SCHOOL OF EARTH, OCEAN AND ATMOSPHERIC SCIENCES

GOA UNIVERSITY

Exam: SEMESTER I

Roll No:

LABORATORY CERTIFICATE

This is to certify that ~~Mr.~~/Ms. MRUNALI DEEPAK PILGAONKAR

has satisfactorily completed the course of practical for M.Sc in Applied Geology.

Experiments conducted are pertaining to paper ----------

Practicals prescribed by the University for ----MSc PART I----class, during the academic year 2022 - 2023

DEAN
SEOAS

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REPORT ON THE GEOLOGICAL MAPPING AND FIELD WORK STUDIES CARRIED OUT IN AND AROUND BAGALKOT

CERTIFICATE

This is to certify that the record of work done by Ms. MRUNALI DEEPAK PILGAONKAR of class MSc Part-1, Roll No. 201900884, Year 2022-2023, contained in this report has been examined and signed and at the course of fieldwork in Geology prescribed by Department of Earth Science of Goa University has been satisfactorily carried out.

_____

Head of the department

_____

Examiner's Signature

Date:

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Any accomplishment requires support of many people. This report was no different event. Through the completion of the field work and the report, the efforts that went in to it, the hard work that was put in was all guided and supported by many. I would like to take this opportunity to extend my gratitude to all of them

I am also grateful to Dr. Anthony Viegas, Dr. Niyati Kalangutkar, Dr. Poornima Dhawaskar, Dr. Nicole Sequeira, Prof. Mahesh Mayenkar and Prof. Pooja Ghadi and all the other faculties of the Earth Science Department of Goa University. This field trip would not have been a success without the Teachers who accompanied with us in Bagalkot, Karnataka, they were Dr. Anthony Viegas, Dr. Poornima Dhawaskar, Dr. Nicole Sequeira. Their friendly nature, humble attitude, sweet behaviour throughout the field trip. I appreciate the help received from the Laboratory Assistant Ms. Heena for providing material required to carry for the field trip.

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INTRODUCTION-GEOLOGY OF INDIA

The geology of India in diverse, Different regions of India contain rocks belonging to different geological periods, dating as far as back as the Eoarchean Era Some of the rocks are very defined and altered. Other deposits include recently deposited alluvium that has yet to undergo ligaments Mineral deposits of great variety are found in the Indian subcontinent in huge quantity. Even India's fossil record is impressive in which stromatolites, invertebrates, vertebrates and plant fossils are included. India's geographical land area can be classified into the Deccan Traps, Gondwana and Vidhya The Deccan Traps covers almost all of Maharashtra, a part of Gujarat, Karnataka, Madhya Pradesh and Andhra Pradesh marginally. During its journey northward after breaking off from the rest of Gondwana, the Indian Plate passed over a geologic hotspot, the Reunion hotspot, which caused extensive melting underneath the Indian Craton. The melting broke through the surface of the craton in a massive flood basalt event, creating the Deccan Traps. It is also thought that Reunion hotspot caused the separation of Madagascar and India. The Gondwana and Vindhyan include within its fold parts of Madhya Pradesh, Chhattisgarh, Odisha, Bihar, Jharkhand, West Bengal, Andhra Pradesh, Maharashtra, Jammu and Kashmir, Panjab, Himachal Pradesh, Rajasthan and Uttarakhand. The Gondwana sediments form a unique sequence of fluviatile rocks deposited in Permo-Carboniferous time. The Damodar and Son rivers valleys and Rajmahal hills in Eastern India contain a record of the Gondwana rocks.

The Indian Craton was once part of the supercontinent of Pangaea. At that time, what is now India's southwest coast was attached to Madagascar and Southern Africa, and what is now its east coast was attached to Australia. During the Jurassic Period about 160 Ma (ICS 2004), rifting caused Pangaea to break apart into two supercontinents, namely Gondwana (to the south) and Laurasia (to the north). The Indian Craton remained attached to Gondwana, until the supercontinent began to rift apart about in the early Cretaceous, about 125 million years ago (ICS 2004). The Indian Plate then rifted northward toward the Eurasian Plate, at a pace that is the fastest known movement of any plate. It is generally believed that the Indian Plate separated from Madagascar about 90 Million years ago (ICS 2004). This orogeny, which is continuing today, is related to closure of the Alps in Europe, and the Caucasus range in western Asia, created the Himalaya Mountains and the Tibetan

Plateau in South Asia. The current orogenic event is causing parts of the Asian continent to deform westward and eastward on either side of the orogen, Concurrently with this collision, the Indian Plate sutured on to the adjacent Australian Plate, forming a new larger plate, the Indo-Australian Plate.

The earliest phase of tectonic evolution was marked by the cooling and solidification of the upper crust of the earth's surface in the Archaean Era (prior to 2.5 billion years) which is represented by the exposure of gneisses and granites especially on the Peninsula. These form the core of the Indian Craton. The Aravalli Range is the remnant of an early Proterozoic orogen called the Aravalli-Delhi Orogen that joined the two older segments that make up the Indian Craton. It extends approximately 500 kilometers (311mi) from its northern end to isolated hills and rocky ridges into Haryana, ending near Delhi.

Minor igneous region, deformation (folding and faulting) and subsequent metamorphism of the Aravalli Mountains represent the main phase of orogenesis. The erosion of the mountains, and further deformation of the sediments of the Dharwarian group (Bijawars) marks the second phase. The volcanic activities and intrusions, associated with this second phase are manded in the composition of these sediments.

Early to Late Proteomic (2.5 to 0.54 billion years) calcareous and arenaceous deposits, which correspond to humid and semi-arid climatic regimes, were deposited the Cuddapah and Vindhyan basins. These basins which bordered or lie within the existing crystalline basement, were uplifted during the Cambrian (500 Ma (ICS 2004)). The sediments are generally undeformed and have in many places preserved their original horizontal stratification. The Vinallyan are believed to have been deposited between-1700 and 650 Ma (ICS 2004).

Early Paleozoic rocks are found in the Himalayas and consist of southerly derived sediments eroded from the crystalline craton and deposited on the Indian platform.

In the Late Paleozoic, Permo-Carboniferous glaciation left extensive glacio-fluvial deposits across Central India, in new basins created by sag/normal faulting. These tillites and glacially derived sediments are designated the Gondwana’s series. The sediments are overlain by rocks resulting from a Permian marine transgression (270 Ma (ICS 2004)).

The Late Paleozoic coincided with the deformation and drift of the Gondwana supercontinent. To this drift, the uplift of the Vindhyan sediments and the deposition of northern peripheral sediments in the Himalayan Sea, can be attributed.

During the Jurassic, as Pangea began to rift-apart, large grabens formed in Central India filling with Upper Jurassic and Lower Cretaceous sandstones and conglomerates.

By the Late Cretaceous India had separated from Australia and Africa and was moving northward towards Asia. At this time, prior to the Deccan eruptions, uplift in the Southern India resulted in sedimentation in the adjacent nascent Indian Ocean. Exposures of these rocks occur along the South Indian coast at Pondicherry and in Tamil Nadu.

At the close of the Mesozoic one of the greatest volcanic eruptions in the earth's history occurred, the Deccan lava flows. Covering more than 500,000 square (193,051 sq. mi) area, these mark the final break from Gondwana.

PHYSIOGRAPHY

Karnataka can be divided into three well defined geomorphic regions viz. (1) the coastal plains on the west bordering the Arabian Sea, (2) the mainland or mountainous region comprising the Western Ghats and (3) the plateau region on the east. The coast line is straight and is about 400km long. The coastal plains rarely exceed 30km in width. To the east of the coastal plain, the Western Ghats forming the sub-continental water divide rise precipitously in a series of scarps and terraces towering more than 1000m above mean sea level within short distance from the coastal plain. The Western Ghats trend NNW-SSE parallel to the west coast and have an average width of about 40 km. They are dotted with high peaks, viz., Kudremukh (11884 m) and Mulaingiri (1912m) in the Bababudan hills.

The WC grade in the plateau regions towards east. This plateau is the southern of the De Plate with an average elevation of about 630m with a series of maps and hill ranges of schistose rocks and bouhlery granitoid hills. The state is drained by three major casterly flowing river systems. These are: (1) Manjira River of the Clear basin in the north, (2) Krishna with its tributaries, Tungabhadra, Ghataprabha, Malpesh Bhima and Vedan draining the northern and central part and (3) Cauvery with its, Kabini, Hemavathi, Simsha and Arkavati draining the southern part. Most of the river courses are principally aligned in two directions: (1) ENE-WSW to WNW ESE (2) oth-south to NNW-SSE and corresponds to the major lineaments, faults, shear zones and Many of the major rivers, particularly the west flowing rivers and some sections of all the east flowing rivers have straight courses and sharp turns suggestive of strong structural control on the drainage pattern

The state experiences humid Tropical to Semi-Arid climate for most part of the year. The annual rainfall is about 300 to 500 cm in the coastal plains and the Western Ghats and about 30 cm on the eastern plateau. The Western Ghats are thickly forested.

