Megascopic Properties of Granitoid suite of rocks around Mahabubnagar District Telanagana: Geological investigations

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Published in IJIRMPS (E-ISSN: 2349-7300), Volume 8, Issue 4, July-August 2020

***Abstract*:** The scope of the current work is confined to an area that is located inside and immediately adjacent to the Amangal Mahbubnagar Districts. The field season program's objectives were to provide a characterization of the granitic terrain and investigate shear zones, faults, and pegmatite veins to determine the role that each had in the formation of the Au-Cu-Mo mineralization. The primary objective of this research is to characterize the granitoids by analyzing their petrography, mineral chemistry, shear zones, faults, and pegmatite veins. This will allow the researchers to determine whether or not these features have any influence on the mineralization of Au, Cu, and Mo, as well as fluorite and REE. "Specialized Thematic Mapping" was carried out on a scale of 1:25,000 across an area that was around 70 km^2 in size (Toposheet No. 56L/9).

Keywords: Megascopic, granitoids, mineralization, shear zones and rocks.

I. Introduction

Studies of the granitoid suite of rocks were conducted in the Amangal region and the surrounding area in the Mahbubnagar district of Telangana. It is included in toposheet number 56 L/9 of the Survey of India [1]. The region was predominately covered by two different forms of granitoids, namely tonalite and granodiorite. Rocks belonging to the suites of Monzogranite (TGM), Monzosyeniye, and Syenogranite. Granitoid or granitic rock is a kind of coarse-grained plutonic rock that is very similar to granite in terms of its mineralogy and composition. Feldspar and quartz make up the majority of the rock's mineralogy. Examples of granitoid rocks include granite, quartz monzonite, quartz diorite, syenite, granodiorite and trondhjemite. The subduction of continental arcs and the collision of sialic masses both contribute to the formation of many. Granitoids and volcanic rocks are similar types of rock that often originated from the same place [2-4]. However, after many years of erosion, they often become worn away and disappear. Granitoid rocks are abundant in regions that have undergone crustal thickening as a result of orogenies; however, there are also granitoids that are not associated with convergent boundaries or subduction zones. These granitoids are known as anorogenic granitoids [5-7]. These anorogenic granitoids might be the deep origins for rift volcanism that have been revealed in the areas where erosion has eliminated the volcanic rocks and other signs of rifting. It's possible that hotspots or mantle plumes were responsible for the formation of these A-type granitoids [8-9].

II. Location and Accessibility

Telangana State's Mahbubnagar district is partially comprised under the scope of this research project. Kalwakurthy is the town that is most immediately adjacent to Amangal. The Amangal region may be reached quickly and simply by road, and its distance from the metropolis of Hyderabad in the southern direction is sixty kilometres [10-12]. The area is traversed by the Srisailam state highway, also known as SH-5. About 35 kilometres to the north-northwest of this Amangal hamlet is Rajiv Gandhi International Airport. The Hyderabad train station is the one that is the most convenient [13-14]. The route that runs between Hyderabad and Nagarjuna Sagar connects the villages of Mall, Chintapalle, and Mallepalle (SH-19). Nagarjun Sagar is 40km SE from Mallepalle village. In addition to this, there are a number of forest roads, metaled and unmetalled roads, and paths that give communication to the communities located further within the region. To connect the various parts of the region, there is a system of post offices, telephone and telegraph offices. The hamlet of Karthal serves as the northern boundary and also serves as the boundary between the Rangareddy district and the Mahbubnagar district [15-17].

III. Physiography and Drainage

The geography of the region is characterized by gentle undulations and a few solitary hillocks. The region's geomorphology and drainage are largely determined by the lithology of the area. Granitoids can be recognized by their distinct hillocky appearance [18-19]. The Mudhivenu reserve forest in the northern section of the area is home to the region's highest point, which is 723 meters above sea level (TS No. 56L/9). Around Ghatla Mallepalle, the region has an average elevation of 333 meters above mean sea level (MSL). In the area under investigation, hill ranges generally trend in a northwest-southeast and east-west orientation. Granitoids can be found in some locations as exposures that seem like sheets. The most notable erosional landforms in the region are granite tors, knolls, mounds, and inselbergs, as well as linear ridges constructed of dolerite dyke and quartz reef. All of these landforms were formed by erosion [20-22].

