Geological studies of granitoid suite of rocks in and around Amangal area Mahabubnagar District Telanagana

[1]B. Shoba Rani*, [2]Sreenu Kunsoth

Department of Geology,
University College of Science,
Osmania University, Hyderabad, TS, INDIA.

***Abstract*: The current work is limited to an area in and around the Amangal Mahbubnagar Districts. The goals of the field season programme were to characterize the granitic terrain and study shear zones, faults, and pegmatite veins to see how they affected Au-Cu-Mo mineralization. The main focus of the study is to describe the granitoids by looking at their petrography, mineral chemistry, shear zones, faults, and pegmatite veins to see how they affect Au-Cu-Mo mineralization, fluorite, and REE, if any. "Specialized Thematic Mapping" was done on a scale of 1:25,000 over an area of about 70 sq. km (Toposheet No. 56L/9).**

***Keywords:* Petrography, mineralization, shear zones, faults, and pegmatite veins.**

I. INTRODUCTION

The scope of the work being done right now is restricted to a region in the granitoid suite of rocks in and around the Amangal area in the Mahbubnagar district of Telangana. It is on Survey of India toposheet no. 56 L/9. The area was mostly made up of two types of granitoids: tonalite and granodiorite [1-3]. A group of rocks called Monzogranite (TGM), Monzosyeniye, and Syenogranite [4-6]. A granitoid or granitic rock is a type of coarse-grained plutonic rock that is similar to granite and is mostly made up of feldspar and quartz. Examples of granitoid rocks include granite, quartz monzonite, quartz diorite, syenite, granodiorite and trondhjemite [7-8]. Many are made by the subduction of a continental arc or the collision of two sialic masses. Granitoids and volcanic rocks are similar and often come from the same place [9-12]. Most of the time, though, they are gone after years of erosion. Many granitoid rocks are found in places where the crust has thickened during orogenies [13-15]. However, some granitoid rocks, called anorogenic granitoid rocks, have nothing to do with convergent boundaries or subduction zones. These anorogenic granitoids may be the deep sources of rift-related volcanism. They can be seen in places where erosion has taken away volcanic rocks and other signs of rifting. These A-type granitoids might have come from hotspots or plumes in the mantle [16-18].

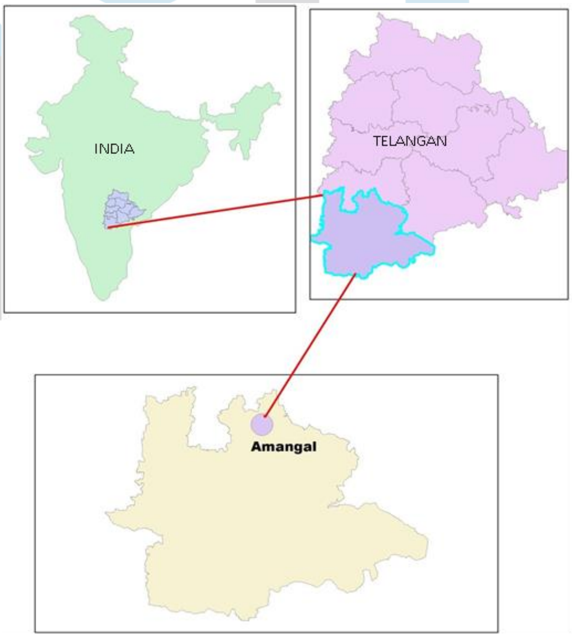

Fig. 1 Key map of the study area, Telangana State, India.

II. Literature

Bruce Foote (1868) worked in the Krishna district and he called the rocks there "granitoids" [19]. Khursid Mirza, who worked for the Hyderabad Geological Survey at the time, came up with the idea of dividing the Peninsular Gneissic Complex (PGC) into two groups: "older grey gneisses" and "younger pink gneisses" [20]. Mukherjee, who worked for the old Hyderabad Geological Survey, did geological mapping in 1941. This includes most of the area that is now mapped on a scale of 1:50,000. Mukherjee put all of the granitoids together into the Peninsular Gneissic Complex and came to the conclusion that the dykes are younger than the quartz reef [21].

