MINERALOGICAL AND GEOCHEMICAL STUDIES ONBED LOAD SEDIMENTS OF GUMANI RIVER "IMPLICATIONS FOR PROVENANCE AND WEATHERING PROCESSES"

Project submitted to the Central University of Punjab

For the award of

Master of Science

In

Geology

BY

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CERTIFICATE

I declare that the project entitled **Mineralogical and geochemical studies on bed load sediments of Gumani river "implications for provenance and weathering processes"** has been prepared by me under the guidance of Dr. Jitendra Kumar Pattanaik, Assistant Professor, Department of Geography and Geology, School of Environment and Earth Sciences, Central University of Punjab. No part of this project has formed the basis for the award of any degree or fellowship previously.

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This is to certify that the work incorporated in this M.sc thesis entitled **Mineralogical and geochemical studies on bed load sediments of Gumani river "implications for provenance and weathering processes"**submitted by BinayaSankarBejto the Central University of Punjab in fulfillment of the requirements for the award of the Degree of M.Sc.Geology, under my guidance. I further certify that this work has not been submitted to any other University or Institution in part or full for the award of any degree or diploma.

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Binaya Sankar Bej

ABSTRACT

MINERALOGICAL AND GEOCHEMICAL STUDIES ON BED LOAD SEDIMENTS OF GUMANI RIVER "IMPLICATIONS FOR PROVENANCE AND WEATHERING PROCESSES"

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Keywords: Geochemistry, Bulk sediment geochemistry, CIA, IOL, Clay minerals

Geochemical and mineralogical study of bed load sediments will help to understand the weathering process, the intensity of weathering and the denudation in various environmental conditions, origin, mode of occurrence, biological and physic-chemical processes, mobilization and transport of various elements. River draining a single lithology helps to study above parameter of the catchment area. So here GumaniriverdrainingRajmahal basalt was selected as there is no report or literature available from this catchment to understand the weathering process in its water shade. The mineral compositions of the river bed load sediments from different locations shows quartz, calcic plagioclase, clinoenstatite clay minerals such as gibbsite, kaolinite, illite, goethite and clay micas, are dominating mineral phases. Clay mineral percentage is higher in the upper reaches compare to thelower reach of the river. Clay mineral gibbsite and kaoline indicate the removal of silica is higher in the upper reach and shows kaolintization, lateritization and upto some degree of Bauxitization process is active in the upper reach. CIA value, A-CN-K, A-CNK-FM ternary diagram indicate the intensity of weathering is moderate to high at different location. The index of lateritization shows clear indication of kaolintization→lateritization→Bauxitization process.

(Name and signature of student) (Name and signature of supervisor)

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Chapter 1

Introduction

The provenance study of the stream sediments depends on the lithology of the catchment area, topography, climatic condition, transportation and hydrodynamics of the depositional site (Sensarma et al., 2008). Major, trace and rare earth elements (REE) analysis of bed load sediments will help to understand the lithology and chemical weathering in the catchment area. Sediments are being produced in the catchment are due to weathering process and subsequently transportedvia various surface processes. The different source of lithology and it is not affected irrespective of intensity of chemical weathering of the source area from the REEs.

1.1. Weathering:

Different types of weathering are active in the catchment area and depending on types, the sediment production will be different. The weathering process is the breakdown of rocks at the Earth's surface, by the activity of water, extremes of temperature, and natural action. It doesn't include the expulsion of rock material. There are three major types of weathering: physical, chemical and biological weathering.

(a) Physical weathering: physical disintegration of rock mass due to variation of temperature, mechanical properties of rock, change in over load, development of new minerals in fracture, mechanical abrasion due to different geological agents.

(b) Chemical weathering: chemical weathering is the weakening and subsequentdecomposing of primary mineral present in the rock by chemical processes. These processes include oxidation, hydrolysis, and carbonation.

i)Oxidation is the response of rock minerals with oxygen, in this way changing the mineral structure of the rock. At the point when minerals in rock oxidize, they turn out to be less resistant to weathering (Krishnaswami and Singh, 2005).

