

# Field Relationships and Petrographic Characterization of Amphibolites from the Khammam Schist Belt, Eastern Margin of the Eastern Dharwar Craton, Southern India

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**Abstract**— The Archaean schist belts are relics of once extensive areas of meta-volcanic and meta-sedimentary rocks, mostly metamorphosed from greenschist to amphibolite facies. The amphibolite from the Khammam Schist Belt (KSB), located at the eastern edge of the Eastern Dharwar Craton (EDC), preserves its original basic magmatic signatures in terms of lithological association, mineral assemblage and geochemical characteristics, elucidating the Archaean magmatic activity, petrogenesis, and evolutionary processes. Amphibolites manifest as distinct enclaves within the granite gneiss of the Peninsular Gneissic Complex, with pronounced foliation and epidote-amphibolite facies metamorphic mineral assemblages. The amphibolites of KSB, which include elevated levels of ferromagnesian minerals, indicate magma fractionation. The majority of amphibolites possess a calcic tonalite composition, possibly ranging from basaltic to basaltic-andesite, categorized within the tholeiitic magmatic series, showing significant iron enrichment during its earliest phases.

**Index Terms**— Khammam Schist Belt, Eastern Dharwar Craton, Eastern Ghats Belt, Amphibolites

## I. INTRODUCTION

Amphibolites have been used to clarify the history of crustal development in Precambrian terrains (Hari Prasad et al., 2000; Meshram et al., 2017). Comparable investigations may be beneficial in the greenstone belts of the Dharwar craton, which consist of amphibolites with subordinate metasedimentary and metavolcanic rocks. The notable greenstone belts of the Eastern Dharwar Craton (EDC) include Kolar, Sandur, and Hutti, located next to the contact zone with the Western Dharwar Craton (WDC) (Jayananda et al., 2019, 2018; Mohan et al., 2019). The Neoproterozoic (~2.7 Ga) greenstone belts in the EDC comprise greenschist to amphibolite facies metabasalts, along with subordinate komatiites, felsic volcanics,

metasediments, banded iron formations (BIF), magnesium-rich pelites, and phyllites (Chadwick et al., 2000; Dey, 2013; Jayananda et al., 2019, 2013; Manikyamba et al., 2005; Manikyamba and Kerrich, 2012; Rogers et al., 2007). The eastern margin of the Khammam schist belt (KSB) within the Eastern Dharwar Craton serves as an excellent geological segment for assessing crustal evolution, particularly regarding granulite-granite and greenstone-granite relationships, the genesis of a sedimentary basin at the craton-mobile belt interface, and the extensional tectonics that resulted in the formation of the Godavari graben (Fig.1a). This section reveals the litho-units that comprise the granite complex of the Dharwar craton, namely the Eastern Dharwar Craton, the Shernawala outlier of the Pakhal Supergroup, and the granulites of the Eastern Ghats Belt. The Marginal Zone, situated between the craton and the mobile belt, together with outliers of Gondwana deposits, are all intimately fused (Sarvothaman, 1996). Additionally, a transcratonic supra crustal belt, namely the Khammam Schist Belt and the Chimalpahad Anorthosite Complex, are located in the Marginal Zone. The research region is a junction of the craton (EDC: Eastern Dharwar Craton), mobile belt (EGB: Eastern Ghats Belt), and granite-greenstone belt (KSB: Khammam Schist Belt), where the rocks of the EDC include assemblages of KSB and EGB rocks (Fig. 1b). The contacts between the craton and mobile belts are delineated by terrane border shear, suture, and thrust zones, which are crucial for the amalgamation of distinct tectonic domains. The western border of the EGB is delineated by the Eastern Ghats border Fault/thrust in the northern section, next to the Singhbhum and Bastar Craton, whereas the southern boundary between the EDC and EGB remains ambiguously defined. The metamorphic grade in the KSB typically progresses from greenschist to upper

amphibolite facies from west to east (Hrushikesh et al., 2020). This research indicates that amphibolite is large and exists as metamorphosed basic intrusive rocks. Prior researchers have proposed an igneous origin for the amphibolites of the KSB. The current research demonstrates the igneous origin of the massive variety of amphibolite.