Eastern Dharwar Craton, which is made up of rocks like granite and granodiorite from the Peninsular Gneissic Complex (PGC) and parts of the Archean-aged Dharwar Supergroup [23-24]. Several intrusive bases and acids pass through these. The older metamorphic enclaves are made up of amphibolite's, hornblende schist, chlorite biotite schist, talc-chlorite schist, metabasites, orthoquartzite, and banded magnetite quartzite, which show retrograde metamorphism from amphibolite's to green schist facies. The migmatite group is made up of pink and grey granite gneisses with medium to coarse grains and small pockets of granodiorite that have a gradational contact [25]. The younger granite is made up of grey and pink biotite granite with medium to coarse grains. This is followed by an intrusive pink and grey granite with medium to fine grains and sharp contacts. Pink granites range from medium to coarse in terms of how much alkali feldspar they have. The foliation of the granite gneiss runs from N40W to S40W. Mafic dykes tend to run north to south and west to east [26-28]. There are a number of shear zones and faults in the area, which are sometimes filled with quartz reefs. Most of the shear zones and faults run WNW-ESE and ENE-WSW, but there are also some that run N-S and NNE-SSW. Fluorite mineralization is found in the shear zones that run from ENE to WSW. Specula rite and sulphides are also found in small amounts in the shear zones. A number of kimberlite bodies were found where the E-W and WNW-ESE faults meet the NW-SE faults to the west of this area [29-30].

Shear zones in calc-alkaline granitoids, which are probably good places for porphyry-type Cu–Mo deposits. It has been shown that molybdenite, fluorite, galena, pyrites, uraninite, and other minerals are present in these zones. The alkaline granites may have formed from the overflow of calc-alkaline magmatism or from a separate magmatic event linked to extensional zones or rifts, which is also important when looking for Mo, Ba, F, and REE mineralization. In the nearby Bastar Craton, there is a well-known Cu-Mo deposit in a porphyry-hosted quartz vein or reef that is linked to the Malanjkhand granite. As a similar setup is expected here, it is possible that porphyry-type Cu-Mo mineralization could exist in dilational zones and changed shear zones that cross calc-alkaline granitoids [31-35].

Christofano and Harris (1960), Uraninite was identified in slag samples, which have radioactivity levels between 300 and 500 cpm. This is much higher than the background level of 150 to 180 cpm in granite gneiss. There are also a lot of zirconium, cesium, and lanthanum in the slags [36]. McClenaghan (2005) found heavy minerals like garnets, ilmenites, zircon, and spinels in stream sediment samples while looking for Kimberlites [37-38].

EDC is highly deformed and tectonised teranne characterized by a number of NNW to SSE and NW-SE trending brittle-ductile regional scale sinistral shear zones which demarcate the boundaries of different terranes/ tectonic blocks constituted by Meso to Neo-Archaean greenstone belts or granitoid belts. In the northeast part of EDC, there are number of NW-SE trending regional scale shear zones formed in the craton interior as well as craton transitional / marginal zone areas lying parallel to the Pakhal Rift valley/ basin. Pakhal basin was developed at the junction of Dharwar and Bastar Cratons [39-40].

No attempt has been made till now to classify the granitoids of Telangana in different suites. Therefore, an attempt has been made to apply the suite classification to the granitoids of Mahbubnagar district of Telangana

III. Local Geology

The Indian shield is one of the Precambrian shield areas where different rocks from the early Archaean to the late Proterozoic are exposed in different tectonic settings. The area being looked at is a small piece of the Dharwar Craton's eastern side. The Eastern Dharwar Craton is made up of granites that formed in the late Archaean (2.6 to 2.5 Ga). Tonalite-Granodiorite-Monzogranite Suite (TGM) and Monzogranite-Syenogranite Suite (MS) are both part of this study. Younger granitoids (Alkali feldspar granite) and pegmatite veins have broken into the above suites [41-43].

IV. lithology

Dharwar Supracrustals, older metamorphic rocks thought to be present inside the granite as an undigested component or restite, are a strong candidate for this occurrence shown in Table 1 [44].

Table 1: Regional stratigraphy of the area.

Lithology	Supergroup	Age
Gabbro, Dolerite, Pyroxenite, Porphyritic dolerite	Basic intrusive	Mesoproterozoic
Quartz veins	Peninsular GneissicComplex II	Archeanto Paleoproterozoic
Pegmatite, aplite veins		
Alkali feldspar granite		
Pink granite		
Porphyritic grey granite		
Grey hornblende-biotitegranite		
Grey biotite granite		
Grey Hornblende granite		
Migmatite	Dharwar Supergroup	Archean
Meta basalt		

V. STRATIGRAPHY

Based on the present study local lithostratigraphy established of the area is given in Table 2 [45-46].

