Petrological studies of Anorthosites from Chimalpahad area, Khammam Schist Belt, Telangana, Southern India

Bhagathlal Gatla*, K. Sreenu*, B. Naveen*, V. Lingaswamy* & K. Rajendraprasad
Department of Geology, Osmania University, Hyderabad-500007, India

***Abstract*—Anorthosites are distinctive among igneous rocks due to their high plagioclase feldspar content. The Chimalpahad layered anorthosite at the border zone of Archean supracrustal rocks of Khammam Schist Belt (KSB) and Eastern Ghats shows normal stratification predominantly in the form of rhythmic layering and sometimes in the form of zebra layering. The massive anorthosites show mineral lineation which indicates deformation in the KSB. The study area samples were collected from the field along the fresh outcrops. Megascopic study reveals that colors are light grey to dark layered in nature and grain size is coarse essentials minerals are Plagioclase, Hornblende, Feldspars and anorthite, accessory minerals.**

***Index Terms*—Anorthosites, Plagioclase, Chimalpahad Complex, KSB, Telangana.**

I. INTRODUCTION

Anorthosites are unique among igneous rocks, characterized by their high plagioclase feldspar content, often exceeding 90%. This composition gives them a light color, typically ranging from white to pale gray, which can create stunning contrasts in landscapes. Anorthosites primarily form in specific tectonic settings, such as during the differentiation of magma bodies in the Earth's crust or in plagioclase-rich magmas that crystallize at high temperatures (T Arai et al 2017). They are often associated with large igneous provinces and can indicate significant geological processes like crustal thickening and tectonic uplift. Anorthosites play a key role in planetary geology as well, with notable examples found on the Moon, where they contribute to our knowledge of lunar formation and evolution (L Zhang et al 2024). Their unique composition and formation processes offer valuable insights into the dynamics of Earth's crust and the broader processes of planetary differentiation. The Chimalpahad Complex provides important new information on the role of arc-generated crustal growth in the Proterozoic. The Chimalpahad Anorthosite Complex (CAC) stands out as the largest deformed and metamorphosed layered complex within the Precambrian shield of South India. First described by Leelanandam in the late 1980s, the CAC features a diverse and well-exposed stratigraphy that includes layered leucogabbro, gabbro, and ultramafic rocks, as detailed by Appavadhanulu et al. in 1976 and further explored by Ashwal in 1993.This complex has undergone significant metamorphism, specifically within the upper amphibolite to lower granulite facies, as documented by Subba Raju in 1987 and later studies by Hari Prasad et al. in 2000. The metamorphic conditions have played a crucial role in shaping the mineralogy and structure of the CAC, offering insights into the geological processes that have influenced the region over geological time. The study of the CAC is essential for understanding the tectonic history of South India and the evolution of the continental crust during the Precambrian era. Its unique composition and metamorphic history make it a significant focus for researchers investigating the dynamics of layered igneous complexes and their role in regional geology.

II. LOCATION AND ACCESSIBILITY OF THE AREA

The research area of Chimalpahad within the Chimalpahad Anorthosite Complex (CAC) is located near Enkoor Mandal, approximately 35 kilometers northeast of Khammam district town. From Enkoor Mandal, the Chimalpahad study area is situated 25 kilometers to the northwest, as shown in Figure 1. The Khammam Schist Belt (KSB) is located in Telangana State, as indicated on Survey of India Toposheet Nos. 65C/07 and 65C/08, bounded by latitudes 17° 15' to 17° 35' N and longitudes 80° 20' to 80° 35' E.

III. CLIMATE AND VEGETATION

The climate of Khammam district in Telangana, India, is characterized by distinct seasons: summer, monsoon, and winter. Temperatures typically range from 27°C to 48°C. The summer season lasts from March to May, with high temperatures reaching 40–48°C. Humidity is low, and conditions are generally dry. The monsoon period spans from June to September, with average temperatures around 30°C; the district receives about 78% of its annual rainfall during this time. Winter occurs from December to February, with temperatures ranging from 27–34°C,

and January is usually the coldest month of the year. The vegetation in Khammam district includes thorny vegetation covering the scattered hills of the plateau areas, dense woodlands found in the northeast along and near the Godavari River, and moist deciduous and dry savanna vegetation in the forests, which cover about one-fourth of the land area. Common tree species include teak, rosewood, wild fruit trees, and bamboo.

IV. GEOLOGICAL SETTING

The Khammam Schist Belt (KSB), closely associated with the Chimalpahad Anorthosite Complex (CAC), is a deformed and metamorphosed mafic-ultramafic mineral complex situated between the Western Dharwar Craton (WDC) and the Eastern Dharwar Craton (EDC) in South India. The Eastern Ghats Belt is a polycyclic granulite facies orogeny, dated to around 1.0 Ga that has been thrust over the Dharwar Craton to the west (Dobmeier and Raith et al., 2003; Mukhopadhyay and Krishnapriya et al., 2009). The Chimalpahad Anorthosite Complex (CAC) is the largest deformed and metamorphosed layered complex in the Precambrian shield of South India (Leelanandam et al., 1987, 1990). It contains a well-exposed Stratigraphy of layered anorthosite - leucogabbro – gabbro - ultramafic rocks (Appavadhanulu et al., 1976, Ashwal et al., 1993).