GEOLOGY

Karnataka forming a part of the Indian Shield is constituted of rock formations ranging in age from 3300 m.y to 5 m.y. Barring a narrow coastal strip of about 5000 sq.km of Tertiary and Quaternary sediments and another 31,250 sq.km of Deccan basalts, the remaining area is dominated by Archaean-Proterozoic rocks, Mysore Plateau, geologically constituted of Dharwar Craton comprises of greenstone-granite belts, gneisses and granulites. Greenstones essentially consist of meta-volcano-sedimentary sequences, surrounded and dissected by Peninsular Gneiss. At the southern end of the craton these give way to granulite suite of rocks. The craton preserves a billion years orogenic history from 3400 m.a to 2400 m.a. Epicratonic or intracratonic sedimentary basins called Purana Basins occupy the northern segment of the craton whose northern part in turn is concealed by Deccan basalt.

INTRODUCTION TO GEOLOGY OF KALADGI

The Kaladgi basin is located in the northern fringes of the Dharwar Craton of South India. It is comparable to other Proterozoic 'Purana Basins' of Peninsular India in its shallow marine, pericratonic sedimentary sequences. It is the only Purana Basin that displays stronger deformation in its central parts than along the fringes. This deformation is restricted to the sedimentary succession of the Bagalkot Group and is not observed in the younger Badami Group. Besides the axial zone post-depositional deformation and associated lower greenschist facies/anchi-zone metamorphism, the sediments of the Bagalkot Group also contain a significant record of syn-sedimentary deformation. These sediments display lateral and vertical sedimentological facies changes, well-exposed lithological contacts, as well as structural geological features.

The Kaladgi basin is exposed between the longitudes 73° E and 76° E and the latitudes of 15'30'N to 17" N. The contiguous exposures of these sediments, occurring in parts of the Belgaum, Bijapur and Bagalkot districts of Karnataka, from Almatti in the east to Ajra in the

West across a distance of about 100km in the E-W Direction are commonly termed as "main Basin". Outliers of these sediments capping the Archean crystalline basement are wowed south of the main basin around Saundatti, Gajendragad and Nargund. Intiers of these etimes within the Decean Traps are present near Jamkhandi in Bawalkot district of Karnataka. Kallamandi in Solapur distret and small isolated patehy exposures at Phonda Malvan and Kankavli district of Sindhudurg district of Karnataka.

Belgaum, Bijapur, Hubli and Dhanvar are major urban centres in this region with significant industrial and economic activities. Bagalkot is the largest town within this basin. followed in wire by Stundatti, Gokak and Badami. Jamkhandi, Lokapur, Mudhol, Nargund, Ramdurg and Yansatti are smaller towns.

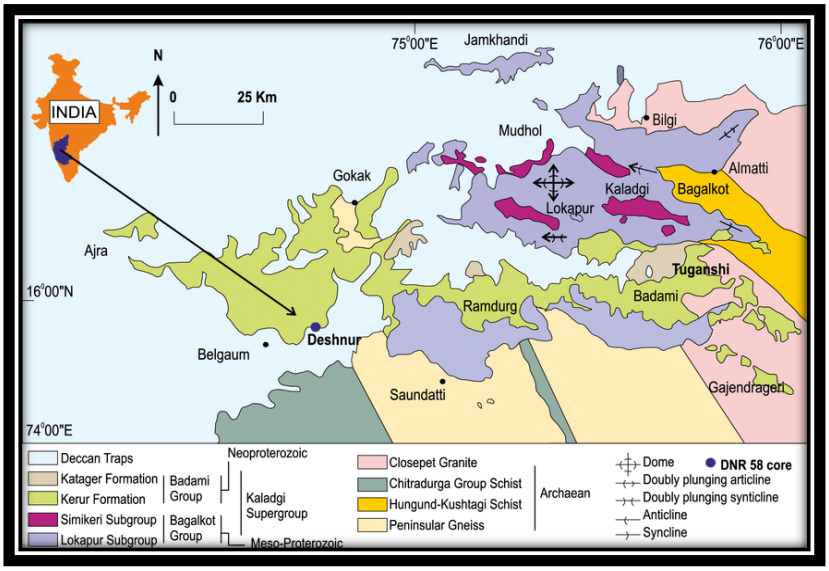


Figure 1: Geological Map of Kaladgi

GEOMORPHOLOGY AND DRAINAGE

The eastern parts of this region display three geomorphic segments, namely:

1.Dissected plateau (representing the southern edge of the Deccan Plateau) in the north, which gradually is replaced by a hilly terrain with moderate to steep-sided hills;

2.Rugged terrain with low hill ranges interspersed with flat cultivated plains: and 3Gently undulating, low-lying plains with few isolated plateaus or tors in the south.

The western parts have the dissected (Deccan) plateau that is followed westward by the spectacular Westem Ghats Escarpment and then the low-lying coastal tract of the Konkan Coastal Belt.

Eastward draining perennial rivers and their tributaries drains this region. River Krishna flows along the northern boundary of this basin. Ghataprabha and Malaprabha are its right bank tributaries, which drain the Kaladgi Basin. In addition, the upper reaches of the left bank tributaries of the river Tungabhadra have their sources in the southwestern parts of this region.

CLIMATE

The region experiences a tropical monsoon climate. Summers are extremely hot and dry peak in the months of April and May, with maximum temperature of 40 °C and above. The hot summer months are good for studying the exposures unhindered by life from vegetal cover, but require appreciate precautions for the heat. The pre-monsoon showers occur around the end of May and early June which bring relief from the hot climate. The following rainy season till October has hot and humid climate.

The post-monsoon months of October and mid-November experience increasing heat and humidity with occasional thunderstorm. November marks the beginning of cool and pleasant winter season, which last till February. December usually is the coldest month, with temperature dropping to 13-15 °C.

REGIONAL GEOLOGY

The E-W elongate basin lies on the northern fringes of the Western Dharwar Craton, with an exposed of around 8000 Km^2. T his polyhistory basin consist of Mesoproterozoic Bagalkot subbasin and Neoproterozoic Badami sub-basin and is estimate to have occupied no less than 20,000 Km^2 before its concealment under younger cover and erosional removal. These Protozoic sediments rest on the Archean-Paleoprotezoic sequences of the Dharwar craton, with profound angular and erosional unconformity. The Deccan Trap basaltic lava flows of Late Cretaceous- Early Paleocene age cover them across this region.

Lithostratigraphy of the kaladgi-Badami Basin (after Jayaprakash et al. 1987)

Age	Group	Subgroup	Formation	Member	Thickness (m)
Neoproterozoic	Badami Group		Katageri Formation	Konkankoppa Limestone Halkurki Shale Belikhindi Arenite	85 69 39
			Kerur Formation	Halgeri Shale Cave Temple Arenite Kendur Conglomerate	3 89 3
Angular unconformity					
Paleo-Mesoproterozoic		Semiri Subgroup	Hoskatti Formation	Mallapur Intrusive Dadanhatti Argillite	7 695
			Arlikatti Formation	Lakshnhatti Dolomite Keralmatti Hematite Schist Niralkeri Chert-Breccia	87 42 39
			Kundargi Formation	Govindkoppa Argillite Muchkundi Quartzite Bevinmatti Conglomerate	80 182 15
	Disconformity				
	Bagalkot Group	Lokapur Subgroup	Yadhalli Formation	Argillite	58
			Muddapur Formation	Bamanbudnal Dolomite Petlur Limestone Jalikatti Argillite	402 121 43
			Yendigeri Formation	Naganur Dolomite Chiksellikere Limestone Hebbal Argillite	93 93 166
			Yargatti Formation	Chitrabhanukot Dolomite Muttalgeri Argillite Mahakut chert-breccia	218 502 133
			Ramdurg Formation	Manoli Argillite Saundatti Quartzite Salgundi Conglomerate	61 383 31
	Nonconformity				
Archaean	Granitoids, gneisses, and metasediments				

FIELD OBSERVATONS

Day 1: 10-12-22

Spot 1

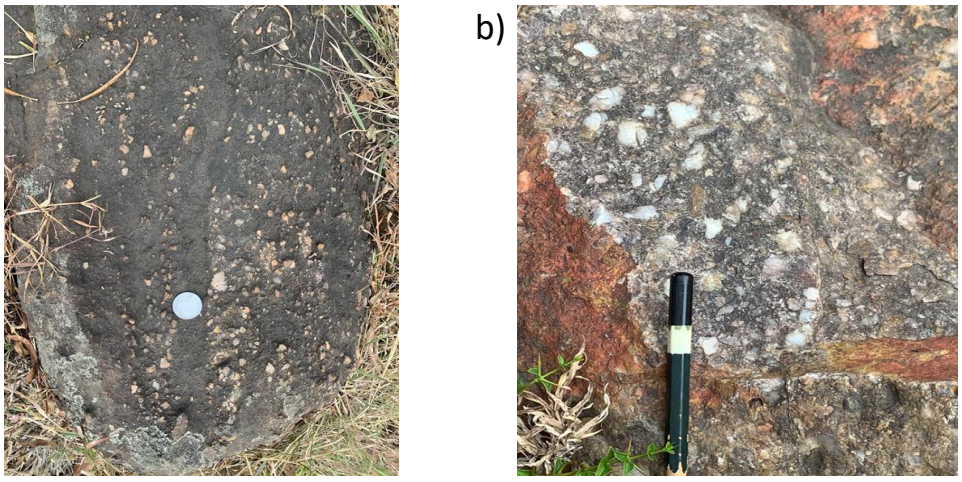
Location- Karadiguddi/ karadigudda.