(ii)Carbonation is the procedure of minerals responding with carbonic acid. Carbonic acid is shaped when water consolidates with carbon dioxide. Carbonic acid disintegrates or separates minerals in the rock.

$$CO_2 + H_2O \rightarrow H_2CO_3$$

$$CaCO_3 + H_2CO_3 \rightarrow Ca^{2+} + 2HCO^{3-}$$

(iii)Hydrolysis is held tocause by water. Water changes the composition of mineral and size of minerals in rock making them less impervious to weathering. At the point when this mineral is totally hydrolyzed, earth minerals and quartz are created and such components as K, Ca, or Na are discharged

$$2KAlSi_3O_8 + 2H^+ + 9H_20 \rightarrow H_4Al_2Si_2O_9 + 4H_4SiO_4 + 2K^+$$

(iv)Hydration is the assimilation of water into the mineral structure. A decent case of hydration is the retention of water by anhydrite, bringing about the development of gypsum. Hydration extends volume and furthermore brings about rock distortion.

(v) Dehydration is the expulsion of water from mineral structures. A decent case of lack of hydration is the expulsion of water from limonite, bringing about the development of hematite.

(c) Biological weathering: Biological weathering is the weakening and consequent breaking down of rock by plants, creatures and microorganisms. Developing plant roots can apply pressure or weight on rock. In spite of the fact that the procedure is physical, the weight is applied by a natural procedure (i.e., developing roots). Natural procedures can likewise create chemical weathering, for instance where plant roots or microorganisms deliver natural acids which help to break up minerals. Microbial movement separates minerals by adjusting the substance piece, along these lines making it more vulnerable to weathering. One case of microbial action is lichen; lichen is growths and green growth, living respectively in an advantageous relationship. Organisms discharge chemicals that separate minerals; the minerals hence discharged from rock are consumed by the green growth. As this procedure proceeds with, openings and holes keep on developing on the rock, uncovering the rock further to physical and chemical weathering.

1.2. Depositional sites:

Sediments are deposited in various depositional environments like flood plain, river bed and ocean floor etc.

(a) Flood plains**:** When the discharge of water is higher than the capacity of the channel, water flows over the banks and out onto the flood plain where overbank or flood plain deposition occurred.Mostly suspended loads are silt and clay size debris is found. If the flow is high, sufficient to take sandy debris in suspension and subsequent drop in velocity helps the deposition of the silty and sandy suspension. Silt and sand deposited over the flood plain and sediments as a thin sheet are (a) very thin and thin beds normally graded from sand to mud. (b)Prove of initial rapid flow and formation of soil. (Nichols, 2008)

(b).River beds:-

(i) Sediments in a stream and waterway are the characteristic part. Sediments travel downstream in suspension when water speed is high or turbulent. At the point when there is decrease in speed particularly deeper area zones waterway silt will settle down and the fine material kept. (ii) In stream and riverssediment exist in two structures either as suspended load or stored material. It is a fine sediments i.e mud and sediment that stored. Under high stream sand may enter the suspended load and under low stream sediment may settle down the stream bed.

(c) Ocean floor sediments:-

Generally these types of sediments are three types (www.cliffsnotes.Com) **(i)Terrigenous sediments:-**Terrigenous sediment are originated from the upper land region from arrive. Aground, rocks are isolated by physical and compound weathering frames. Physical weathering breaks rocks into pieces stretching out from massiverocks to soil. Weathering helps to disintegrate of the source rocks and built up terrigenous sediments. A bit of the rock material is really split down away, which is the source of broken down particles in seawater. The sorts and degrees of weathering of the source rock area, generally called sedimentary provenance.(Geology. Uprm. Edu)

(**ii**) **<u>Pelagic sediment</u>**: - It is the mixture of the clay particles and the micro skeletons of marine organisms of biogenic ooze that is consistently rich in foraminifera with 60% pelagic and neritic grains. It is present in red mud, with under 40% siliciclastic and volcano clastic grains. It can moreover be a silica flood. Pelagic deposit are put away at such low rates that they tend to be close near shore. Thus, pelagic sediments arecommonly associated with sea floor.