Fig. 1 Map showing location of the study area

Peddavagu and Bhimanpalle Vagu, both of which are tributaries of the Krishna River and run in a southeasterly direction, drain the majority of the region. The drainage system is dendritic to sub-dendritic in kind, and it consists of a number of perennial monsoon streams and nalas draining into Peddavagu towards the west and Chennavagu towards the southwest, which eventually unite to form a minor tributary named Bhimanpalle Vagu. The Krishna River is fed in part by a several smaller rivers, including the Vagus. The lithology and the structures work together to determine the drainage (TS No. 56L/9) [23-25]. The Halia River is located in the north-eastern region of the study area and flows in the direction of the east. There are two significant vagus there; one can be found to the north of Vinjamur, while the other can be found to the south of Chintapally, which is a tributary of the Bhimnapalle vagu. Both are moving in a southeasterly direction and are parallel to one another. There are a number of perennial monsoon streams and nalas that flow into Peddavagu and Bhimnapalle vagu. The drainage pattern is dendritic to sub-dendritic and parallel in kind [26-28].

IV. CLIMATE

The climate is characterized by a predominance of arid conditions. During the summer, temperatures may reach up to 46 degrees Celsius, while during the winter, they can drop as low as 12 degrees Celsius. 45 centimeters of rain fall each year on average. Because of the southwest monsoon, rainfall is sparse and unpredictable, especially during the months of June through September [29-30].

V. FLORA AND FAUNA

The region is characterized by a limited vegetative cover due to the fact that the forest has been denuded, resulting in isolated areas of dry deciduous flora. The area is home to a variety of animals. The primary types of plants that make up vegetation include xerophytes, shrubs, and grasses. The region is home to a variety of small thorny plants and trees, the most of which being Tamarindus indicus, Azadirachta indica, Acacia arabica, and Phoenix dactylifera. The majority of the land is used for agricultural purposes, and some of the products farmed here include grains, pulses, groundnuts, sunflowers, cotton, chilli peppers, and maize. The area is home to a relatively limited number of species of birds and mammals, such as hares, black bugs, wild boars, foxes, jackals, and snakes. There are also extremely few species of hares and black bugs [31-33].

VI. GEOLOGY OF THE REGION

The region under investigation is located within the Eastern Dharwar Craton and is characterized by granite and greenstone terrain. The Dharwar Craton was separated into the Western Block and the Eastern Blocks [34-35]. The Chitradurga shear zone, also known as the Chitradurga ductile shear zone, is a regional scale ductile shear zone that is identified as running all along and closer to the eastern edge of the Chitradurga Schist Belt. This zone is thought to represent the separation boundary between the two blocks [36-37].

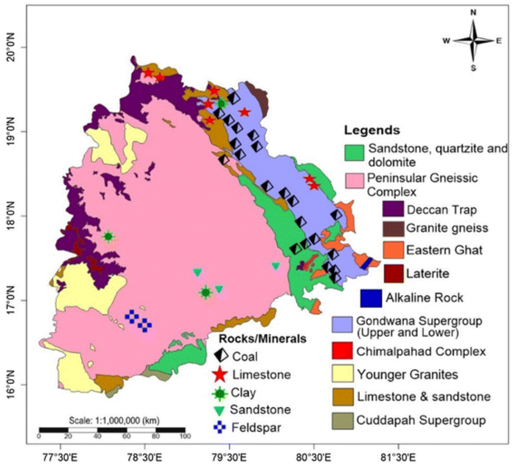

Fig. 2 Geological map of Telangana

The Western Divide Craton is made up of many older tonalite-trondhjemite-granodiorite gneisses that date back to around 3300–3580 Ma [38-41]. These older gneisses and granodiorites along with interspersed older, medium to high grade supracrustals, named as the Sargur Group of approximately 3100-3300 million years ago, form basement to low grade volcano sedimentary sequences of the Late Archaean Dharwar Supergroup of approximately 2600-2900 million years ago, which are located in India [42-44]. The newer granitoid group within WDC is composed of calc-alkaline to high potassic granitoids and dates back to around 2500-2600 million years ago [45]. This group contains the Closepet granite [47]. Late Archaean juvenile and anatectic calc-alkaline granitoid complexes predominate in the EDC. These complexes are interlaced by schist belts that are lithologically comparable to the Dharwar Supergroup in the WDC [48]. Due to their strong lithological similarities, structural coherence, and shared emplacement age of around 2700-2510 Ma, Chadwick et al. (1997) collectively referred to the granitoid complexes as the Dharwar batholith [47, 49-52]. In comparison to those in the WDC, the age restrictions on the greenstone belts in the EDC are only known from a few sites, and all of them appear to be of Neoarchaean age [51]. Based on the lithology, field relations, and emplacement characteristics, the gneiss-granite terrane of the southern portion of EDC that surrounds the green stone belts of Gadwal, Jonnagiri Ramagiri, Kadiri, Tsundupalli, and Veligallu has been delineated into four spatial associations of granitoid suites [53].