## II. GEOLOGICAL SETUP

Usually, the schist belts in EDC manifest as a linear arrangement (Gadwal schist belt, Paddavuru schist belt, Ghanpur schist belt, and Yerraballi schist belt), whereas the Khammam Schist Belt (KSB) rocks are found as isolated outcrops within the granite gneisses of the Peninsular Gneissic Complex (PGC-II) on the eastern side of EDC (Fig.3). The Khammam Schist Belt (KSB) (Fig. 1b), situated within the Proterozoic collision zone of southern India, is positioned between the Eastern Dharwar Craton (EDC) and the Eastern Ghats Mobile Belt (EGMB) (Hari Prasad et al., 2000; Hrushikesh et al., 2020; Meshram et al., 2017). The belt comprises a collage of imbricated metasedimentary stages accreted to the EDC's eastern boundary (Hari Prasad et al., 2000; Hrushikesh et al., 2020; Meshram et al., 2017). Throughout this accretion and cratonization, the lithologies of the KSB and adjacent domains have undergone several episodes of syn- to post-collisional deformation and metamorphism. The tectonic events suggest that the belt retains an extensive accretionary history at the eastern margin of the EDC (Hari Prasad et al., 2000). A prior metamorphic investigation of the KSB amphibolites has determined peak pressure-temperature conditions of 8–12 kbar and 650–750 °C, indicating evidence of high-temperature metamorphism in the belt (Hari Prasad et al., 2000). The KSB mostly consisted of meta-basics and minor meta-sedimentary rocks (Sarvothaman, 1995), associated with the transcratonic supracrustal belt. (Sarvothaman, 1995) identified two kinds of amphibolite in the area: i) supracrustal amphibolite and ii) amphibolite dykes, based on field relationships, petrographic analysis, and geochemical markers. Our current study on Amphibolites from the eastern margin of the Eastern Dharwar Craton uncovers diverse microstructures, including those linked to magmatic processes. This study aims to analyse the field and petrographic of the Amphibolites from KSB, understand the magmatic history of the Khammam schist belt (KSB).

## III. RESULTS AND DISCUSSION

The amphibolites in the Khammam-Wira Sector occur within the Khammam granitoid, and also as a coherent unit east of the granitoid body. Most of the amphibolites within the granitoid and preserve excellent igneous textures. The enclosing granitoid clearly acted as a strain buffer, shielding the metabasics from much of the strain accompanying deformation.

In megascopic appearance, amphibolites are massive or crudely foliated (Fig. 2a). The rocks are showing sharp contact relationship with the granitoids (Fig. 2b). Sharp contact relationship also observed between amphibolites and quartzofeldspathic gneiss. These rocks occur as lenticular bodies of different dimensions. At places, the amphibole consist felsic veins from 1 meters to 15 meters (Fig. 2 c,d). The most prominent feature of the metagabbros is their intergranular texture, with laths of randomly oriented plagioclase enclosing clinopyroxene crystals.

Petrographically, they are characterized as medium- to fine-grained and massive in nature (Fig. 3). The amphibolites mostly consist of medium to coarse-grained hornblende, accompanied by clinopyroxene, plagioclase, and accessory minerals such as epidote, chlorite, ilmenite, apatite, and sphene, along with a slight presence of tiny magnetite grains. The hornblende grains are present as both clusters of larger subhedral grains and tiny greenish prismatic grains inside the feldspathic groundmass. Texturally, amphibolites are granoblastic polygonal. The polygonal texture is defined by subidioblastic hornblende, biotite and xenoblastic grain of plagioclase (Fig.3 a,b,c). The hornblende/palgioclase ratios are equal in most thin section. Texturally two varieties of biotite present in the rocks, the matrix biotite with well-defined gneissic foliation, while secondary biotite which are localized along the border of hornblende (Fig.3d). Sphene is present in the rocks as subordinate amount (Fig.3e). Both prismatic and basal sections of hornblende are present in these rocks (Fig.3d). Secondary biotite and quartz are commonly found together. In the rocks bearing rocks clinopyroxene occurs as porphyroblast containing inclusions of hornblende and quartz. However, inclusions of hornblende and quartz (Fig.3f) do not show contact relationship with each other. Chlorite and clinozoisite are appeared to be secondary in nature.

Chlorite replaces biotite while clinozoisite is seen to be localised along the border of hornblende.