Time of arrival: 4:33 pm

Latitude: 15°52'55" N Longitude: 74°41 42'' E

The area predominates with conglomerate which are part of Kundargi formation of simikeri subgroup of Badami group. The outcrop in exposed of the Bagalkot road at an elevation of 810 m above mean sea level ~ 18 km from Belgaum. The conglomerate exposed in the outcrop shows variation in its matrix, clast and thickness of the layers is not uniform. At the bottom of the outcrop. the rocks exposed were consisting of siliceous matrix as we move upward there was variation observed in matrix as it was ferruginous matrix. The clast size varied from < 1cm to > 6cm, along with variation in shape from Rounded - Subrounded, subangular in few places. Clasts were dominantly of Quartz which has silisiclastic fragments and were aligned clasts other than Quartz were of chert, jasper which appeared to be blood red and yellow in color as we approach the region from bottom to top grain size decreases. The trend of the outcrop is N120°.

a) b)



a-Smaller Clasts

b- Larger Clasts

Figure 2: Conglomerate clasts size variation

Spot 2

Location: ~500 m away from spot 1

Time of arrival 5:18 pm

Latitude: 15°52'37.5" N

Longitude: 74°41'48.9'' E

The observed outcrop was 500m from the spot 1. The rock observed here is of basaltic composition which has a peculiar feature called spheroidal Weathering which are huge bulbous structure ranging in diameter from 15 cm to 30 cm and the rock looses its layers like onion skin. This feature is supposedly formed due to right - angle joints in rock. The basalts were highly fractured they were fine grained and are vesicular. At certain places the vesicles were filled with secondary minerals. Amygdales are also present in rock.

Figure 3: Spheroidal weathering in rock.

Day 2: 11-12-22

Spot 1

Location: Ramthal.

Time of arrival: 9:09 am

Latitude: 16°'5'8" N

Longitude: 75°52'31" E

Ramthal is place situated on the bank of Malaprabha river at a distance of 25 km from Bagalkot. This region is particularly is the basement of the Kaladgi and intensely tightly folded. The rock types found here are slates and phyllites of Hungund schist belt or meta-volcanics with ultramafics which are been metamorphosed and meta-sediments with acid volcanics and greywackes with BIF's.

It was observed the phyllites are intensely weathered to calcareous clay, which derived from gneisses belonging to Hungund schist belt. The beds are highly folded and steeply dipping. Deformation has taken place due to tectonic activity and hence we see the basement rock which are actually older.

- The structural data recorded of phyllite bed is as follow,

Strike Direction	N 163°	N 166°	N 143°	N 168°
Dip Direction	NE	NE	SW	NE
Amount of Dip	76° (Top)	67° (along curvature)	40° (along curvature shallow dipping)	4° (steepest) (Bottom)

Structural data on folded series of BHQ

Strike Direction	N161°	N133°	N155°	N148°
Dip Direction	SW	SW	SW	NE
Amount of Dip	38°	75°	40° (Close to hinge)	20° (Close to hinge)

The Hungund schist Belt in of Archean age (0-4-2.5ma) older than the Proterozoic/2.5-541 Ma)

There are competent and incompetent layers with longer wavelength (competent) and shorter wavelength (incompetent) with shallow plunge with the amount of 24° in the direction NA333°. There are large folds with microfolds.

The Basal part of Badami has an unconformity. The type of unconformity is the Non-conformity with crystalline rocks at the basement. Badami are of Neoproterozoic 1150 Ma. The gap between depositional events (unconformity) 500 Ma. The basement separating the formation above by an unconformity is demarkated by the. conglomerate with varying clast size from 8cm to > 15 cm made up of Quartzite clasts. It was also observed Sn is parallel to Axial plane and Sn + 1 is the intrafolial fabric.

- The Structural data is as follows,

Strike Direction	N 334°	N 325°	N 326°	N 332°	N 333°
Dip Direction	NE	NE	NE	NE	SW
Amount of Dip	76°	65°	80°	86°	80°

Figure 4: Foliation in phyllite rock.

Figure 5: Folded series of BHQ.

Spot 2

Time of arrival: 11:00am

Latitude: 16°4'53" N

Longitude: 75°52'29" E

We observed soil of Calcium carbonate known as caliche deposit. This has formed by leaching of calcium carbonate rock. It consists of non-crystalline variety of $CaCo_3$ which could be Ankerite. There were no cleavage possessing minerals to indicate presence of calcite (3 set of cleavage) hence it was absent. Other minerals present were smoky quartz (vitreous, Lusture, white smoky appearance) and amorphous variety of Calcite. These deposits are formed in semi-arid region under dry condition or of scanty rainfall. The presence of $CaCo_3$ was confirmed by effervescence from the outcrop surface when reacted with HCl. The caliche is generally light in color cemented together with material like gravel, silt, clay, silt.

Figure 6: Caliche deposit

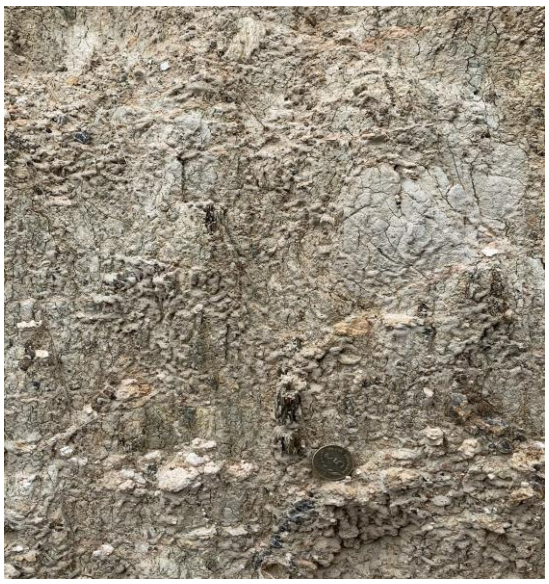


Figure 7: Caliche deposit

Spot 3

Time of arrival: 11:50am

Latitude: 16.0808321° N

Longitude: 75.8684231° E

The prominent lithology observed is of alternating bands of phyllite and BHQ.

Reading along the section observed the roadside towards N

Strike Direction	N 355°
Dip Direction	SW
Amount of Dip	62°

There was warping in the layers of the fold. An intrafolial fold is enclosed by steep fold layers on either side, with well exposed hinges.

❖ Structural data to the N side of Roadside of the fold,

Strike Direction	N 40°	N 306°	N 320°
Dip Direction	NW	NE	NE
Amount of Dip	34°	40°	74°