The main objectives of this research are to conduct a thorough evaluation of the petrological properties of anorthosite rock types within the Chimalpahad Anorthosite Complex. This study focuses on specific areas of Chimalpahad, encompassing approximately 30 square kilometers, as outlined in Toposheet number 65C/7. The aim is to achieve accurate delineation of the contacts between these rock types and the surrounding country rocks. Fieldwork is optimally conducted during May and June, when conditions are most favorable for detailed geological mapping and rock sample collection.

V. PETROGRAPHY

Chimalpahad Complex have been metamorphosed, the rocks mostly contains anorthosites which are layered and massive (Fig 3 & Fig 4). Anorthosites it contains >90% plagioclase, they are medium- to coarse-grained rocks, and contain predominant plagioclase, minor hornblende, and clinopyroxenes are important accessories minerals. Plagioclase, in general is coarse grained and subhedral to anhedral and grain size decreases with decreasing modal content (98 to 40 volumes %) from anorthositic to gabbroic rocks. The Chimalpahad anorthosite shows rhythmic layering which are measured to millimeter to centimeter formed by the alteration of layers characterized by the variation proportion in plagioclase and hornblende. The layered rock, the individual layers ranging in thickness from a fraction of centimeter to a fraction of a meter.Massive anorthosite often forms in specific tectonic settings, such as in large igneous provinces or as a result of magmatic differentiation. The magmatic structures in strain zones are planar foliation and mineral lineation (Fig 4) of the deformation.

Petrographic studies observed under microscope anorthosites (Fig 5&6) of Chimalpahad revels that subhedral form of grain size, low relief and directional cleavage present. Plagioclase feldspar predominantly observed, often showing characteristics like polysynthetic twinning and zoning. When observed in crossed polars inclined extinction, Lamellar twinning with feeble to strong zoning are frequently noticed in plagioclases from the anorthosite. Plagioclase shows distinct birefringence under polarized light, aiding in mineral identification.

VI. ANALYTICAL METHOD

The Chimalpahad anorthosite rocks were prepared as thin sections, measuring up to 0.03 mm in thickness, to enable microscopic examination of their petrographic features. These thin sections were analyzed using a LEICA DM750P petrological microscope in the microscopy lab at the Department of Geology, Osmania University, Hyderabad, Telangana, India. This analytical approach facilitated a detailed investigation and characterization of the mineralogical and textural properties of the anorthosite samples.

VII. ACKNOWLEDGMENTS

The authors are grateful to the Head of the Department of Geology at Osmania University, Hyderabad, for providing the facilities necessary to carry out this research. The authors also thank the anonymous reviewers for their valuable suggestions and comments, which helped improve the quality of the paper.

VIII. FIGURES

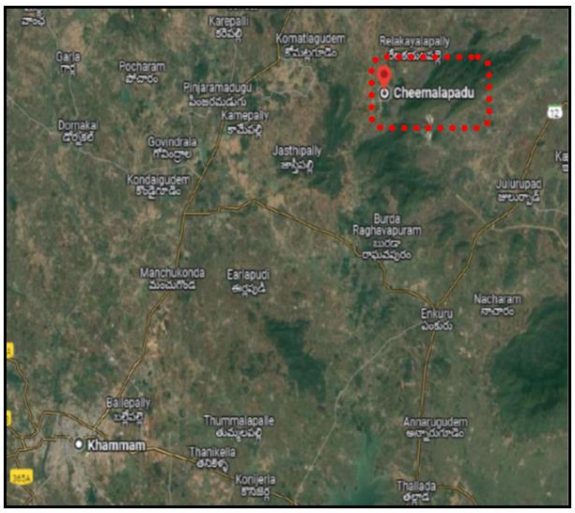

Figure 1.Satellite image of the research area.

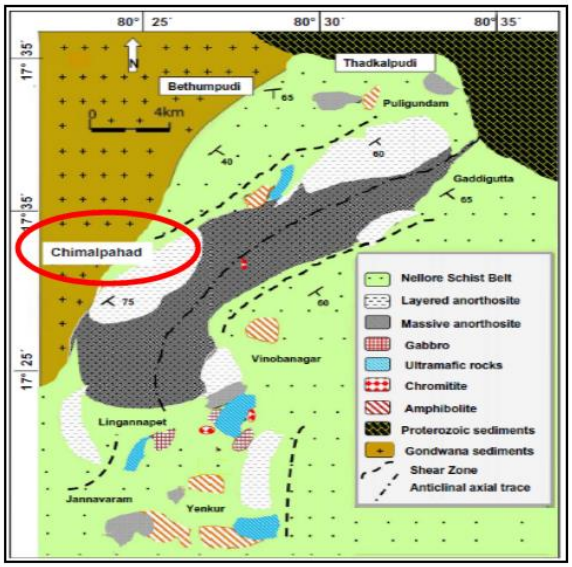

Figure 2: Chimalpahad Complex Modified after Appavadhanulu et al. (1976). C.V. Dharma Rao et.al. / Journal of Asian Earth Sciences 40 (2011) 1027–1043.