The amphibolites of the present study are dominantly composed of hornblende and plagioclase with clinopyroxene and subordinate amount of sphene, opaque oxides. The granoblastic texture defined by hornblende + plagioclase is indicative of equilibrium assemblage representing amphibolites facies condition. The existence of gneissic foliation on the rocks describes metamorphism and deformations were contemporary during the formation of these rocks. Inclusions of hornblende and quartz within clinopyroxene porphyroblast indicate development of clinopyroxene in response to rising temperature.

Presence of hornblende domain without sphene and biotite domain with sphene and symplectitic intergrowth of biotite and sphene indicate that they were formed after hornblende due to addition of K<sup>+</sup> ion at the contact region of granitoids. The presence of sphene and hornblende further indicates the metaluminous nature of these rocks. The frequent development of biotite at the decomposed border of hornblende also indicates replacement of hornblende due to K-metasomatism. The nearly equal amount of hornblende and plagioclase and presence of insignificant amount of sphene, calcite, zoisite/epidote in the rocks indicate that the present amphibolites were basic intrusive rocks prior to amphibolites facies metamorphism. The amphibolites of the region were characterized comprehensively using both megascopic and petrographic analysis, were used to elucidate the magmatic formation of the Khammam schist belt. Most of the amphibolite samples fall calcic tonalite field (Fig.4) (CIPW norm calculation Q vs ANOR plot) which may be basaltic to basaltic-andesite composition and distinguished into tholeiitic magma series.

#### IV. CONCLUSIONS

The Amphibolites rocks preserve excellent igneous textures and are characterized as medium- to fine-grained and massive, mainly consisting of hornblende, clinopyroxene, plagioclase, and accessory minerals like epidote, chlorite, ilmenite, apatite, and sphene. The amphibolites are granoblastic polygonal, with a granoblastic texture defined by hornblende + plagioclase. The presence of gneissic foliation on the rocks describes metamorphism and deformations during the formation. The presence of sphene and hornblende

indicates the metaluminous nature of the rocks. Most samples fall into the calcic tonalite field, which may be basaltic to basaltic-andesite composition and distinguished into tholeiitic magma series.

#### V. ACKNOWLEDGEMENTS

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VII. FIGURES

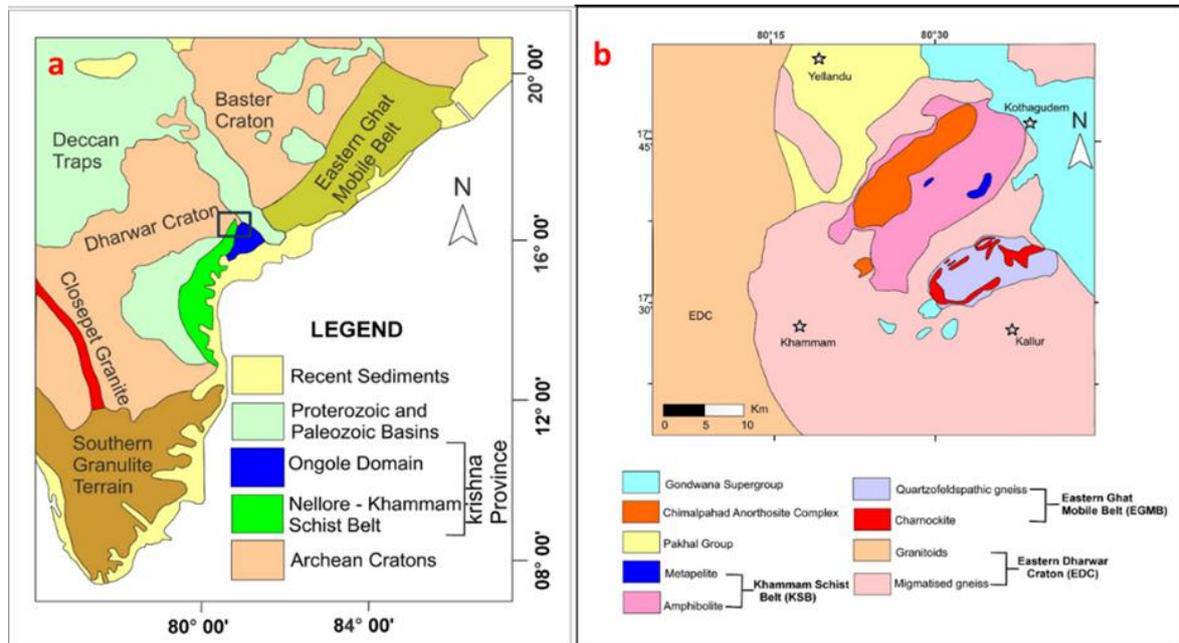


Fig. 1 (a) Geological map of the Dharwar Craton (after Chardon et al. 2008). (b) Khammam schist belt (after Hrushikesh et al. 2020).