EDC is made up of a conglomerated and accretionary linear array of north-south to northwest-southeast trending series of parallel greenstone belts (inner arc basins) and calc-alkaline granitoid belts [54-55]. These belts are separated by shear zones (transpressive) and together make up the "Dharwar Batholith" [50]. The Peddavura shear zone serves as the dividing line, and to the east of it, the enderbite- mangerite suite of rocks and granulites are increasingly exposed while moving towards the northeastern edge of the craton [56-57].

These magmatic suites are comparable to those that are connected with the Abitibi greenstone belt [58]. The granitoid suites were identified as tonalite-granodiorite-monzogranite (TGM) suite and monzogranite syenogranite suite (MS suite). The formation of the TGM suite is thought to have been caused by the concomitant mingling and mixing of contemporaneous mafic and felsic magmas in a calc-alkaline arc environment, as well as fractional crystallisation processes [59-61].

VII. Granitoid Suites

Separate descriptions are provided for the distribution, general characteristics, and enclave types of the several granitoids that make up each suite. The granitoids that were examined in this research have a variety of different types of constituents. Granitoids belonging to the TGM suite are distinguished by the textures they exhibit as well as the broad range of modal contents of the various mineral elements they include. Granitoids belonging to the TGM suite are composed of varying quantities of the mineral's plagioclase feldspar, k-feldspar, quartz, hornblende, and biotite. Zircon, sphene, opaque minerals, and apatite are the accessory phases, and their abundances decrease from most abundant to least abundant. Quartz, potash feldspar, and plagioclase feldspar are the key minerals that make up the MS suite. Biotite is an important accessory mineral, but hornblende is an extremely uncommon mineral. Magnetite, sphene, zircon, apatite, and opaque are the other components of the accessories [62-63].

VIII. monzogranite-syenogranite suite (ms)

The Monzogranite-Syenogranite Suite (MS) appears as enormous hills or boulder outcrops and is widespread throughout the majority of the studied region. The difference in composition between monzogranite and syenogranite is so subtle that it can only be described as gradational. The MS suite contains pegmatite and aplites of varying size in several different locations. Gradational interaction is there between the MS suite and the TGM suite [64-65].

IX. Monzogranite

The grain size of monzogranite ranges from medium to coarse, it is pink in colour, holocrystalline, and it is huge. It has a granular texture with hypidiomorphic characteristics. Quartz, plagioclase, and k-feldspar make up the majority of the rock's composition. Orthoclase is the other k-feldspar present; however, microcline is the most abundant one. The minor mafic ingredient is biotite, and hornblende is quite uncommon. Zircon, titanite, ilmenite, sphene, and opaque are the minerals that are considered to be accessory minerals. Despite the fact that the compositional range of monzogranite is rather limited, it does define a differentiation trend that is mostly determined by the fractionation of biotite and plagioclase. In general, the texture is comparable to that of granodiorites, characterised by the presence of subhedral plagioclase, euhedral microcline, and quartz. Microcline, on the other hand, is frequently perthitic and contains fine-grained plagioclase and quartz. The deformation that was observed led to a number of textural changes, including the generation of sub grains, the recovery and recrystallization of quartz grains, the peripheral granulation of mineral grains, and the development of myrmekite along the feldspar borders [66-67].

X. Syenogranite

Pink, leucocratic syenogranite with medium to extremely coarse grains is characteristic of the MS suite of granites. Quartz, k-feldspar, plagioclase feldspar, biotite, and hornblende are the minerals that make up the rocks. In most cases, the rock has a porphyritic structure, and the majority of its phenocrysts are composed of alkali feldspar. Granophyre-like texture can be seen in some locations. It reveals a hypidiomorphic granular texture when seen via a microscope. Feldspars are medium-sized minerals that have a subhedral crystal structure. Interstitial K-feldspar can be found. When seen with a microscope, the replacement perthitic texture may be seen. This granite has a significant amount of perthite. Plagioclase can sometimes be seen to be slightly sericitized and to have a look that is a little bit tarnished. The most abundant mafic mineral is biotite, followed by amphibole and chlorite in decreasing abundance. In addition, zircon is a component of the accessory phases. When seen using a microscope, syenogranite exhibits evidence of sub grain quartz production [58, 68].