Figure 8: Intrafolial fold in BHQ

Figure 9: Slumping in rock

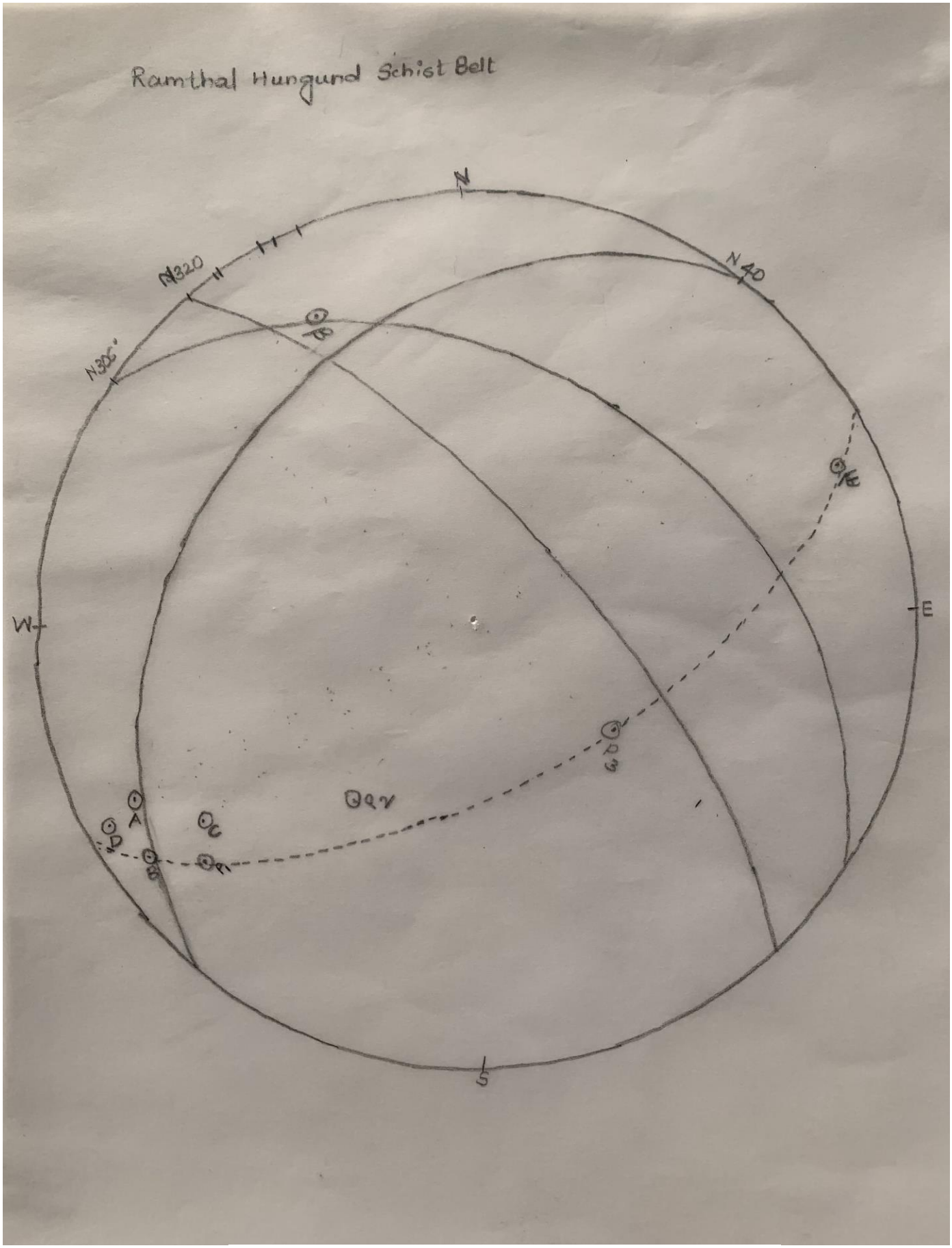


Figure 10: Spot 3; Plotted structural data of fold and foliation plane

DAY 3: 12-12-22

Spot 1

Location: Nargund.

Time of arrival: 11:00am

Latitude - 15°44'23'N

Longitude: 75°22 '28"E

The outcrop exposed is a metamorphic rock and foliation is developed by growth of new minerals and their alignment according to the stresses present. There is a broad warp in foliation,therefore strike is changing and dip is varying by < 10. foliation is penetrative in nature. Quartz veins are present which shows a parallel relationship to the foliation. The phyllitic nock does not undergo more than green schist facies of metamorphism and as the foliations are planes of weakness it was easier for Quartz vein to intrude into the rock. The intrusion is synchronous with deformation. of the rocks.

- The Structural data on the foliation planes of the outcrop are as follows,

Strike Direction	N 150°	N 148°	N 160°	N 168°	N 153°
Dip Direction	SW	SW	SW	SW	SW
Amount of Dip	76°	79°	76°	85°	86°

Figure 11: Phyllitic outcrop: showing warping in rock.

It was observed near the warping infoliation there is a horizontal shear zone which could be the reason for variation of the strike data. It was observed their obliterated fabric which was present in few places known as Sn-1. Sn is penetrative and Sn+1 is spaced couple of meter scale indicative of sinistral shear zone.

Figure 12: Pen pointed part towards N shows sinistral sense of shear.

Spot 2

Location: ~20m away from Nargund.

Time of arrival: 11:57am

Latitude - 15°44'24''N

Longitude: 75°26'22''E

The rocks present at this location ~20 m away from the spot 1. It was observed that there is a steeper weathered foliation at bottom overlain by a layer of soil in horizontal manner indicating angular type of unconformity. The soil layer may be transported from top of hill and then deposited as a layer or it was earlier horizontal bed weathered enough making it look like layer of soil. Above the horizontal bed there is laver of cobbles, pebbles which are deposited indicating they are recent in age and not a part of Proterozoic Kaladgi Basin. The Quartz vein that appears to be

vertical / steep at the bottom section becomes horizontal as we move upwards, which happens when there is an erosional surface and slumping of the vein.

- ❖ Structural data on the foliation planes,

Strike Direction	N 145°	N 150°	N 150°
Dip Direction	SW	SW	SW
Amount of Dip	65°	46°	84°

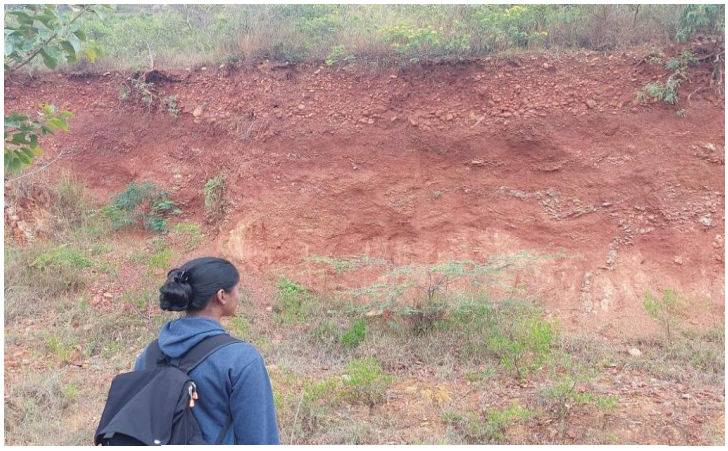


Figure 13: Angular Unconformity

Spot 3

Location: Nargund hill top near Bhoruka powerplant corporation limited.

Time of arrival: 12:42pm

Latitude: 15°43'50" N.

Longitude: 75°22'47'E

The outcrop observed is a ferruginous quartzite, which situated on top of the Nargund hill at 700m, above mean sea level the rock is highly fractured and two types of joint sets are observed- Orthogonal and Conjugate. There are 9 windmills in the area

generating around 8 MW of power situated bear the outcrop. It was also observed that there are features lite ripple marks, herringbone pattern on the outcrop, also cross bedding was observed at various places on the rock. This exposure is an outlier as the younger rocks are surrounded by older rocks formed due to erosion of surrounding rock.

- ❖ Structural data of the joint sets

Orthogonal	Conjugate
N225°	N250°
N226°	N161°
N252°	N245°

Figure 14: Ferruginous quartzite

Figure 15: Ripple marks

Figure 16: Herringbone pattern

DAY 4: 13-12-22

Spot 1

Location: 1.5 km away from Heritage Temple, Bagalkot, Karntaka

Time of arrival: 9:38 am

Latitude: 16°0'49" N

Longitude: 75°93'5" E

It was observed on N side of road expansive outcrop of horizontal beds and on S side of road the rocks are inclined. These rocks have not undergone complete metamorphism and have experienced sub green schist facies metamorphism; hence the grain boundaries are still visible. The rock could be termed as Quartzite where the grains of sand size particle have fused with no distinguishable grain boundaries and one can call it a sandstone where the grain boundaries are visible. The massive outcrop has well defined "bedding plane which are dipping and not horizontal Bedding planes are dipping towards SSW dipping it moderately at about 45°, with the bedding junction, we could see cross bedding structures that are well preserved, it appears as alternate bands of red and white colors. There are intraformational conglomerate beds parallel to bedding junction, which are around 10 cm wide. The conglomerate has clasts made up of Feldspar, Quartz and Jasper which are varying in size from 1 to 10cm from bottom to top of inclined strata.

Figure 17: Cross bedding in Quartzite

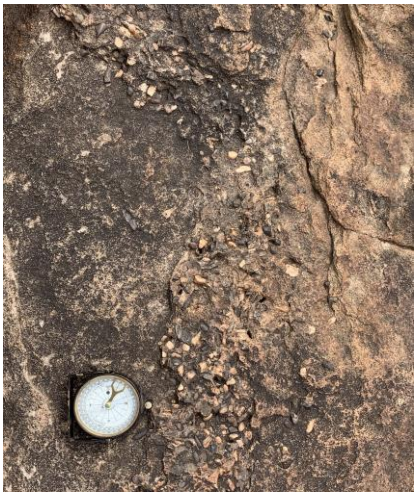


Figure 18: Intraformational conglomerate (close view)

Figure 19: Steeply Inclined beds of Quartzite

The rock type is a sandstone horizontal bed, which is hard, compact with different shades of red. The primary sedimentary structures can be seen that is current bedding herring bone pattern, cross bedding which indicates the weathering and erosion. There is presence of two joint sets. The trend of joint is N255° and N234°. These beds are shallow dipping.