Figure 3: Layered Anorthosite in the Chimalpahad area.

Figure 4: Massive Anorthosite mineral lineation in the Chimalpahad area.

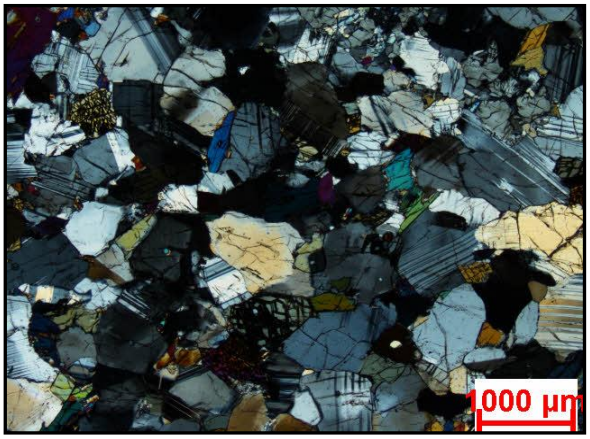

Figure 5: Plagioclase dominant anorthosite.

Figure 6: Plag, Cpx dominated anorthosites.

IX. CONCLUSIONS

Petrological studies of the anorthosite rocks in the Chimalpahad Complex have led to the following conclusions: The complex contains calcic, hornblende-bearing layered anorthosites as well as massive anorthosites. Evidence of their igneous origin is observed in the field through rhythmic layering and zebra banding. These structures suggest formation by the gravitational settling of magmas, resulting in alternating layers of felsic and mafic minerals. The plagioclase mineral grains are typically subhedral,

colorless, and exhibit low relief. Directional cleavage is absent, but lamellar twinning is present. Additionally, the CAC exhibits some foliation as a result of metamorphic processes.

REFERENCES

[1]. Appavadhanulu, K., et al. "The Chimalpahad meta-anorthosite complex, Khammam district, Andhra Pradesh." GeolSurv India MiscPubl 23 (1976): 267-278.

[2]. Arai, Tatsuyuki, and Shigenori Maruyama."Formation of anorthosite on the Moon through magma ocean fractional crystallization." Geoscience Frontiers 8.2 (2017): 299-308.

[3]. Leelanandam, C., 1987. Archaean anorthosite complexes: an overview. In: Saha, A.K. (Ed.), Geological Evolution of Peninsular India – Petrological and Structural Aspects, vol. 13. Recent Researches in Geology, Hindustan Publication Corporation, pp. 108–116.

[4]. Prasad, B. Hari, et al. "Petrology and geochemistry of amphibolites from the Nellore-Khammam schist belt, SE India." Geological Society of India 56.1 (2000): 67-78.

[5]. Rao, CV Dharma, B. F. Windley, and A. K. Choudhary. "The Chimalpahad anorthosite Complex and associated basaltic amphibolites, Nellore Schist Belt, India: Magma chamber and roof of a Proterozoic island arc." Journal of Asian Earth Sciences 40.5 (2011): 1027-1043.

[6]. Rao, CV Dharma, M. Santosh, and Yan-Jie Tang. "Re–Os isotope systematics of Archean chromitites from the Chimalpahad Anorthosite Complex, south-east India: Implications for mantle extraction processes." Ore Geology Reviews 65 (2015): 274-282.

[7]. Reddy, M. Narsimha and C. Leelanandam. "Magmatic and tectonic structures from the Chimalpahad layered complex, Andhra Pradesh, India." Gondwana Research 7.3 (2004): 887-896.

[8]. Stratification and Cross-stratification in the layered anorthosite of chimalpahad, khammamdistrict,Andhra Pradesh, India T. Ramamohana rag and B. V. Satyanarayanaraju department of geology, Andhra university, Waltair 530003 journal geological society of india Vol. 28, july 1986, pp. 51 to 53

[9]. Tectonomagmatism, geochemistry and metamorphism of precambrian terrains, Editors K.C. Gyani and P. Kataria, published by the Department of Geology, M.L. Sukhadia University, Udaipur - 3 13 002,2000, p.iv+438 :127-142

[10]. Windley, B. F. "A Discussion on the evolution of the Precambrian crust-Crustal development in the Precambrian." Philosophical Transactions of the Royal Society of London. Series A, Mathematical and Physical Sciences 273.1235 (1973): 321-341.

[11]. Zhang, Le, et al. "Elemental and Sr isotopic compositions of plagioclase as an indicator of lunar source-rock type: Insights from Chang'e 5 plagioclase fragments." Icarus 413 (2024): 116002.