Table 2. Local lithostratigraphy established of the area

PROTEROZOIC		Ultramafic intrusive
		Pegmatite and quartz veins
	Younger intrusive	Basic intrusive (Gabbro/Dolerite/Porphyritic Dolerite)
ARCHAEAN		Alkali Feldspar Granite
	Granitoid Suits	Monzogranite – Syenogranite suite (MS)
		Tonalite – Granodiorite – Monzogranite suite (TGM)
	Dharwar Supergroup	Amphibolite/Quartzite/ Mica schist

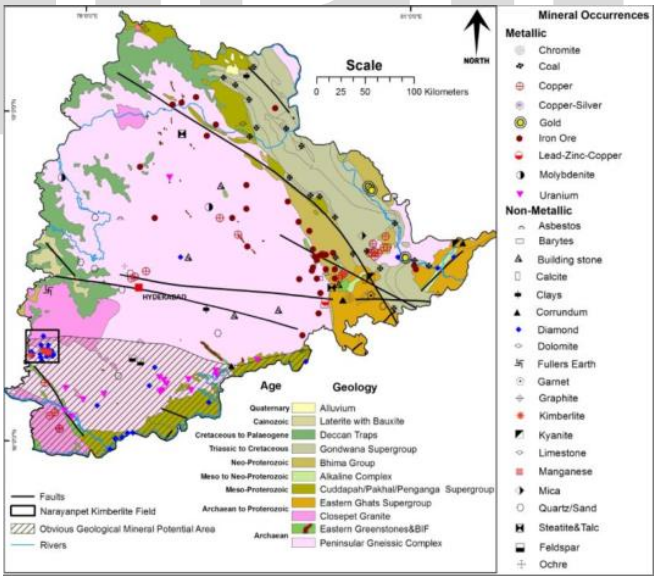

Fig. 2 Generalized geological map of Telangana State adopted from Geological Survey of India

VI. GRANITOID SUITES

Each suite's different granitoids have their own distribution, general characteristics, and types of enclaves. The granitoids in the study are made of different things. Granitoids in the Tonalite-Granodiorite-Monzogranite suite (TGM) suite have different textures and a wide range in how much of each mineral they are made up of. The TGM suite of granitoids is made up of different amounts of plagioclase feldspar, k-feldspar, quartz, hornblende, and biotite. In order of decreasing abundance, the accessory phases are made up of zircon, sphene, opaque minerals, and apatite. The most important minerals in Monzogranite-Syenogranite (MS) suite are potash feldspar, plagioclase feldspar, and quartz. Biotite is an important accessory mineral, and hornblende isn't found very often. Magnetite, sphene, zircon, apatite, and opaque are the other pieces [47]. This type of rock makes up most of the TGM suite. In the eastern part of the mapped area (56L/9), there are a lot of granodiorite rocks, and they cover about 40% of the mapped area, where granodiorite and monzogranite can't be told apart. It is mostly made up of plagioclase and alkali feldspars in about equal amounts. This lithounit is from the Mesocratic period. It is grey and has medium to large grains. This lithounit is defined by the presence of mafic clots and the way they are arranged in a line. This granitoid has medium to large grains, and in some PLACES, it is equigranularity (hypidiomorphic) and in other places it is not. Under a microscope, plagioclase feldspars look like they have a subhedral shape that tends to change into a euhedral shape. In a few places in granodiorite, the twin lamellae of plagioclase are well formed. Potash feldspar grains are always perthitic, and patterns like braid, string, and patch are common. The unit is called a monzogranite-syenogranite suite based on its texture and modal mineralogy on the Quartz-Alkali Feldspar-Plagioclase (QAP) plot [48]. The values of quartz, plagioclase and potash feldspars are recalculated to 100 and plotted in trilinear diagram (Fig. 3). In Fig. 4, the granitoids fall in the granodiorite and monzogranite fields. According to the International Union of Geological Sciences (IUGS) -Streisen classification, most of the rocks in the MS suite group belong to the syenogranite fields [49-51].

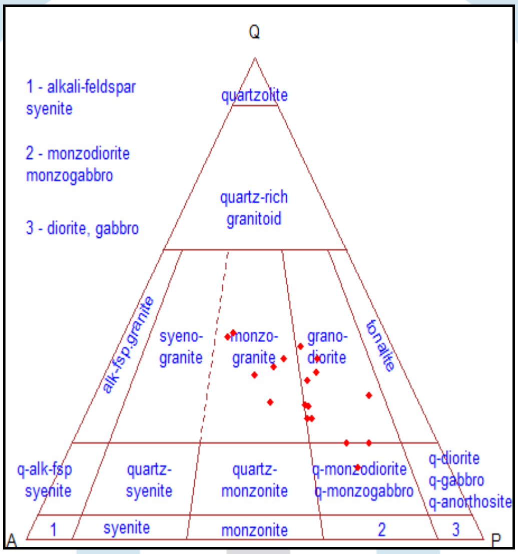

Fig. 3 Quartz-Alkali Feldspar-Plagioclase (QAP) of TGM suite explained with ternary phase model.