Figure 20: Badami sandstone

Spot 2

Location: Sirur

Time of arrival: 3:41 pm

Latitude: 16°5'34" N

Longitude: 75°46'59" E

The outcrop exposed next to the temple is an expansive outcrop entirely made up of Quartzite. We observed a fault plane that is indicated by presence of striations, no secondary mineral formed along striations. It's a plane not a zone no shear sense indicator or offset marker is observed. We could observe lineation on fault plane; which are called surface lineation and some places there is slickensides are observed where there is precipitation of secondary mineral. Fault plane is a shallow dipping and

not steep. By using Anderson's theory of faulting, we can conclude that the observed fault is a reverse fault but we need to confirm by using shear sense indicator or by offset markers.

The presence of joint sets on the bedding plane are indicative of brittle deformation, the observed joint set are conjugate joints.

Figure 21: Slickensides observed in rock

Figure 22: Surface Lineation.

Day 5: 14-12-22

Spot 1

Location: Amingarh.

Time of arrival: 9:44am

Latitude: 16°3'31" N

Longitude: 75°56'54'' E

The outcrop is situated on the right side of the steps towards the Amingarh Temple. The outcrop consists of Boulders of granite which is pinkish in color, coarsed grained, minerals such as Feldspar and Quartz are seen. Feldspars are pink in color indicating it is a K-feldspar. Feldspar forms the clasts. It is an undeformed granite as there is no foliation observed.

Accessory minerals are Biotite. The Boulders are of closepet granite (age 2:5 Ba) which is a part of the basement for the kaladgi basin. The rock consists of xenoliths which varies in size from 7-12cm and they have formed sub rounded patches. Xenoliths consists of mafic minerals which are fine grained.

It was observed that the Xenolith is of cognate type which are formed deep in mantle which are taken out during emplacement of magma and gets trapped.

Figure 23: Xenolith in closepet granite boulder

Spot 2

Location: ~15 m away from spot 1

Time of arrival: 10:32 am

Latitude: 16°3'31" N

Longitude: 75°56'54'' E

As we move forward over the hill the outcrop is exposed at ~20m distance from spot 1 and is situated near sacred tree . It was observed that rock on NE side has undergone extensive weathering compared to that of rock exposed in NW side with development of, joint sets and fractures it indicates presence of shear zone. Alignment of minerals is observed suggesting rock has undergone deformation

Trend of the joint is as follows

- N145°

Trend is similar to the Hungund schist belt inferring, we are studying the basement rock. The schistosity here is weakly formed and locally developed Although it is penetrative but at local scales.

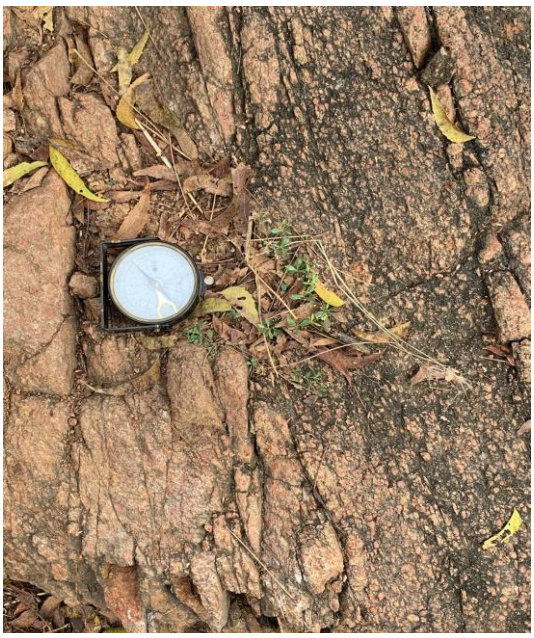


Figure 24: Joint sets and fractures

Spot 3

Location: ~10m away from spot 2.

Time of arrival: 10 am

Latitude: 16°3'33'' N

Longitude: 75°56'56'' E

Outcrop exposed ~10 m away from spot 2. Contact between the basement and the formations above is separated by conglomerate that is intercalated with BIF. The BIF clasts are more in this location compared to the conglomerate at Ramthal. The conglomerate here are intercalated and not Basal. While taking a traverse towards the Temple we also observed, sandstone outcrop which was fine grained and was light pink color. The rock is metamorphosed at some places showing Quartzitic samples.

- ❖ Structural data on plane of sandstone is as follows

Strike Direction	N 120°	N 116°	N 125°
Dip Direction	NNW	NNW	NNW
Amount of Dip	21°	21°	25°

Figure 25: Conglomerate intercalated with BIF

Spot 4

Location: Hungund Schist Belt

Time of arrival: 3:31 pm

Latitude: 16°4'9" N

Longitude: 76°3'3" E

The outcrop exposed is massive and it situated near Adarsha Mahavidyalaya. This a type area of the schist belt. BIF's is observed and Iron concentration here is much more than in BIF's observed at Ramthal.

- Structural data on the foliation plane

Strike Direction	N 125°	N 127°	N 125°	N 127°
Dip Direction	NNE	NNE	NNE	NNE
Amount of Dip	56°	73°	71°	83°

The outcrop consists of Quartz vein intruding the rock suggesting they are younger than the rock. It is observed that folding is preserved in the BHQ's and developed easily rather than phyllitic rock.

- Structural Data on fold hinge (Axial plane of intrafolial fold)

Strike Direction	N 142°
Dip Direction	NNE
Amount of Dip	85°

Folds in BHQ are not tight where as in phyllitic rock these are tight intrafolial fold. We observed rocks which are older than the sedimentary rocks of the Kaladgi Basin. Here we have intrafolial domain, or a lens that is preserving early Structures in the rock overprinted by the very penetrative fabric which is having strike 125°N and the dip is 55° due N. Now we observe the horizontal bed and the steep close to vertical plane is becoming horizontal. Horizontal shear is curving the steep fabric, we are close that curvature so the dip value decreases which is shallower than then steep beds. In between this curving belt parts of the basement are Remaining like lenses which are not taking part in deformation known as Shear lenses. They preserve the structure of basement without getting affected by later deformation.

Figure 26: Hungund schist belt type area

Figure 27: Fold in BHQ

Day 6: 15-12-22

Spot 1

Location: Bilgi

Time of arrival: 9:30 am

Latitude: 16°11'17'' N

longitude: 75°36'43''E

The study area. is an expansive outcrop situated ~ 50m away from the main road. Weathering is observed in the rock. The rock is grey granite with abundant Quartz, Feldspar and Biotite as accessory mineral. Granite is recrystallised, grain size Varies form 2mm-5mm, the rock is leucocratic, felsic igneous pock. Although we don't see well defined foliation the rack is deformed as it has recrystallized, A pegmatite vein having a thickness of 30 cm was seen intruding these granites along with other pegmatite veins having comparatively less thickness of 7-8 cm. The trend of the pegmatite vein is N55°.The pegmatite vein has coarser grains of K-feldspar, Quartz and Biotite. The vein crystals are coarser than granite. The weathering pattern such as exfoliation joints or sheet joints were seen all over the outcrop. Some of the joints are faults the pegmatites are jointed.

Geological history of the area:
The granite got deformed and recrystallised, Pegmatites vein then intruded, then jointing took place which also affected the vein.

Another important observation made were presence of Xenolith some are elongated some are rounded and xenolith within a xenolith was also observed. Xenolith vary in size and shape. Minerals in xenolith are Quartz and feldspar, also there is Hornblende which appear to be aligned and crystalized. The elongated xenolith has orientation with trend of N 73°.The thickness of xenoliths varying between 30cm-15cm in width.

Figure 28: Pegmatite vein intruding granitic rock

Figure 29: Xenolith in granite

Figure 30: Xenolith within Xenolith

Figure 31: Closer view of fault in pegmatite vein

Spot 2

Location: Opposite Siddheshwar Devasthan, Quartzite quarry.

Time of arrival: 11:36 am

Latitude: 16°20'14" N

Longitude: 75°36'43" E

The study area is a quarry of Quartzite and shows sharp contact between sandstone and Quartzite. Different types color bending is seen, leaching of the rock is observed. The dark bands are ferruginous and light ones are siliceous in nature The Quartzite is in shape of blocks. The thickness of the bed was variable. Two prominent sets are observed one parallel to the bedding plane and one perpendicular to the bedding plane.

- ❖ Structural data on the bedding plane

Strike Direction	N 88°	N 114°	N 110°
Dip Direction	NS	NS	NS
Amount of Dip	11°	6°	5°

In between the contact planes of beds there are highly weathered layers that appears. flaky and can be easily crushed into white powder with hands.