XI. Structures

A stretching lineation is seen in the mylonite close to Murtuzapalle, and the orientation of the stretching lineation is 250 kilometres from the southern end on the N-S plane. In Murtuzapalle In addition to this, shear folds can be seen, the axial plane of which is gradually orientated along the C plane. According to an interpretation that was made based on the sheared granite found in the Murtuzapalle area, this litho unit underwent two distinct stages of deformation. Brittle deformation came after the ductile deformation that had previously occurred. At a more profound level, the rock has undergone ductile deformation, whereas at a more superficial level, the rock has undergone brittle deformation. Crushing, granulation, and the creation of angular grains are all indications that the material has a brittle deformation. Every single angular grain displays well developed foliation, which is indication that the grain has undergone ductile deformation [69-71].

XII. Rocks

The term "Rock" refers to the material that makes up the outermost layer of the Earth's crust. This layer is composed of various mineral aggregates. Marble, for example, is a mono-mineral rock, whereas granite, on the other hand, is a poly-mineral rock. The make-up of a rock's minerals is nearly always the same, but the chemical make-up of a rock is determined by the sorts of component minerals. Therefore, it is impossible to represent it using a formula since the amount of various minerals present varies. Every kind of rock is characterised by its own unique set of physical characteristics, which may include colour, density, mechanical strengths, fusibility, and so on [72-73]. Rock is an aggregate of mineral grains that are more or less consistent numerically or qualitatively and differ from one another in specific textural traits, physical attributes, and the geological conditions under which they are generated. The rock is generated under certain geological conditions, and these conditions have a significant influence on the manner in which its component minerals exist, as well as the nature of those relationships. All rocks may be classified into one of these three primary categories according on their point of origin [74-76]:

i. Igneous: Relating to or originating from magmatic processes
ii. Sedimentary: Relating to an external process.
iii. Metamorphic rocks: Formed as a consequence of the change of sedimentary and igneous rocks.

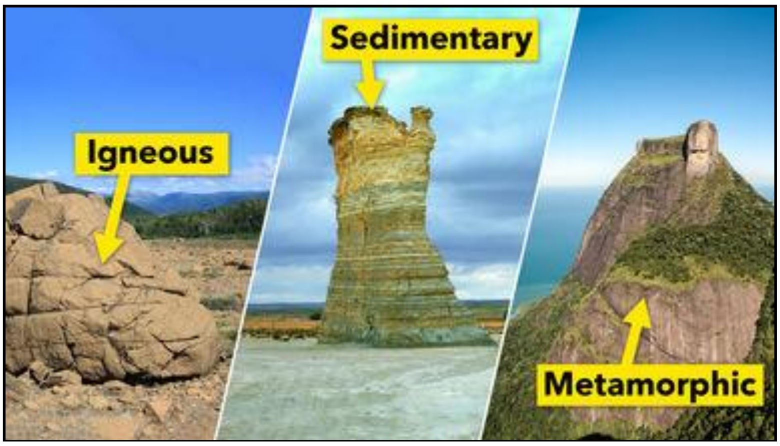

Fig.3 Classification of rocks

There is no pattern to the distribution of these rocks. The lithosphere is composed almost entirely of rocks that are igneous and metamorphic, with only 5% of its total mass consisting of sedimentary rocks. Crust and a section of the upper mantle are both included in the lithosphere. On time scales of thousands of years or more, the lithosphere acts elastically [77-79]. The nature of the rock mass is that it is a naturally existing prestressed medium that is discontinuous, anisotropic, and inhomogeneous. The existence of faults, joints, shear planes, bedding plane cleavage, and schistosity all contribute to the fact that rock mass is a discontinuous medium [80].

XIII. MEGASCOPIC CHARACTERISTICS OF ROCKS

Field petrographic investigations conducted on the granitoids found in the Amangal region were the impetus for the formation of the Eastern Dharwar Craton. In the eastern part of the Dharwar craton, the granitic rocks that are being looked into encompass an area that is ten kilometres squared. Alkali feldspar, plagioclase feldspar, granodiorite, monzogranite, quartzmonzonite, and syenogranite make up the area. The principal minerals responsible for the formation of rocks include K-feldspar, quartz, plagioclase, biotite, and hornblende. Zircon and biotite are both considered to be accessories. The IUGS categorization states that the majority of the granitoids that make up the TGM suite are magnesian in composition, range from calc-alkalic to alkali-calcic, and are metaluminous to weakly peraluminous. Including all megascopic properties and including all samples (i.e., L0, L1, L2, L 3, L 4 etc.,) of filed photographs rock types, colour, crystallinity and fabric was found as Plutonic, Mesocratic, Holocrystalline and Equigranularity respectively [82]