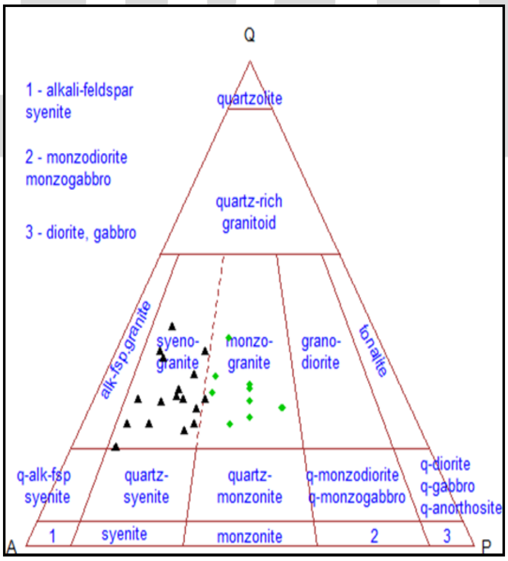

Fig. 4 Quartz-Alkali Feldspar-Plagioclase (QAP) of MS suite explained with ternary phase model.

Monzogranite is less common than granodiorite in the studied region. Field identification of the TGM suite minerals, particularly monzogranite and granodiorite, is notoriously challenging. Monzogranite, in contrast to granodiorite, is leucocratic, ranging from a very light pink to an off-white tint, and has medium to coarse grains. Similar amounts of K-feldspar and plagioclase can be found in this granitoid. Porphyritic texture can be seen in areas where K-feldspar phenocrysts predominate. This granitoid is found to be in-equigranularity upon closer inspection. The most common minerals are K-feldspar, plagioclase feldspar, and quartz, while the least common are biotite, magnetite, and opaque. In certain places the quartz grains have recrystallized and the plagioclase feldspar has been transformed into zoisite. Lamellar twinning of plagioclase feldspar is frequently [52-53].

MS suites are widespread over the majority of the study region and typically take the form of large hills or boulder outcrops. Differences in composition between monzogranite and syenogranite are so subtle that they are impossible to detect with the naked eye. All across the MS suite, you may find pegmatite and aplite's of all sizes. Both the MS and TGM suites are in gradual touch with one another. This granitoid suite is mostly porphyritic but locally thin grained. The phenocrysts of MS suite porphyritic granite are K- feldspar, and in some locations, this feldspar is oriented preferentially. Pinkish in colour, this suite of granitoids typically has an equal amount of plagioclase feldspar and k-feldspar. Accessories include magnetite, zircon, sphene, and rare earth elements [54].

The plotted region has both TGM and MS suite sheared granite. Minerals like mylonite and ultramylonite are spotted in the shear zone. Most porphyroclasts are made up of quartz, alkali feldspar, and perthite. Some of the alkali feldspar porphyroclasts in the MS suite porphyritic granite are rotated. There is evidence of S-C fabric growth in the TGM series of granitoids. Sheared granites have many of the same primary mineralogical components as their corresponding suites of granitoids (TGM and MS) [55].

VII. STRUCTURES.

In the present study's granitoids, little deformation has occurred; only magmatic structures and tiny, discontinuous shear zones can be found. In geology, shear zones are small bands of rock that have experienced significant strain and are characterized by spatial gradients of finite strain. The development and continuity of these shear zones occur only at the local level. Specifically, Toposheet no. 56L/9 shows three large shear zones [56-57].

Mylonitization of the granitoids and localized ultra-mylonitization of the granitoids shown in Fig. 5. These shear zones display both horizontal and vertical motion (dextral and sinistral). Mylonite has evidence for S-C fabric evolution crystallized quartz sliver (Fig. 6) [58-59].

Fig. 5 S-C fabric in mylonite showing sinistral sense of movement

Fig. 6 Quartz ribbon due to shearing in the study area

VIII. JOINTS

Two major set of sub vertical to vertical joints having trend N-S and E-Ware noticed in the mapped area. Some of the field photographs also included below (Fig. 7 to Fig 12) [60].