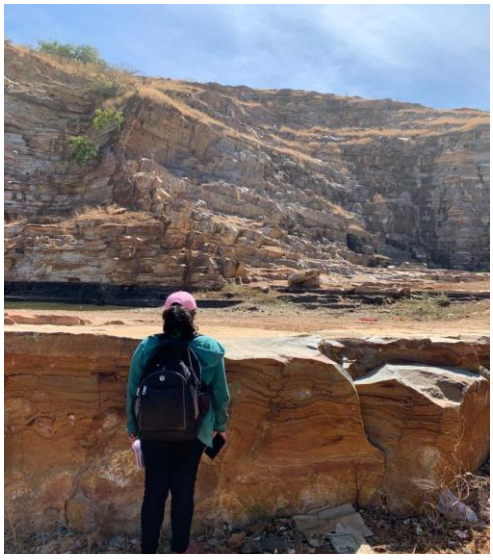


Figure 32: Quarry of Quartzite

Figure 33: Ferruginous and siliceous bands in quartzite

Spot 3

Location: Behind Rudra Gouda Govt First Grade Collage.

Time of arrival: 12:37 pm

Latitude: 16°20'3 " N

Longitude: 75°36'59" E

The outcrop is of intraformational conglomerate we can observe fine layers, it was not a basal conglomerate. The thickness of the layers differs from top to bottom of the outcrop 3-7 cm so it indicates cyclic deposition. Graded bedding is also observed. The clasts in conglomerate layer are largest but the layers in-between conglomerate wherein we can observe syndepositional sedimentary structure. Some layer are pink and some are more buff color suggesting presence of current bedding structures therefore the rock is sandstone. The conglomerate observed is oligomictic conglomerate. The clast size varies from 3-8 cm.

- ❖ Structural data on the bedding plane

Strike Direction	N 114°	N 110°	N 112°
Dip Direction	SW	SW	SW
Amount of Dip	11°	6°	8°

Figure 34: Graded Bedding in Rock

DAY 7: 16-12-2022

Spot 1

Location: Budangad KA, NH 367

Time of arrival: 9:14 am

Latitude: 16°06'46'' N

Longitude: 75° 47’ 07'' E

The study area shows highly fractured and jointed rocks which is pink or buff in color. The entire rock is made up of Quartz. There are few joint sets which are continuous rest all are non- continuous. There are numerous joint set which has similar strike but different dip. There are shorter joint sets which are not penetrative across entire outcrop they extend locally the rock is Ferruginous Quartzite consist of Quartz and Feldspar as mineral constituent There are vein sets which are cross cutting each other and some are parallel. The veins are in size from 0-7cm to 15cm. The orientation of minerals varies from one place to the another. Trend of the vein set N57°. The veins sets are orthogonal to each other. This are Quartz vein the completely brecciated rock. The fault zone is EW trending.

Another important observation is the presence of Gash vein. These are formed because of extension of fracture within this we can have growth of secondary precipitated mineral. The minerals in vein are elongated in nature which appear like teeth and elongation is perpendicular to vein wall. Such structure is known as “Comb structure”. Formation of the Vein: Fluid plays an important role in fault zone. Fluid gets pathways to transverse through rock they crystalises and forms veins.

Figure 35: Highly Jointed and Fractured Quartzite

Figure 36: Gash vein of Quartz

Spot 2

Location: NH 367, Budanagad KA

Time of arrival: 10:33 am

Latitude: 16°5'8''N

Longitude: 75°48'46'' E

A large expansive outcrop located, around 1-1.5 Km from spot 1. Wherein we observed a coarse-grained Hornblende Rich granite which showed foliation indicating deformation: The outcrop is highly weathered, perpendicular to foliation plane coarse grained quartz vein is intruded which are of same generation, Although they are cross cutting at some places and are younger then foliation.

Width of the veins is 10-12 cm while some were 5-7cm, they are exposed throughout the outcrop while some are metamorphosed. At a distance of ~50m we found a contact between igneous and metamorphic rocks. We also observed pegmatic vein onto a Granitic boulder next to schists. As we move along hills the Granitic exposure had increased percentage of feldspar as compared to Quartz The large phenocryst of feldspar were observed and hence rock was named as Porphyry syenite.

Trend of the vein

1.N 275°

2. N 60°

3. N 189°

Figure 37: Intrusion of Quartz veins in granite

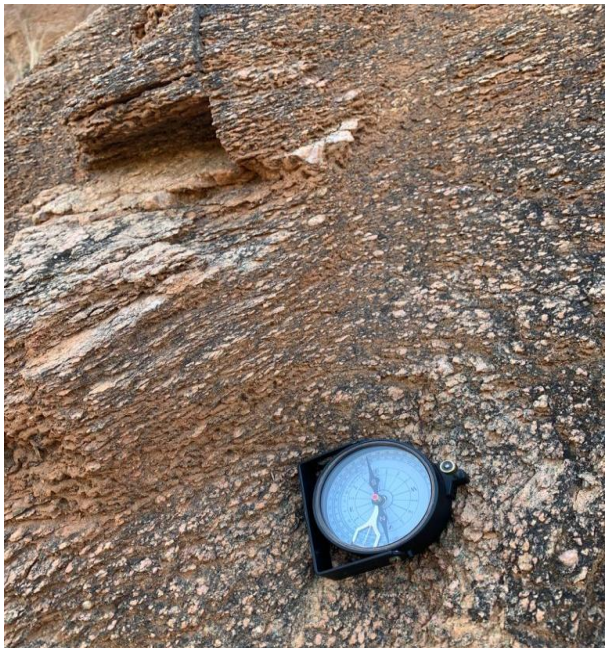


Figure 38: Hornblende rich granite showing foliation

Spot: 3

Location: Murudi

Time of arrival: 2:09 pm

Latitude: 16°2'7" N

Longitude: 75°45'26" E

The expansive outcrop of quartzite is exposed at this place, rock is fractured and intensely weathered. It shows two types of prominent jointing i.e. orthogonal and conjugate joints.

Outcrop also shows cross bedding and herring bone structure, Quartzite also has clasts in it which are of Jasper, quartz, some amorphous variety of minerals and feldspar. There were two types of Quartzite which were observed they are siliceous and ferruginous which were slightly reddish in color. This Quartzite belong to saundatti formation.

Figure 39: Outcrop of Quartzite

Spot: 4

Location: Kerkalmatti, Rajyogi, road murudi Karnataka

Time of arrival: 3:09 pm

Latitude: 16°4'1" N

Longitude: 75°41'26" E

A small exposure of phyllitic folded layers were exposed along the road cut section of Rajyogi road. Rock identified here was phyllite.

❖ Structural data taken on limbs and hinge of fold

Strike Direction	N 95°	N 81°	N 145°	N 103°	N 105°	N 85°
Dip Direction	S	NNW	S	S	N	N
Amount of Dip	35°	26°	23°	19°	10°	20°

