of Barberton greenstone belt.The range of Silica content of analysed samples varies

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from 42.44 to 53.13 wt%, which suggeststhat these litho units are basic in composition.On the Harker's variation diagram (Fig.2) the plots of Al2O3, Fe2O3, MgO, CaO, TiO2, K2O and P2O5 exhibit negative correlation whereas Na2O and Mno do not show any definite trend.The study area rocks belong to sub-alkaline series and few alkaline, for the magma type, silica versus total alkali discrimination diagram of Irvine and Baragar, 1971 plotted (Fig.3), defines distinct trend of sub-alkaline affinity for samples.In AFM ternary diagram silica content range falls well within the range of tholeiitic basalt (Fig.4).Tio2, Al2o3, Cao, Mgo, Na2o and P2o5 showed similar range of compositions.Based on the commonly used variation diagram of alkalies vs silica (fig.5) of Cox et., al (1979), these rocks have been classified as basalts. The major elements of Kudrekonda area have been used to prepare a Jensen diagram (Fig.6) to distinguish tholeiites and komatites, the data fall within the tholeiitic and particularly in high Fe field.

Table.1

Composition	Tholeiites (Av, of 6 samples)			
	Min	Max	Av*	Barberton TB**
SiO2	42.44	53.13	46.87	50.60
TiO2	0.81	1.12	0.92	1.04
Al2O3	12.83	17.81	14.76	13.70
MnO	0.12	0.30	0.2	11.87
Fe2O3	13.77	20.73	17.73	0.21
CaO	2.66	10.10	6.69	6.30
MgO	5.80	11.16	8.76	9.64
Na2O	0.19	4.45	2.66	2.83
K2O	0.02	2.99	0.70	0.31
P2O5	0.08	0.18	0.11	0.10
Na2o+K2o	0.21	7.44	3.36	3.14
Na2o/K20	9.5	1.48	3.8	9.12
Cao/Al2o3	0.20	0.56	0.45	0.91
Fe2o3/Mgo	2.37	1.85	2.0	1.88

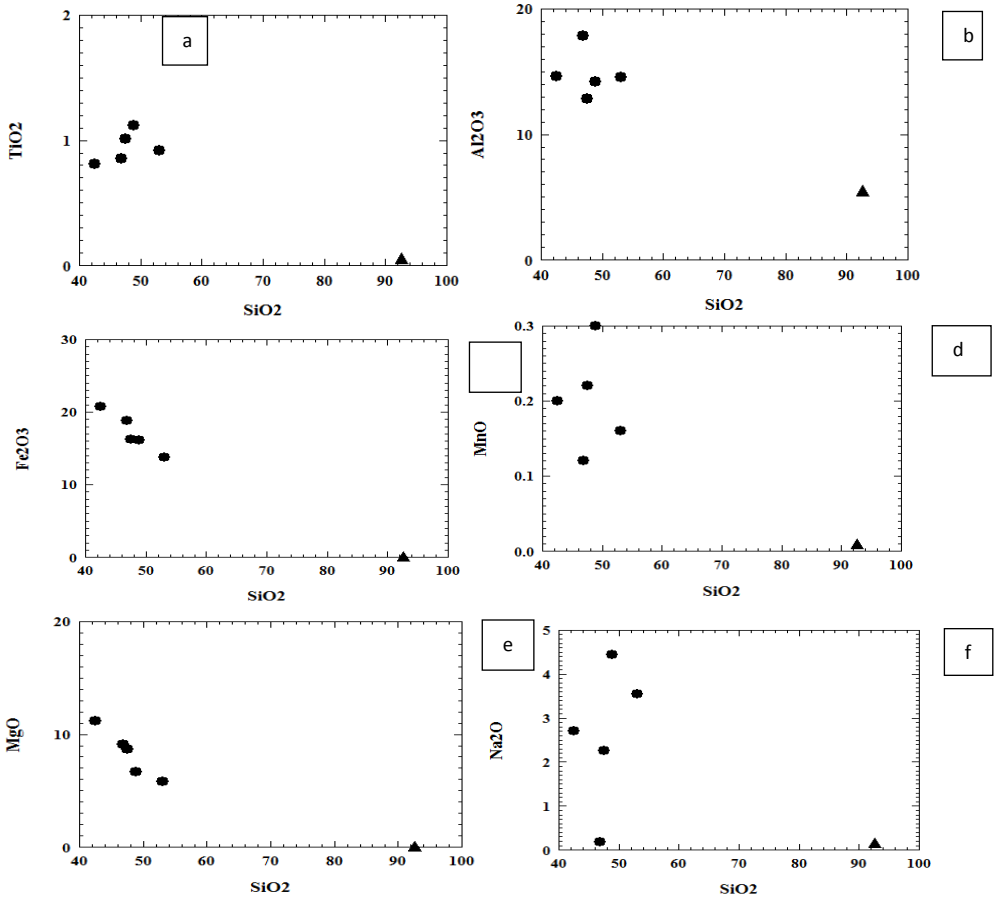
Av* average values: Barberton TB**-average major elemental composition of Barberton tholeiitic basalts (Glikson, 1983).

Conclusion

The litho units of Kudrekonda have under gone upper green schist to lower amphibolite facies metamorphism. Preliminary field and petrographic studies have suggested that amphibolite is hosting mineralized quartz vein and has undergone wall rock alterations viz., chloritisation followed by carbonaitsation, sericitisation and silicification is common type of wall rock alteration. The field petrography and ore petropraphic study reveals that the gold and sulphide deposit of Kudrekonda is an epigene type and has lithological and structural control. The ore petrographic study has indicated the presence of sulphide minerals such as pyrite,

chalcopyrite, arsenopyrite, sphalerite magnetite, covellite and fine specks of gold. The detailed geochemical and fluid inclusion studies area under progress.