IJRTI

Fig. 7 N-S and E-W trending two sets of joints in the study area

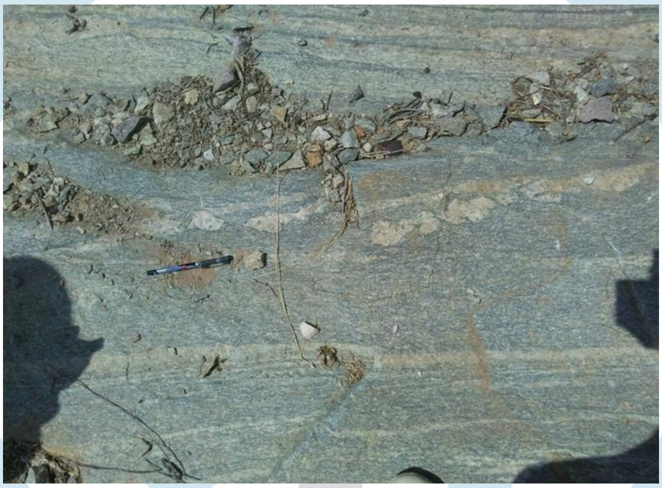

Fig. 8 Field photograph of quartz vein in TGM suite of rocks

Fig. 9 Field photograph showing pegmatite intrusion in TGM suite of rocks

Fig. 10 Field photograph showing mylonites in TGM suite of rocks.

Fig. 11 Field photograph showing porphyritic texture of syenogranite of MS suite of rocks.

Fig. 12 Field photograph showing cluster of magnetite in porphyritic granite at amangal

IX. SUMMARY

The Eastern Dharwar Craton may be broken up into its component components based on the findings of field and petrographic studies of the granitoids in the Amangal region. In the eastern Dharwar craton, the granitic rocks that are the subject of this study cover an area of ten square kilometers. The region is made up of granodiorite, syenogranite, monzogranite, alkali feldspar, and plagioclase feldspar as well as alkali feldspar and plagioclase feldspar. Accessories include biotite, zircon K-feldspar, quartz, plagioclase, biotite, and hornblende are the primary minerals that are responsible for the formation of rock [61-62].

X. Conclusion

According to the categorization system used by the IUGS, the granitoids that make up the TGM suite are mostly magmatic, calc-alkalic to alkali-calcic, and meta luminous to weakly per-aluminous. In addition, the primary element chemistry of the region's granitoids appears to be quite similar to that of the Cordilleran granitoids that were generated in a convergent context. It has been determined, on the basis of mineralogy and texture, in addition to field relations, that the sequence of the differentiation of parental magma for granitoids of Amangal rocks.