Figure 40: Phylitic Folded rock

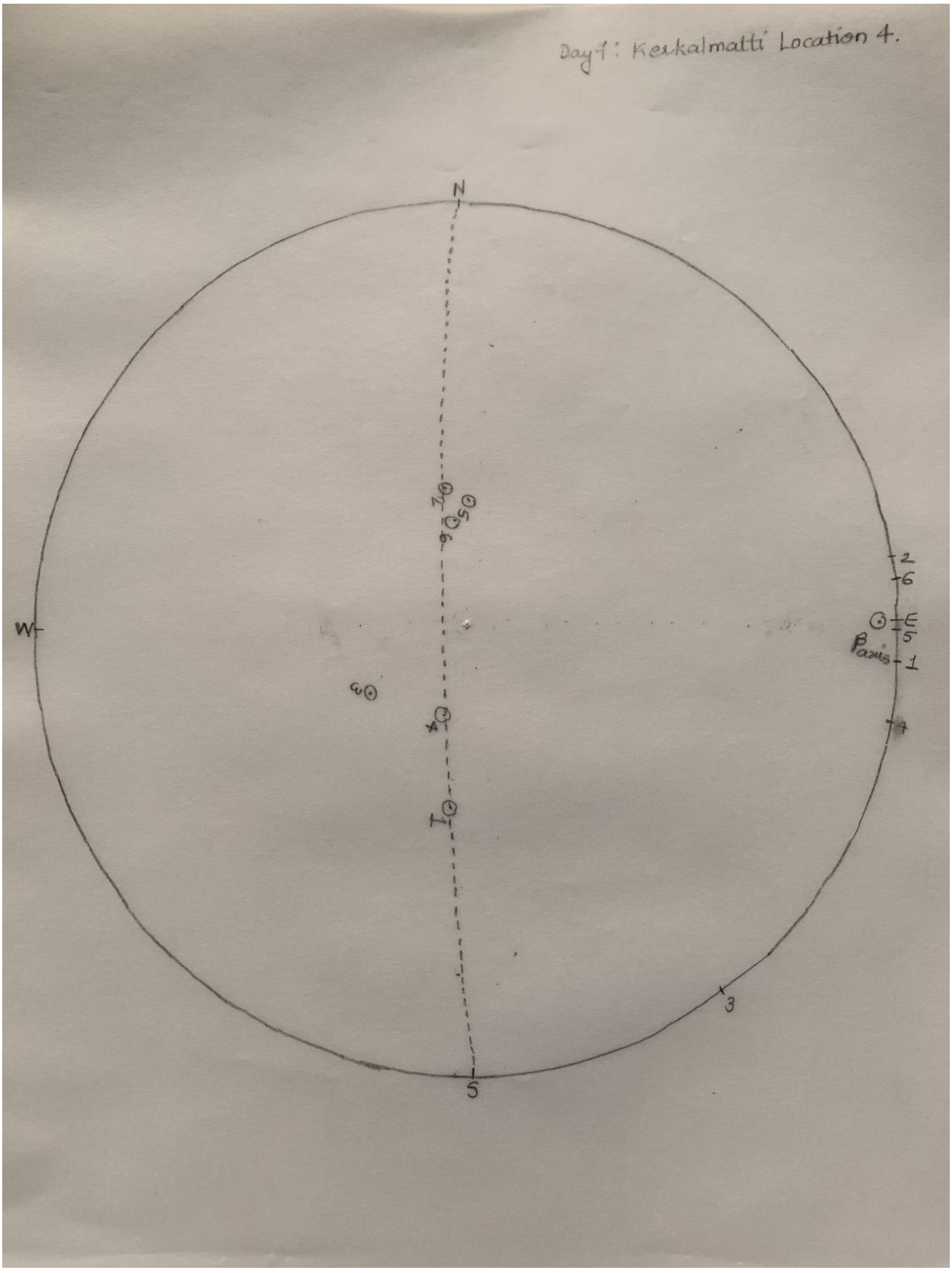


Figure 41: Spot4; Plotted structural data of fold of Phyllite

Spot: 5

Location: Niralakeri Dolomite mine

Time of arrival: 4:34 pm

Latitude: 16°7'3" N

Longitude: 75°41'55" E

The study area observed is a Dolomite mine. It is an open cast mining and the benches are very steeply dipping. The width of benches will be around 5 m and the height of the face will be around 6-7 m.

Figure 42: Nilarakeri dolomite mine

DAY 8: 17-12-2022

Spot 1

Location: Kagalkomb

Time of arrival: 8:54 am

Latitude: 16°06 48"N

Longitude :75°38'23' E

A huge body of Quartz towards the N of the road few meters away nearly 40-50 m width is exposed at this location. In this area, we have seen quartz which is milky white in color indicating presence of impurities, vitreous lusture, conchoidal fracture and absence of cleavage. The general trend of quartz vein is in E-W direction. This quartz may have been formed due to mineralization. There are also Joint sets present.

The trend of joint set recorded is as follows,

1.N 157°

2.N 150°

3.N 50°

As we move towards the top, the folding pattern can be seen but it cannot be called as fold because it is a monomineralic mineral and it is called as whopping structure. There are also radial joints present, highly fractured. Some joint sets are at right angle. There are some hexagonal quartz crystals developed in cavities of Quartz. Secondary mineral crystallization is observed along the cracks developed. Few local extent deformations at some places have undergone bending mechanism which resulted in the development of extensional cracks on the outer arc and tensional cracks perpendicular to the extension. As we move down the hill, in the vicinity of the road towards the N are inclined Dolomite beds.

❖ Structural data on the dolomite bed facing towards N

Strike direction	N 102°	N 104°	N 105°	N 108°	N 105°
Dip direction	SSW	SSW	SSW	SSW	SSW
Amount of Dip	40°	44°	40°	40°	45°

Figure 43: Radial joints in Quartz

Figure 44: Tensional cracks perpendicular to the extensional cracks

Figure 45: Hexagonal crystal of Quartz developed in the cavities

Spot 2

Location: Katageri dolomite mine

Time of arrival: 10:31 am

Latitude: 16° 6’33” N

Longitude: 75° 38’47” E

This location is a dolomite mine, trending in N270°, along the Strike the dip steepens, and it is observed the mining is done along Strike direction. The height of the bench face is around 5m and width of the bench is around 5-6m.

- ❖ Structural data recorded on plane in mine

Strike direction	N 50°
Dip direction	SW
Amount of dip	26°

Figure 46: Dolomite mine

Spot 3

Location: Kokankappa limestone

Time of arrival: 11:00 am

Latitude: 16°3’19” N

Longitude- 75°38'45" E

The place is near Konkankappa below the bridge, the rock type exposed here is limestone which is medium grained, bedded sub-horizontally, pale grey in color with fine siliceous banding. Warping of the plane is observed. Parallel sets of jointing almost equally spaced and shallow dipping. The strike direction is changing. These members may be the Konkankappa Limestone of Katageri Formation or the youngest formation of the whole Badami Group. The trend of the bridge is N 10°.

- ❖ The structural data on plane is recorded as follows

Strike direction	N 140°	N 132°	N 111°	N 94°	N 114°	N 125°
Dip direction	SSW	SSW	SSW	SSW	SSW	SSW
Amount of dip	5°	4°	2°	7°	5°	6°

Spot 4

Location: Halkurki shale

Time of arrival: 11:50 am

Latitude: 16 1’15” N

Longitude: 75°38'60" E

The study area is along the stream oh the way to Halkurki. The area showed exposures of Halkurki Shale of the Katageri Formation belonging to the Badami Group. The Halkurki shale exhibited a reddish- brown color and was found to be intercalated with

the limestone having greyish buff color. The beds were shallow dipping and has prominent slaty cleavage. The tectonic deformation has been slightly taken place. There are calcareous and ferruginous layers seen. The amount of dip is changing all along the strike.

- ❖ The structural data recorded here is as follows:

Strike direction	N 140°	N 120°	N 125 °
Dip direction	SSE	SSE	SSE
Amount of dip	2°	6°	4°

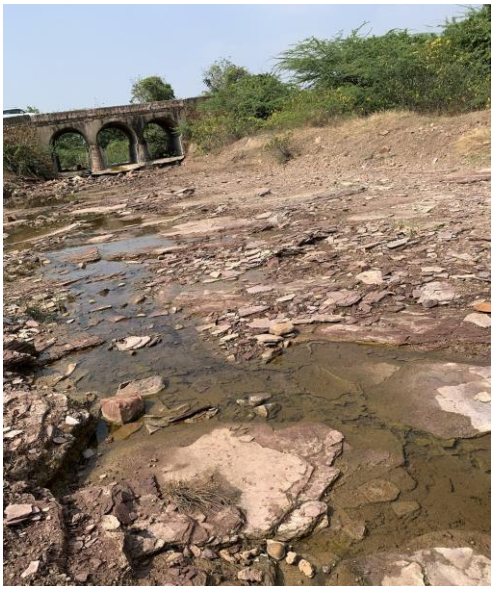


Figure 47: Outcrop of halkuri shale

Spot 5

Location: Near HP petrol pump. Badami sandstone

Time of arrival: 12:45 pm

Latitude- 15°56'18"N

Longitude- 75°40°45"E

The study area is located behind the HP petrol pump. Observations made along the hill section. The rock encountered here is sandstone. The matrix was ferruginous and grain size were sand size. This rock is exposed as flat-topped barren hillocks. The sedimentary structures such as cross bedding, herringbone structures, ripple marks, lamination can be seen. The three joint sets are observed which are parallel. The right-angle joints, scissor joints are also observed. The trend of the joint is N85° and NI0°. These rocks belong to Badami Group.

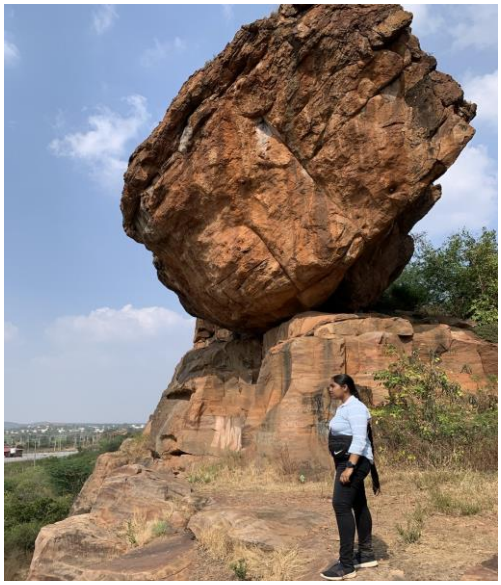


Figure 48: Badami sandstone

Spot 6

Location: Badami Caves

Time of arrival: 3:10 pm.

Latitude: 15°55’06”N

Longitude: 75°41’3”E

The Badami cave temples are a complex of Hindu and Jain cave temples located in Badami, a town in the Bagalkot district in northern part of Karnataka, India. The caves are important examples of Indian rock-cut architecture, especially Badami Chalukya architecture, and the earliest date from the 6th century. Badami is situated on the west bank of a man-made lake ringed by an earthen wall with stone steps; it is surrounded on the north and south by forts built in later times. These caves were discovered by Stella Kramrisch in 1924.