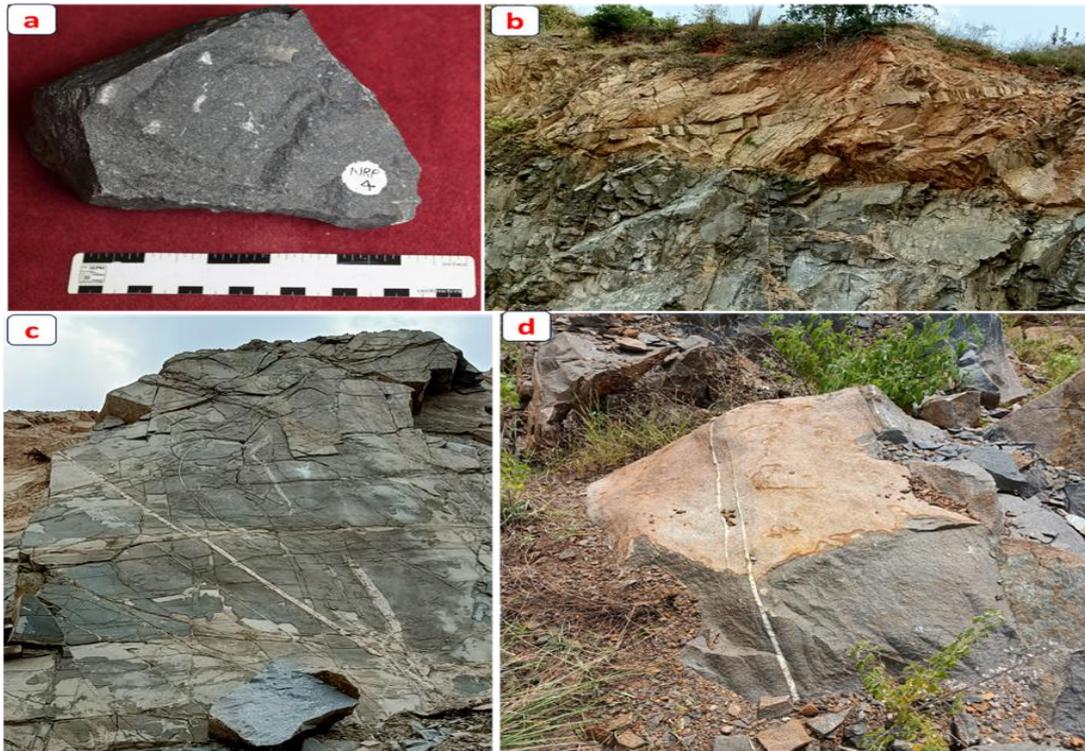


Fig. 2. (a) The amphibolites are shown as black and massive. (b) The amphibolites have a sharp contact relationship with the granitoids. (c, d) The amphibole consists of felsic veins from 1 meter to 15 meters.