References

[1]. Dey, S., Rai, A.K. and Chaki, A., 2009. Geochemistry of granitoids of Bilgi area, northern part of eastern Dharwar craton, southern India—Example of transitional TTGs derived from depleted source. Journal of the Geological Society of India, 73(6), pp.854-870.
[2]. Shang, C.K., Satir, M., Nsifa, E.N., Liégeois, J.P., Siebel, W. and Taubald, H., 2007. Archaean high-K granitoids produced by remelting of earlier Tonalite–Trondhjemite–Granodiorite (TTG) in the Sangmelima region of the Ntem complex of the Congo craton, southern Cameroon. International Journal of Earth Sciences, 96(5), pp.817-841.
[3]. Madhnure, P., Rao, P.N. and Rao, A.D., 2014. An Appraisal of Hydrogeological and Hydrochemical Parameters from Basalt and Granite Aquifers, In Parts of Ranga Reddy and Mahabubnagar Districts, Telangana State, India.
[4]. Martin, H., Smithies, R.H., Rapp, R., Moyen, J.F. and Champion, D., 2005. An overview of adakite, tonalite–trondhjemite–granodiorite (TTG), and sanukitoid: relationships and some implications for crustal evolution. Lithos, 79(1-2), pp.1-24.
[5]. Meshram, R. and Rao, S.V., 2009. Mineralogy and geochemistry of lamprophyres from Kalwakurty, Mahabubnagar district, Andhra Pradesh. Indian Journal of Geosciences, 63(4), pp.361-372.
[6]. Frost, C.D., Frost, B.R., Kirkwood, R. and Chamberlain, K.R., 2006. The tonalite–trondhjemite–granodiorite (TTG) to granodiorite–granite (GG) transition in the late Archean plutonic rocks of the central Wyoming Province. Canadian Journal of Earth Sciences, 43(10), pp.1419-1444.
[7]. Mondal, N.C., Adike, S., Singh, V.S., Ahmed, S. and Jayakumar, K.V., 2017. Determining shallow aquifer vulnerability by the drastic model and hydrochemistry in granitic terrain, southern India. Journal of Earth System Science, 126(6), pp.1-23.
[8]. Kumar, D., Shankar, G.B.K., Mondal, S., Venkatesam, V., Sridhar, K., Rao, P.N., Madhnure, P. and Rangarajan, R., 2016. Mapping lithology and assessing recharge characteristics in a granitic hard rock aquifer: Inference from 2D resistivity, induced polarization, tracer and moisture measurements. Journal of the Geological Society of India, 88(1), pp.29-38.
[9]. Llambías, E.J., Sato, A.M., Suárez, A.O. and Prozzi, C., 1998. The granitoids of the Sierra de San Luis. Geological Society, London, Special Publications, 142(1), pp.325-341.
[10]. Hine, R., Williams, I.S., Chappell, B.W. and White, A.J.R., 1978. Contrasts between I-and S-type granitoids of the Kosciusko Batholith. Journal of the Geological Society of Australia, 25(3-4), pp.219-234.
[11]. Castro, A., 2014. The off-crust origin of granite batholiths. Geoscience Frontiers, 5(1), pp.63-75.
[12]. Sage, R.P., Lightfoot, P.C. and Doherty, W., 1996. Geochemical characteristics of granitoid rocks from within the Archean Michipicoten Greenstone Belt, Wawa Subprovince, Superior Province, Canada: implications for source regions and tectonic evolution. Precambrian Research, 76(3-4), pp.155-190.
[13]. Brown, G.C., 1981. Space and time in granite plutonism. Philosophical Transactions of the Royal Society of London. Series A, Mathematical and Physical Sciences, 301(1461), pp.321-336.
[14]. Hossain, I., Tsunogae, T., Tsutsumi, Y. and Takahashi, K., 2018. Petrology, geochemistry and LA-ICP-MS U-Pb geochronology of Paleoproterozoic basement rocks in Bangladesh: an evaluation of calc-alkaline magmatism and implication for Columbia supercontinent amalgamation. Journal of Asian Earth Sciences, 157, pp.22-39.
[15]. Manikyamba, C. and Kerrich, R., 2012. Eastern Dharwar Craton, India: continental lithosphere growth by accretion of diverse plume and arc terranes. Geoscience Frontiers, 3(3), pp.225-240.
[16]. Radhakrishna, T., 1994. Temporal variations and mantle sources of the mafic dyke swarms in south India. Earth Planet. Sci. Lett, 121, pp.213-226.
[17]. Talukdar, D., Pandey, A., Chalapathi Rao, N.V., Kumar, A., Pandit, D., Belyatsky, B. and Lehmann, B., 2018. Petrology and geochemistry of the Mesoproterozoic Vattikod lamproites, Eastern Dharwar Craton, southern India: evidence for multiple enrichment of sub-continental lithospheric mantle and links with amalgamation and break-up of the Columbia supercontinent. Contributions to Mineralogy and Petrology, 173(8), pp.1-27.
[18]. Ceccato, A., Menegon, L., Pennacchioni, G. and Morales, L.F.G., 2018. Myrmekite and strain weakening in granitoid mylonites. Solid Earth, 9(6), pp.1399-1419.
[19]. Foote, R.B., 1868. On the distribution of stone implements in Southern India. Quarterly Journal of the Geological Society, 24(1-2), pp.484-495.
[20]. Mirza, K.H., 1943. A brief outline of the geological history of Hyderabad State with special reference to its mineral resources. Hyderabad Geol. Surv. Bull, 2.
[21]. Mukherjee, S.K., 1941. Geology of parts of Surapur and Shahpur taluks, Gulbarga district. Journal of the Hyderabad Geological Survey, 4(1), pp.9-54.
[22]. Singh, S.P. and Bhattacharya, A.R., 2017. N–S crustal shear system in the Bundelkhand massif: A unique crustal evolution signature in the northern Indian peninsula. Journal of Earth System Science, 126(8), pp.1-9.
[23]. Argast, S. and Donnelly, T.W., 1986. Compositions and sources of metasediments in the upper Dharwar Supergroup, South India. The Journal of Geology, 94(2), pp.215-231.
[24]. Radhakrishna, B.P., 1974. Peninsular gneissic complex of the dharwar craton: A suggested model for its evolution.
[25]. Gibbs, A.K., 1980. Geology of the Barama-Mazaruni Supergroup of Guyana. Harvard University.