Discovery in 6th Century. Sandstone is the main rock type. UNESCO world heritage site candidate; The Badami cave temples represent some of the earliest known examples of Hindu temples in the Deccan region. They along with the temples in Aihole transformed the Mallaprabha River valley into a cradle of temple architecture that influenced the components of later Hindu temples elsewhere in India.

Caves 1 to 4 are in the escarpment of the hill in soft Badami sandstone formation, to the south-east of the town. In Cave 1, among various sculptures of Hindu divinities and themes, a prominent carving is of the Tandava-dancing Shiva as Nataraja. Cave 2 is mostly similar to Cave 1 in terms of its layout and dimensions, featuring Hindu subjects of which the relief of Vishnu as Trivikrama is the largest. The largest cave is Cave 3, featuring Vishnu-relate, and it is also the most intricately carved cave in the complex. Cave 4 is dedicated to revered figures of Jainism. Around the lake, Badami has additional caves of which one may be a Buddhist cave. Another cave was discovered in 2015, about 500 meters (1,600 ft) from the four main caves, with 27 Hindu carvings.

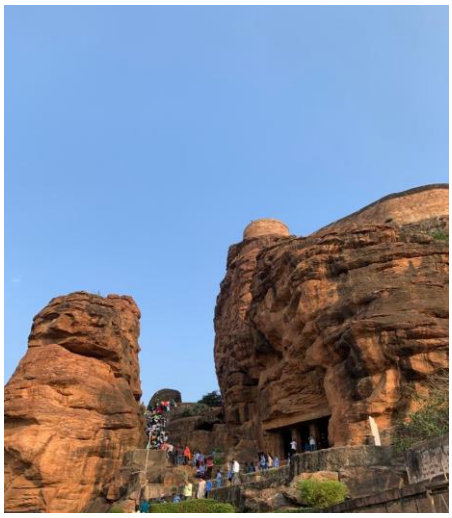


Figure 49: Badami caves

DAY 9: 18-12-22

Spot 1

Location: Naganapur, lokapur.

Time of arrival: 9:52am

Latitude: 16°10'5" N

Longitude: 75° 21'32" E

A large expansive outcrop is located in NW direction of the road. The rock is mainly limestone we can observe silicate rich bands are formed in $CaCo_3$ dominant rock. The rock is highly deformed and shows penetrative foliation and rock is steeply dipping. Important observations: presence of stromatolites that they are layered structure which looks like flower and vary in size from mm- cm's. Stromatolites are made up of algal mats. As the rock is deformed we observed deformed stromatolites in intrafolial domains of rocks. There are different types of stromatolites-irregular, pink color, eye shaped , 3D appearing based on morphology, can be used to date rock. Kaladgi Basin is dated based on types of stromatolites formed. Stromatolites date the formation of rock as the sediments get deposited.

Strike direction	N 121°	N 125°	N 120°
Dip direction	SSW	SSW	SSW
Amount of dip	75°	71°	71°

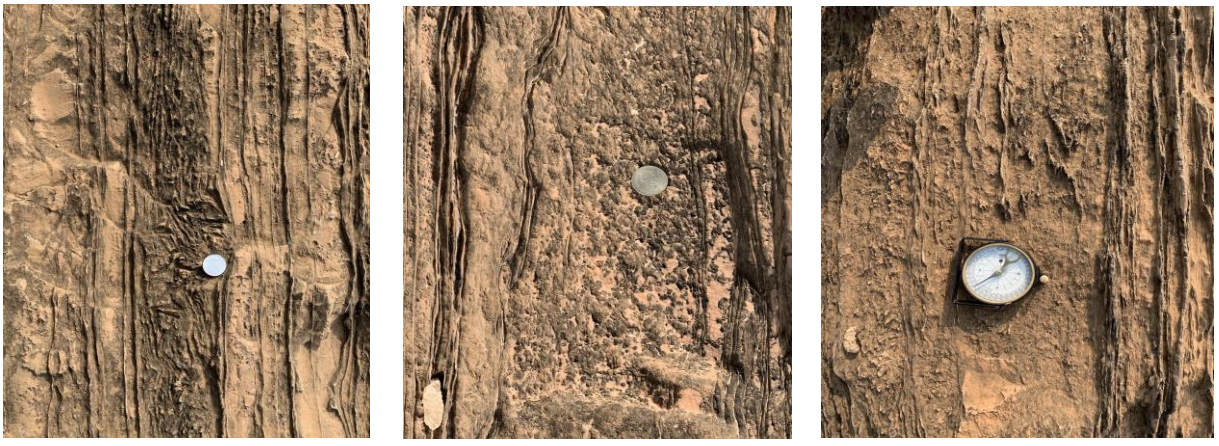


Figure 50: Stromatolites in rock

Spot 2

Location: Jalikatti

Time 12:41pm

Latitude: 15° 9’ 36” N

Longitude: 73° 22’ 58” E

This location is 1 km from Lokapur Bridge. The rock type is a limestone. The trend of the mine is N115°. The number of benches observed were three. There was presence of Calcite mineral in the mine. The limestone is fine grained and grey in color.

Figure 51: Calcite mineral mine

Day 10: 19-12-22

Spot 1

Location: Almatti,Nidgundi, Bijapur district, Karnataka

Latitude: 16.331°N

Longitude: 75.888°E

The Lal Bahadur Shastri Dam is also known as Almatti Dam is a hydroelectric project on the Krishna River in North Karnataka, India which was completed in July 2005. The target annual electric output of the dam is 560 MU (or GWh). Lal Bahadur Shastri Dam Almatti Dam with its right bank power house Official name is Upper Krishna-I (Almatti) of which construction began in 1963.Minimum Draw Down Level: 504.75 m MSL.

The Almatti Dam is the main reservoir of the Upper Krishna Irrigation Project; the 290 MW power station is located on the right side of the Almatti Dam. The facility uses vertical Kaplan turbines: five 55MW generators and one 15MW generator. Water is released in to the Narayan reservoir after using for power generation to serve the downstream irrigation needs. Two separate facilities namely, Almatti 1 Powerhouse and Almatti II Powerhouse each separated by distance do provide power generation capabilities. The entire dam was finished in less than forty months, with construction ending in July 2005. The dam is located on the edge of Bijapur and Bagalkot districts. Geographically, it is located in the Bijapur district but large areas of Bagalkot district have also been submerged due to filling of the reservoir. The dam holds a gross water storage capacity of 123.08 TMC at 519 meters MSL.The backwaters of the dam host several migratory birds during summer.

The full reservoir level of Almatti dam was originally restricted to 160 meters above mean sea level.

Figure 52: Almatti Dam

Spot 2

Location: Vijayapura

Time: 12:26pm

Latitude: 16°20'28" N

Longitude: 15°55'34" E

The study area is a large expansive outcrop of Archean rock which has several generations of melts, produce. There are in total 6 rock types observed. The outcrop has undergone several episodes of melting producing different granites. The mafic rock is the oldest (xenoliths) which are caught up in gneissic rock. There are large mafic xenoliths and smaller ones as well and mafic rock also occur as bands in some places.

The gneissic rock has folds on the bands, the mafic rock bands within gneissic rock are also folded we use can call it as mineralogical segregational layering. After the bands are folded we observe white Granite intruding the banded rock and follows the bands suggesting it could be syn-tectonic or pretectonic to the formation of that bands. Then the grey granite which cuts across the white granite, we observed that pink granite cross cuts the white granite and pegmatite vein which cross cuts the pink granite is the youngest of all. It was also observed pink granite cross cutting the vein as there can be more sets of pegmatite veins. There is possibility that both the

pegmatite vein and pink granite could be formed synchronous. We also observed faulting of the pegmatite vein at some place.

Figure 53: Cross cutting relationship in rock of various rock types

Figure 54: Faulting of pegmatite vein

CONCLUSION

From the field site visit in the kaladgi Supergroup, it is inferred that the BHQ, BHJ and the metapelites of the Hungund schist belt serve as the basement rock for the Kaladgi supergroup.

After this Salgundi conglomerate of the Ramdurg formation is the oldest rock of the kaladgi sequence of rocks. It is followed by Saundatti Quartzite and the Manoli Argillite. Over lying Chiksellikere Limestone of the Yendigeri Formation of the Lokapur Subgroup. Bevinmatti Conglomerate of Kundargi Formation marks disconfirmity between the Lokapur Subgroup and the Simikeri Subgroup and overlying is the Muchkundi Quartzite.

Bagalkot group and Badami Group is are separated by an angular unconformity. Followed by the Cave temple Arenite of the Keru Formation and then after Halkurki shale and konkankappa Limestone of the Katageri Formation of the Badami Group.

This basin is intruded by Granites and pegmatites and the overlying Deccan traps.

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