Fig.2(a-j) Harker"s variation diagram of major element plotted against SiO2 for amphibolite, chlorite schist and quarts sericite schist (Note: triangular is quartz sericite schist).



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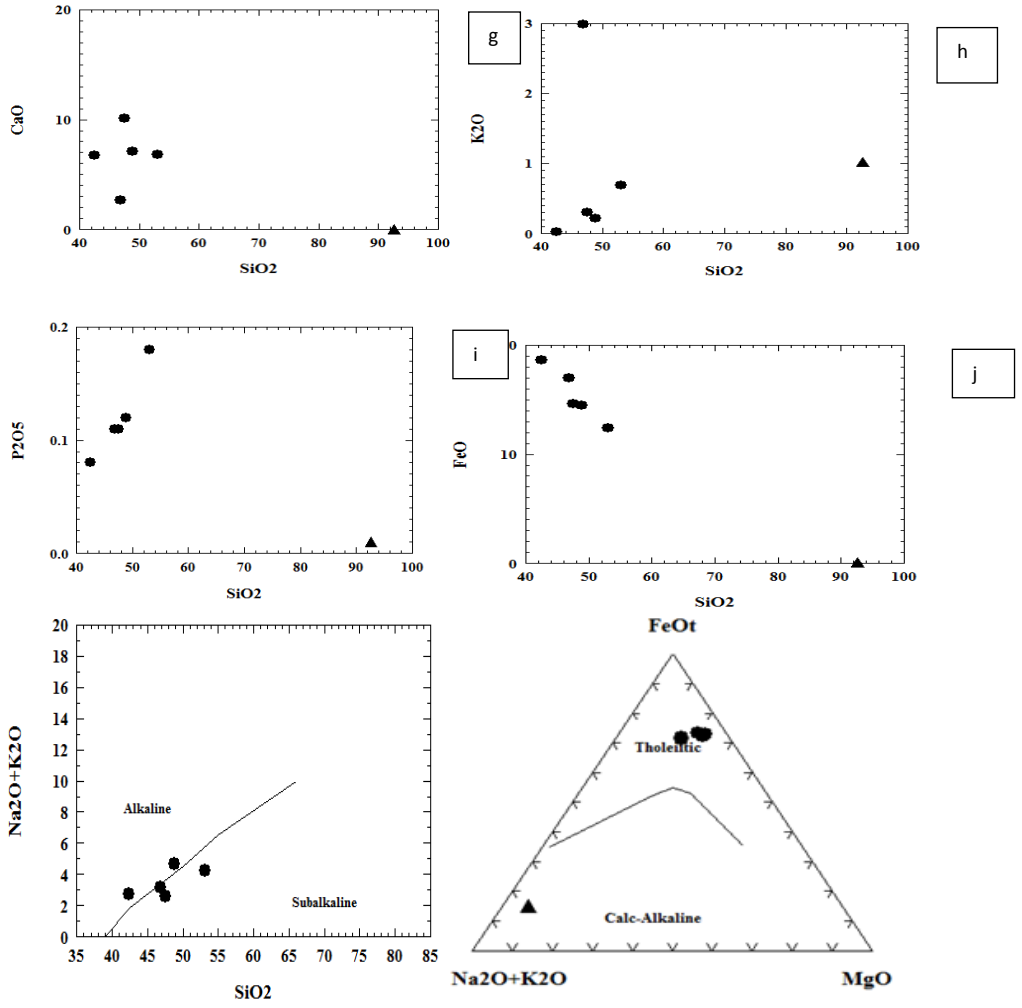

Fig.3. the silica versus total alkali plot (Series boundaries after Irvine and Baragar, 1971)
Fig.4. AFM ternary diagram for amphibolite, chlorite schist, quartz sericite schist

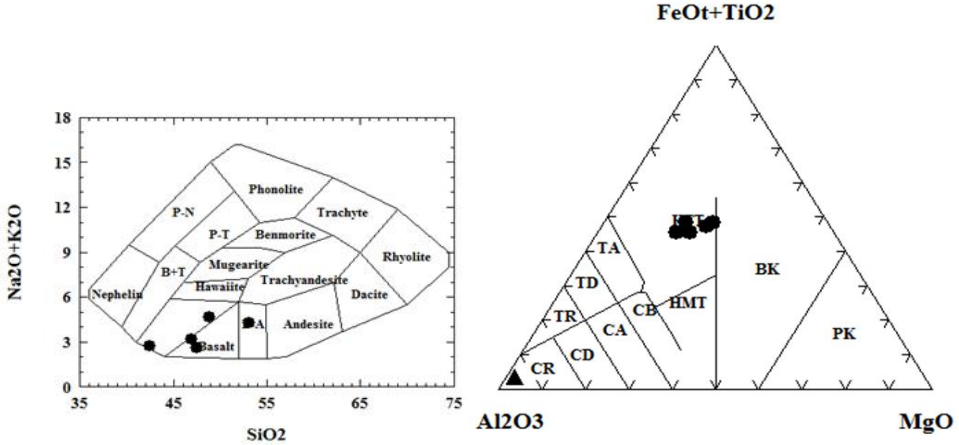

Fig.5. Chemical classification diagram of the samples based on TAS (wt %) (Na2O + K2O vs. SiO2) of Cox et., al 1979
Fig. 6. Al2o3-Fe2o3+Mgo ternay diagram of Jensen (1976) (•- Tholeiites:)calc-alkalic)

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