[26]. Sturm, A. and Carryer, S.J., 1970. Geology of the region between the Matusevich and Tucker glaciers, North Victoria Land, Antarctica. New Zealand Journal of Geology and Geophysics, 13(2), pp.408-435.
[27]. Prabhakar, B.C., Jayananda, M., Shareef, M. and Kano, T., 2009. Petrology and geochemistry of late archaean granitoids in the northern part of Eastern Dharwar Craton, Southern India: implications for transitional geodynamic setting. Journal of the Geological Society of India, 74(3), pp.299-317.
[28]. Verma, S.K., Verma, S.P., Oliveira, E.P., Singh, V.K. and Moreno, J.A., 2016. LA-SF-ICP-MS zircon U–Pb geochronology of granitic rocks from the central Bundelkhand greenstone complex, Bundelkhand craton, India. Journal of Asian Earth Sciences, 118, pp.125-137.
[29]. Quirk, D.G., 1987. Structure and genesis of the South Pennine Orefield (Doctoral dissertation, University of Leicester).
[30]. Sharma, R.S., 2009. Cratons of the Indian shield. In Cratons and fold belts of India (pp. 41-115). Springer, Berlin, Heidelberg.
[31]. Reddy, A.E. and Ram, D.S., 1989. Jawaharlal Nehru and Modern India. The Indian Journal of Political Science, 50(4), pp.445-468.
[32]. Mutschler, F.E., Wright, E.G., Ludington, S. and Abbott, J.T., 1981. Granite molybdenite systems. Economic Geology, 76(4), pp.874-897.
[33]. Bettencourt, J.S., Juliani, C., Xavier, R.P., Monteiro, L.V., Neto, A.C.B., Klein, E.L., Assis, R.R., Leite Jr, W.B., Moreto, C.P., Fernandes, C.M.D. and Pereira, V.P., 2016. Metallogenetic systems associated with granitoid magmatism in the Amazonian Craton: An overview of the present level of understanding and exploration significance. Journal of South American Earth Sciences, 68, pp.22-49.
[34]. Steenfelt, A., Kolb, J. and Thrane, K., 2016. Metallogeny of South Greenland: a review of geological evolution, mineral occurrences and geochemical exploration data. Ore Geology Reviews, 77, pp.194-245.
[35]. Jensen, E.P. and Barton, M.D., 2000. Gold deposits related to alkaline magmatism.
[36]. Christofano, E. and Harris, W.B., 1960. The industrial hygiene of uranium refining. Archives of Environmental Health: An International Journal, 1(5), pp.438-460.
[37]. McClenaghan, M.B., 2005. Indicator mineral methods in mineral exploration. Geochemistry: Exploration, Environment, Analysis, 5(3), pp.233-245.
[38]. Gurney, J.J. and Zweistra, P., 1995. The interpretation of the major element compositions of mantle minerals in diamond exploration. Journal of Geochemical Exploration, 53(1-3), pp.293-309.
[39]. Misra, A.A. and Mukherjee, S., 2015. Tectonic inheritance in continental rifts and passive margins (p. 87). Cham, Switzerland: Springer.
[40]. Meert, J.G., Pandit, M.K., Pradhan, V.R., Banks, J., Sirianni, R., Stroud, M., Newstead, B. and Gifford, J., 2010. Precambrian crustal evolution of Peninsular India: A 3.0-billion-year odyssey. Journal of Asian Earth Sciences, 39(6), pp.483-515.
[41]. Gupta, M.L., Sundar, A. and Sharma, S.R., 1991. Heat flow and heat generation in the Archaean Dharwar cratons and implications for the Southern Indian Shield geotherm and lithospheric thickness. Tectonophysics, 194(1-2), pp.107-122.
[42]. Kumar, P.S. and Reddy, G.K., 2004. Radioelements and heat production of an exposed Archaean crustal cross-section, Dharwar craton, south India. Earth and Planetary Science Letters, 224(3-4), pp.309-324.
[43]. Rajaram, M. and Anand, S.P., 2014. Aeromagnetic signatures of Precambrian shield and suture zones of Peninsular India. Geoscience Frontiers, 5(1), pp.3-15.
[44]. Fiero, B., 2009. Geology of the Great Basin. University of Nevada Press.
[45]. Sundaram, R., Henderson, R.A., Ayyasami, K. and Stilwell, J.D., 2001. A lithostratigraphic revision and palaeoenvironmental assessment of the Cretaceous System exposed in the onshore Cauvery Basin, southern India. Cretaceous Research, 22(6), pp.743-762.
[46]. Chaudhuri, A.K., 2003. Stratigraphy and palaeogeography of the Godavari Supergroup in the south-central Pranhita-Godavari Valley, south India. Journal of Asian Earth Sciences, 21(6), pp.595-611.
[47]. Taylor, P.N., Chadwick, B., Moorbath, S., Ramakrishnan, M. and Viswanatha, M.N., 1984. Petrography, chemistry and isotopic ages of Peninsular Gneiss, Dharwar acid volcanic rocks and the Chitradurga Granite with special reference to the late Archean evolution of the Karnataka Craton, southern India. Precambrian Research, 23(3-4), pp.349-375.
[48]. Kumar, A.A., Reddy, T.G., David, J.S., Randive, K.R., Tripathy, A.K. and Murthy, P.R., 2017. Petro-mineralogical characterization of the compositionally expanded Tonalite-Granodiorite-Monzogranite (TGM) suite of granitoids showing evidences of magma mixing and mingling in parts of Eastern Dharwar Craton, India.
[49]. Matsuhisa, Y., Goldsmith, J.R. and Clayton, R.N., 1979. Oxygen isotopic fractionation in the system quartz-albite-anorthite-water. Geochimica et cosmochimica acta, 43(7), pp.1131-1140.
[50]. Nesbitt, H.W. and Young, G.M., 1984. Prediction of some weathering trends of plutonic and volcanic rocks based on thermodynamic and kinetic considerations. Geochimica et cosmochimica acta, 48(7), pp.1523-1534.
[51]. El Bouseily, A.M. and El Sokkary, A.A., 1975. The relation between Rb, Ba and Sr in granitic rocks. Chemical Geology, 16(3), pp.207-219.
[52]. Jayananda, M., Chardon, D., Peucat, J.J. and Capdevila, R., 2006. 2.61 Ga potassic granites and crustal reworking in the western Dharwar craton, southern India: tectonic, geochronologic and geochemical constraints. Precambrian Research, 150(1-2), pp.1-26.
[53]. Dey, S., Pandey, U.K., Rai, A.K. and Chaki, A., 2012. Geochemical and Nd isotope constraints on petrogenesis of granitoids from NW part of the eastern Dharwar craton: possible implications for late Archaean crustal accretion. Journal of Asian Earth Sciences, 45, pp.40-56.
[54]. White, C., 2015. Atlantic Geoscience Society Abstracts: 41st Annual Colloquium & Annual General Meeting 2015. Atlantic Geoscience, 51, pp.105-138.