Table 1: Megascopic Properties of various samples

Sample code	**Name**	**Megascopic Properties**			
		Texture	**Minerology**		**Origin**
		Grain size	***Essential***	***Accessories***	
L_0	Monzonite	Coarse grained	K-Feldspar and plagioclase feldspar	Epidote and hornblende	Formed in greater depths, under high pressure by slow cooling of magma.
L_1	Diorite	Medium to coarse grained		Biotite, mostly dominated by hornblende	Formed in intermediate depths, under medium pressure and medium temperature by moderate cooling of magma
L_2	Granodiorite				
L_3	Monzogranite		Quartz and Feldspar	Biotite, Muscovite, Apatite Hornblende	
L_4	Syenogranite		Quartz, K-Feldspar and plagioclase feldspar	Biotite, mostly dominated by hornblende	

Fig. 4 Field photographs with sample Numbers (i.e., L_0, L_1, L_2, L_3, L_4)

XIV. Conclusion

In addition, the chemistry of the major elements in the granitoids that were created in a convergent environment in the Cordillera is very similar to the chemistry of the principal elements in the granitoids that were generated in the region. It has been determined, on the basis of mineralogy and texture, in addition to the field relationships, that the following order represents the sequence of parental magma differentiation for granitoids that can be found in Amangal rocks. This sequence was arrived at by considering both the field relationships and the mineralogy.

References

[1]. Reddy, S., Sahadevan, D.K., Gupta, H. and Reddy, D.V., 2019. GIS-based prediction of groundwater fluoride contamination zones in Telangana, India. Journal of Earth System Science, 128(5), pp.1-18.

[2]. Le Fort, P., 1988. Granites in the tectonic evolution of the Himalaya, Karakoram and southern Tibet. Philosophical Transactions of the Royal Society of London. Series A, Mathematical and Physical Sciences, 326(1589), pp.281-299.

[3]. Hussein, A.A.A., Ali, M.M. and El Ramly, M.F., 1982. A proposed new classification of the granites of Egypt. Journal of Volcanology and Geothermal Research, 14(1-2), pp.187-198.

[4]. Draut, A.E., Clift, P.D., Amato, J.M., Blusztajn, J. and Schouten, H., 2009. Arc–continent collision and the formation of continental crust: a new geochemical and isotopic record from the Ordovician Tyrone Igneous Complex, Ireland. Journal of the Geological Society, 166(3), pp.485-500.

[5]. Dickinson, W.R., 1970. Relations of andesites, granites, and derivative sandstones to arc ‐ trench tectonics. Reviews of Geophysics, 8(4), pp.813-860.

[6]. Anhaeusser, C.R., Mason, R., Viljoen, M.J. and Viljoen, R.P., 1969. A reappraisal of some aspects of Precambrian shield geology. Geological Society of America Bulletin, 80(11), pp.2175-2200.

[7]. Le Fort, P., 1975. Himalayas: the collided range. Present knowledge of the continental arc. American Journal of Science, 275(1), pp.1-44.

[8]. Burke, K. and Dewey, J.F., 1973. Plume-generated triple junctions: key indicators in applying plate tectonics to old rocks. The Journal of Geology, 81(4), pp.406-433.

[9]. Rogers, J.J. and Santosh, M., 2004. Continents and supercontinents. Oxford University Press.

[10]. Chaudhry, V., 2012. Disability and participatory development in South India: Perils of neoliberal governance (Doctoral dissertation, University of Illinois at Chicago).

[11]. Talbot, C., 2001. Precolonial India in practice: Society, region, and identity in medieval Andhra. Oxford University Press.

[12]. Walker, T.S. and Ryan, J.G., 1990. Village and household economics in India's semi-arid tropics. Johns Hopkins University Press.

[13]. Reddy, B.A., Urban Infrastructure: A Special Reference to PPP in Telangana State.

[14]. De, P., 2011. ASEAN-India Connectivity: An Indian Perspective. ASEAN-India Connectivity: The Comprehensive Asia Development Plan Phase II, pp.96-150.

[15]. Chittibabu, C.V. and Parthasarathy, N., 2000. Attenuated tree species diversity in human-impacted tropical evergreen forest sites at Kolli hills, Eastern Ghats, India. Biodiversity & Conservation, 9(11), pp.1493-1519.

[16]. Laurance, W.F., Goosem, M. and Laurance, S.G., 2009. Impacts of roads and linear clearings on tropical forests. Trends in ecology & evolution, 24(12), pp.659-669.

[17]. Krishna, A.K. and Govil, P.K., 2008. Assessment of heavy metal contamination in soils around Manali industrial area, Chennai, Southern India. Environmental Geology, 54(7), pp.1465-1472.

[18]. Bárdossy, G., 2013. Karst bauxites. Elsevier.