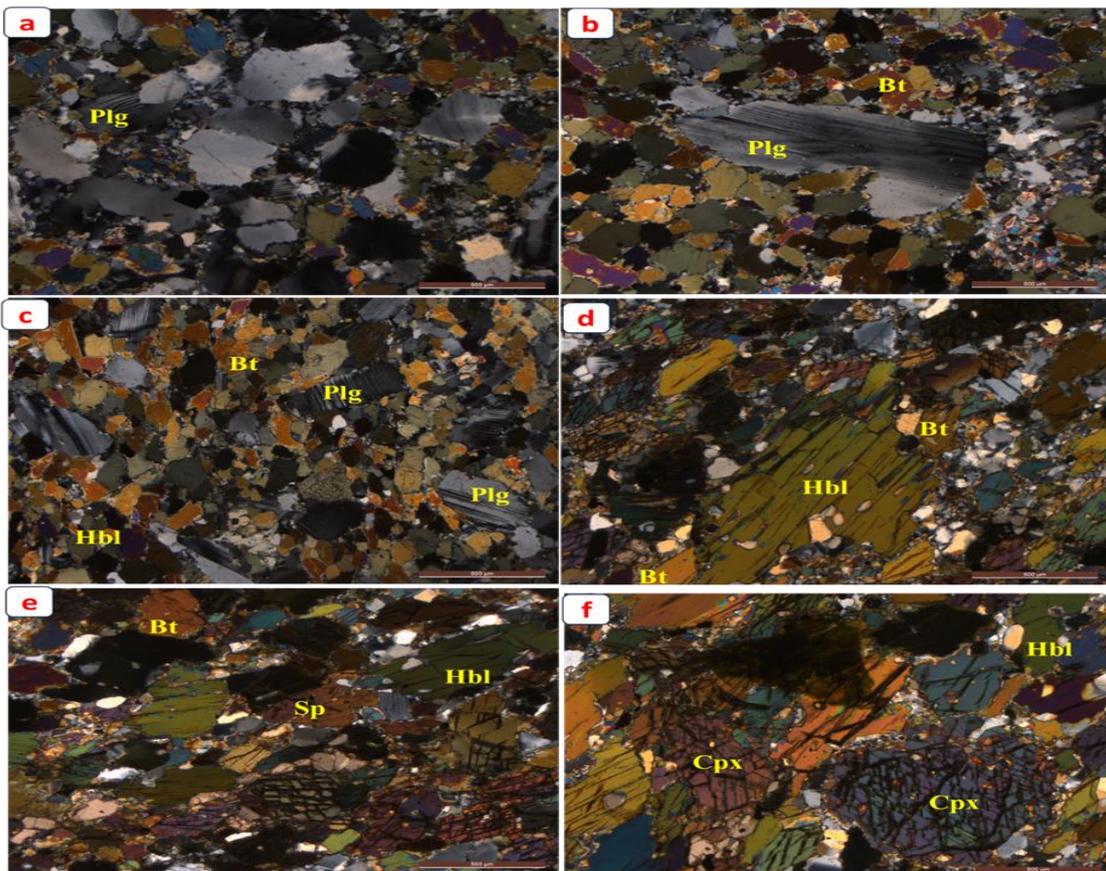


Fig. 3. (a) Cluster of un twinned plagioclases; (b) Cluster of large plagioclase and biotite and hornblende; (c) Cluster of plagioclase and biotite and hornblende; (d) large hornblende bordered by secondary biotite, (e) Close association of hornblende and sphene; (f) Large clinopyroxene contains smaller hornblende.

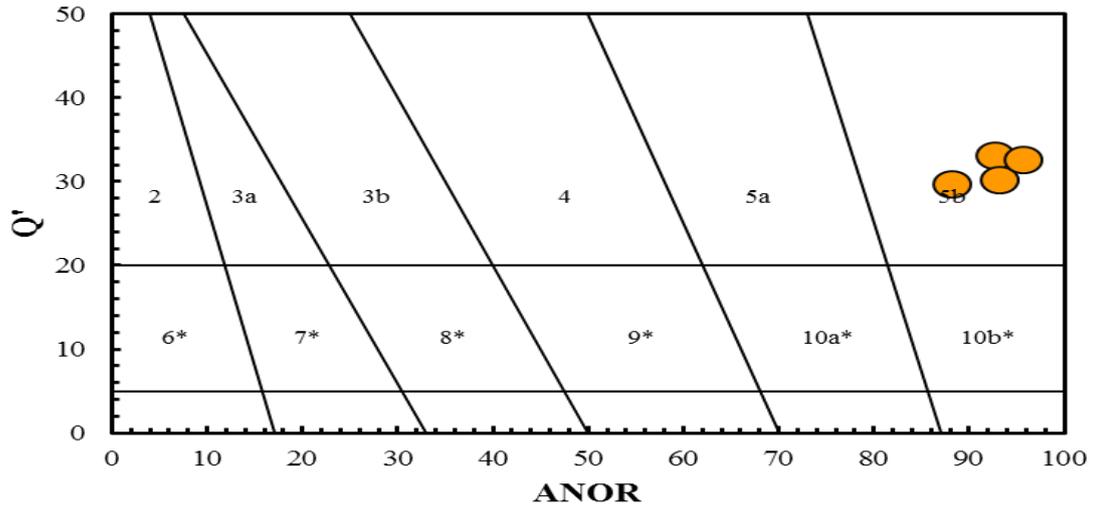


Fig. 4 CIPW normative Q vs ANOR binary diagram of Amphibolites for Khammam schist belt (KSB).