[55]. Van Staal, C.R., Rogers, N. and Taylor, B.E., 2001. Formation of low-temperature mylonites and phyllonites by alkali-metasomatic weakening of felsic volcanic rocks during progressive, subduction-related deformation. Journal of Structural Geology, 23(6-7), pp.903-921.
[56]. Pal, D.C., Barton, M.D. and Sarangi, A.K., 2009. Deciphering a multistage history affecting U–Cu (–Fe) mineralization in the Singhbhum Shear Zone, eastern India, using pyrite textures and compositions in the Turamdih U–Cu (–Fe) deposit. Mineralium Deposita, 44(1), pp.61-80.
[57]. Davis, G.H., Reynolds, S.J. and Kluth, C.F., 2011. Structural geology of rocks and regions. John Wiley & Sons.
[58]. Patro, R., Mahapatro, S.N., Bhattacharya, A., Pant, N.C., Nanda, J.K., Dey, A. and Tripathy, A.K., 2011. Chemical heterogeneity in an enderbite-hosted pseudotachylite, eastern India: evidence for syn-deformation multi-reaction melting in pseudotachylite. Contributions to Mineralogy and Petrology, 161(4), pp.547-563.
[59]. Bhattacharyya, S. and Sengupta, P., 2014. Modelling of dissolution–reprecipitation ion-exchange reactions for the development of flame perthite in a suite of sheared alkaline rocks: an example from Chimakurthy, Eastern Ghats, India. Mineralogical Magazine, 78(5), pp.1301-1323.
[60]. Whitfield, N., 1990. Celtic Filigree from the Seventh to the Ninth Century AD with Particular Reference to that on Brooches. University of London, University College London (United Kingdom).
[61]. Rogers, J.J., 1986. The Dharwar craton and the assembly of peninsular India. The Journal of Geology, 94(2), pp.129-143.
[62]. Rao, N.C., Kumar, A., Sahoo, S., Dongre, A.N. and Talukdar, D., 2014. Petrology and petrogenesis of Mesoproterozoic lamproites from the Ramadugu field, NW margin of the Cuddapah basin, Eastern Dharwar craton, southern India. Lithos, 196, pp.150-168.