[19]. Chouhan, T.S. and Sharma, U.K., 2009. Desert ecosystems in India. Trop Biol Conserv Manag, 9, pp.51-111.

[20]. Clark, D.J. and Bodorkos, S., 2004. Fracture systems in granite pavements of the eastern Pilbara Craton, Western Australia: indicators of neotectonic activity? Australian Journal of Earth Sciences, 51(6), pp.831-846.

[21]. Hill, S.M., Eggleton, R.A. and Taylor, G., 2003. Neotectonic disruption of silicified palaeovalley systems in an intraplate, cratonic landscape: regolith and landscape evolution of the Mulculca range - front, Broken Hill Domain, New South Wales. Australian Journal of Earth Sciences, 50(5), pp.691-707.

[22]. Thomas, D. and Shaw, P.A., 1991. The Kalahari Environment. Cambridge University Press.

[23]. Das, A. and Panchal, M., 2018. Krishna river basin. In The Indian Rivers (pp. 339-351). Springer, Singapore.

[24]. Negi, S.S., 1991. Himalayan rivers, lakes, and glaciers. Indus Publishing.

[25]. Jain, S.K., Agarwal, P.K. and Singh, V.P., 2007. Krishna and Godavari Basins. In Hydrology and Water Resources of India (pp. 641-699). Springer, Dordrecht.

[26]. MacGillivray, W., 1844. A History of the Molluscous Animals of Scotland: As Found in the North-eastern District, particularly in the Shires of Aberdeen, Kincardine, and Banff; to which is Appended an Account of the Cirripedal Animals of the Same District. HG Bohn, York Street, Covent Garden.

[27]. Djabri, L., Hani, A., Laouar, R., Mania, J., Mudry, J. and Louhi, A., 2003. Potential pollution of groundwater in the valley of the Seybouse River, north-eastern Algeria. Environmental Geology, 44(6), pp.738-744.

[28]. Houghton, P., 1991. Selective influences and morphological variation amongst PacificHomo sapiens. Journal of human evolution, 21(1), pp.49-59.

[29]. Jagai, J.S., Sarkar, R., Castronovo, D., Kattula, D., McEntee, J., Ward, H., Kang, G. and Naumova, E.N., 2012. Seasonality of rotavirus in South Asia: a meta-analysis approach assessing associations with temperature, precipitation, and vegetation index. PloS one, 7(5), p.e38168.

[30]. Wannasek, L., Ortner, M., Amon, B. and Amon, T., 2017. Sorghum, a sustainable feedstock for biogas production? Impact of climate, variety and harvesting time on maturity and biomass yield. Biomass and Bioenergy, 106, pp.137-145.

[31]. Longton, R.E., Clarke, A.C., Drewry, D.J., Walton, D.W.H. and Williams, P.J., 1988. Biology of polar bryophytes and lichens. CUP Archive.

[32]. Negi, S.S., 1993. Biodiversity and its Conservation in India. Indus Publishing.

[33]. Dikshit, K.R. and Dikshit, J.K., 2014. Natural vegetation: forests and grasslands of North-East India. In North-East India: Land, People and Economy (pp. 213-255). Springer, Dordrecht.

[34]. Rollinson, H.R., Windley, B.F. and Ramakrishnan, M., 1981. Contrasting high and intermediate pressures of metamorphism in the Archaean Sargur Schists of southern India. Contributions to Mineralogy and Petrology, 76(4), pp.420-429.

[35]. Devaraju, T.C., Viljoen, R.P., Sawkar, R.H. and Sudhakara, T.L., 2009. Mafic and ultramafic magmatism and associated mineralization in the Dharwar craton, southern India. Journal of the Geological Society of India, 73(1), pp.73-100.

[36]. Kaila, K.L., Chowdhury, K.R., Reddy, P.R., Krishna, V.G., Narain, H., Subbotin, S.I., Sollogub, V.B., Chekunov, A.V., Kharetchko, G.E., Lazarenko, M.A. and Ilchenko, T.V., 1979. Crustal structure along Kavali-Udipi profile in the Indian peninsular shield from deep seismic sounding. J. Geol. Soc. India, 20(7), pp.307-333.

[37]. Raval, U. and Veeraswamy, K., 2003. India-Madagascar separation: breakup along a pre-existing mobile belt and chipping of the craton. Gondwana Research, 6(3), pp.467-485.

[38]. Mohanty, S.P., 2015. Palaeoproterozoic supracrustals of the Bastar Craton: Dongargarh supergroup and Sausar group. Geological Society, London, Memoirs, 43(1), pp.151-164.

[39]. Lowe, D.R. and Byerly, G.R., 1999. Geologic evolution of the Barberton Greenstone Belt and vicinity. Special Papers-Geological Society of America, pp.287-312.

[40]. Jayananda, M., Chardon, D., Peucat, J.J. and Fanning, C.M., 2015. Paleo-to Mesoarchean TTG accretion and continental growth in the western Dharwar craton, Southern India: constraints from SHRIMP U–Pb zircon geochronology, whole-rock geochemistry and Nd–Sr isotopes. Precambrian Research, 268, pp.295-322.

[41]. Kumar, A., Rao, Y.B., Sivaraman, T.V. and Gopalan, K., 1996. Sm-Nd ages of Archaean metavolcanics of the Dharwar craton, South India. Precambrian Research, 80(3-4), pp.205-216.

[42]. Peucat, J.J., Bouhallier, H., Fanning, C.M. and Jayananda, M., 1995. Age of the Holenarsipur greenstone belt, relationships with the surrounding gneisses (Karnataka, South India). The Journal of Geology, 103(6), pp.701-710.

[43]. Manikyamba, C. and Naqvi, S.M., 1995. Geochemistry of Fe · Mn formations of the Archaean Sandur schist belt, India-mixing of clastic and chemical processes at a shallow shelf. Precambrian Research, 72(1-2), pp.69-95.

[44]. Radhakrishna, B.P. and Vaidyanadhan, R., 1997. Geology of Karnataka Geol. Soc. India, Bangalore, 353p.

[45]. Sharma, R., 2009. Cratons and fold belts of India (Vol. 127). Springer.

[46]. 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.

[47]. Finzi, D., Hermankova, M., Pierson, T., Carruth, L.M., Buck, C., Chaisson, R.E., Quinn, T.C., Chadwick, K., Margolick, J., Brookmeyer, R. and Gallant, J., 1997. Identification of a reservoir for HIV-1 in patients on highly active antiretroviral therapy. Science, 278(5341), pp.1295-1300.

[48]. Basu, A. K., Geodynamic Model for Precambrian Crustal Evolution, Central India: based on Granite Emplacement at Malanjkhand.

[49]. Meert, J.G. and Pandit, M.K., 2015. The Archaean and Proterozoic history of Peninsular India: tectonic framework for Precambrian sedimentary basins in India. Geological Society, London, Memoirs, 43(1), pp.29-54.

[50]. Chadwick, B., Vasudev, V.N. and Hegde, G.V., 2000. The Dharwar craton, southern India, interpreted as the result of Late Archaean oblique convergence. Precambrian Research, 99(1-2), pp.91-111.

[51]. 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.

[52]. Singh, T.D., Manikyamba, C., Lakshminarayana, G. and Subramanyam, K.S.V., 2017. Geochemical signatures of adoni porphyritic granitoids, Eastern Dharwar Craton, India: Implication for partial melting of lower continental crust. Journal of Applied Geochemistry, 19(2), p.183.

[53]. Manikyamba, C., Ganguly, S., Santosh, M., Singh, M.R. and Saha, A., 2015. Arc‐nascent back‐arc signature in metabasalts from the Neoarchaean Jonnagiri greenstone terrane, Eastern Dharwar Craton, India. Geological Journal, 50(5), pp.651-669.

[54]. Angerer, T., Kerrich, R. and Hagemann, S.G., 2013. Geochemistry of a komatiitic, boninitic, and tholeiitic basalt association in the Mesoarchean Koolyanobbing greenstone belt, Southern Cross Domain, Yilgarn craton: Implications for mantle sources and geodynamic setting of banded iron formation. Precambrian Research, 224, pp.110-128.

[55]. Bateman, R., Ayer, J.A. and Dubé, B., 2008. The Timmins-Porcupine gold camp, Ontario: Anatomy of an Archean greenstone belt and ontogeny of gold mineralization. Economic Geology, 103(6), pp.1285-1308.

[56]. Streckeisen, A., 1975. How should charnockitic rocks be named? Annales de la Société géologique de Belgique.

[57]. Frost, B.R. and Frost, C.D., 2008. On charnockites. Gondwana Research, 13(1), pp.30-44.

[58]. Suresh, G., Ananthanarayana, R., Hanumanthu, R.C., Ghosh, S., Anil Kumar, A. and Reddy, K.V.S., 2010. Geology of Pulikonda and Dancherla Alkaline Complexes, Andhra Pradesh. Journal of the Geological Society of India, 75(4), pp.576-595.

[59]. Bonin, B., 1990. From orogenic to anorogenic settings: evolution of granitoid suites after a major orogenesis. Geological Journal, 25(3 - 4), pp.261-270.

[60]. Emslie, R.F., 1991. Granitoids of rapakivi granite-anorthosite and related associations. Precambrian Research, 51(1-4), pp.173-192.

[61]. Eby, G.N., 1990. The A-type granitoids: a review of their occurrence and chemical characteristics and speculations on their petrogenesis. Lithos, 26(1-2), pp.115-134.

[62]. Cantagrel, J.M., Didier, J. and Gourgaud, A., 1984. Magma mixing: origin of intermediate rocks and "enclaves" from volcanism to plutonism. Physics of the earth and planetary interiors, 35(1-3), pp.63-76.

[63]. Barbarin, B., 2005. Mafic magmatic enclaves and mafic rocks associated with some granitoids of the central Sierra Nevada batholith, California: nature, origin, and relations with the hosts. Lithos, 80(1-4), pp.155-177.

[64]. Sarkar, A. and Dasgupta, S., 1995. The granitic rocks. The Bhutan Himalaya: A Geological Account. Special Publication of Geological Survey of India, 39, pp.143-171.

[65]. Neilson, J.C., 2008. From slab breakoff to triggered eruptions: Tectonic controls of Caledonian post-orogenic magmatism. The University of Liverpool (United Kingdom).

[66]. Matos, R., Teixeira, W., Geraldes, M.C. and Bettencourt, J.S., 2009. Geochemistry and Nd-Sr isotopic signatures of the Pensamiento granitoid complex, Rondonian-San Ignacio Province, Eastern Precambrian Shield of Bolivia: Petrogenetic constraints for a mesoproterozoic magmatic arc setting. Revista do Instituto de Geociências USP. Geol. USP, Sér. cient, 9(2), pp.89-117.

[67]. Saha, D. and Chakraborti, S., 2007. Advective heat transfer and fabric development in a shallow crustal intrusive granite—the case of Proterozoic Vellaturu granite, south India. Journal of Earth System Science, 116(5), pp.433-450.

[68]. Barr, S.M., 2010. Granites and terranes in Cape Breton Island.

[69]. Bell, T.H. and Hammond, R.L., 1984. On the internal geometry of mylonite zones. The Journal of Geology, 92(6), pp.667-686.

[70]. Carreras, J., Estrada, A. and White, S., 1977. The effects of folding on the c-axis fabrics of a quartz mylonite. Tectonophysics, 39(1-3), pp.3-24.

[71]. Ghosh, S.K. and Sengupta, S., 1987. Progressive development of structures in a ductile shear zone. Journal of Structural Geology, 9(3), pp.277-287.

[72]. RowN, E.T., 1988. The Hoek-Brown failure criterion–a 1988 update. In Proc. 15th Can. Rock Mech. Symp, Toronto, Canada.

[73]. Tomanovic, Z., 2006. Rheological model of soft rock creep based on the tests on marl. Mechanics of Time-Dependent Materials, 10(2), pp.135-154.

[74]. Deere, D.U. and Miller, R.P., 1966. Engineering classification and index properties for intact rock. Illinois Univ At Urbana Dept Of Civil Engineering.

[75]. Watson, E.B. and Brenan, J.M., 1987. Fluids in the lithosphere, 1. Experimentally-determined wetting characteristics of CO2H2O fluids and their implications for fluid transport, host-rock physical properties, and fluid inclusion formation. Earth and Planetary Science Letters, 85(4), pp.497-515.

[76]. Phillips, O.M., 1991. Flow and reactions in permeable rocks. Cambridge University Press.

[77]. Stern, R.J. and Johnson, P., 2010. Continental lithosphere of the Arabian Plate: a geologic, petrologic, and geophysical synthesis. Earth-Science Reviews, 101(1-2), pp.29-67.

[78]. Griffin, W.L., Ryan, C.G., Kaminsky, F.V., O'Reilly, S.Y., Natapov, L.M., Win, T.T., Kinny, P.D. and Ilupin, I.P., 1999. The Siberian lithosphere traverse: mantle terranes and the assembly of the Siberian Craton. Tectonophysics, 310(1-4), pp.1-35.

[79]. DeCelles, P.G., Robinson, D.M. and Zandt, G., 2002. Implications of shortening in the Himalayan fold - thrust belt for uplift of the Tibetan Plateau. Tectonics, 21(6), pp.12-1.

[80]. Ramamurthy, T. ed., 2010. Engineering in rocks for slopes, foundations and tunnels. PHI Learning Pvt. Ltd.

[81]. Pupin, J.P., 1980. Zircon and granite petrology. Contributions to mineralogy and petrology, 73(3), pp.207-220.

[82]. Bell, F.G., 2007. Engineering geology. Elsevier.