(iii) <u>Hydrogenous sediments</u>:-It is richer in manganese nodules, which precipitate from ocean water and accumulated on the sea depths. Run-off is the major controlling variable for silt deposition. In organic and specific bacterial movement, hydrothermalism process and yearly hydrogenous silt deposited and settled down on the sea bed.

1.4 <u>provenance study</u>:-

Streams are water bodies that stream downslope because of gravity through a characteristic open channel. The channel may contain water for at any rate some portion of the year. Streams with a significant volume of water are considered waterways and normally sediments drained along the river and mixed with the sea floor sediments, while others end, Stream activity is high power in charge of forming the Earth's surface and for transporting sediment from land to sea. Lithology is the important factor which helps to deposited the amount of sediments, grain size distribution; identify the provenance source materials due to the geochemical study.The lithological arrangement of the channel bed material is equivalent to the lithological arrangement of the aggregate upstream watershed.The lithological arrangement of the channel bed material is equivalent to the lithological arrangement of the slope. In this study area the single lithological composition is seen, mainly focused on basalt outcrop and alluvium soil. Single lithology means the one type of lithological composition in anarea and multiple lithology defines different type of lithology. Single and multiple river channel identified from river channel morphology and geometry of the river channel.The lithology can be determined by the help of major, trace elemental compositions. (M. Latrubesse, park, 2017)

1.5 Review Literature:-

For this project work various published literatures were reviewed to understand the background information and related works. Which helped to shape our approach. Some are discussed as below:-

1. Sensarma et al., 2008;

Small rivers (≤ 100 km length) are likely to drain fewer rock types. Therefore, their solutes and sediments are good indicators of weathering environments typical of their basins and help constraining the nature of their source rocks. To understand this, the texture, mineralogy, major and trace element compositions of the sediments deposited by the River Hemavati, a northern upland tributary of the Cauvery River in southern India, are analyzed and discussed.

The Hemavati sediments are overall of fine sand size (mean 2–3ϕ), and have high concentrations of FeO (≤ 7 wt.%), TiO_2 (≤ 1.2 wt.%), Cr (≤ 350 ppm) and Ni (≤ 125 ppm). Major and trace element distribution call for a binary source for the sediments, and particularly point to contrasting climatic conditions of their provenances. The source areas in the upstream and downstream parts are exposed to sub-humid high relief and sub-arid low relief conditions, respectively, with distinct weathering characteristics. The CIA suggests that the downstream rain-shadow part of the catchment suffered only minor chemical weathering.
On the other hand, the REE distribution in the Hemavati sediments indicates contrasting lithologies in their provenance, and is not controlled by chemical weathering. On the basis of REE patterns, the sediments are divided into two compositional groups. The Type 1 sediments have a REE chemistry similar to the upper continental crust, and have been derived from the > 3.2 Ga composite peninsular gneisses occurring in the low-lying, semi-arid Mysore Plateau. The Type 2

sediments, however, have dominantly intermediate to mafic granulite contributions from the tectonically uplifted Western Ghats, weathered under sub-humid conditions. High concentrations of FeO, TiO_2, Cr and Ni in the sediments suggest mafic-dominated source lithologies in the upper catchment, a feature also confirmed by field observations and petrographic study.

2.Pramod Singh, 2009:

The Ganga River sediments from different depositional environment in the Plain region such as the river channel, active flood-plain and the older flood-plain sediments from the inter-fluve region were analysed for major, trace and the rare earth elements. The CIA values ranging between 55 and 74, with average value of 59, 61.4 and 67 for sediments from the Plain's bed-load, active flood-plain and older flood-plain from the inter-fluvial region indicates that silicate weathering of Ganga River sediments has occurred only after entering into the plains and the value of CIA indicate a moderate chemical weathering in the plains. The plots of sediments in ternary diagram among La, Th, Sc and ratios involving Co/Th, La/Sc and Sc/Th indicate granitic to granodioritic source rocks to the sediments. The Bivariate ratio plots involving Al_2O_3, TiO_2 and FeO like oxdies along with REE plots suggest that the out of the major Himalayan lithologies, gneisses. The plots of Log Na_2O/K_2O vs. Log SiO_2/Al_2O_3 and FeO/SiO_2 vs. Al_2O_3/SiO_2 diagrams show that the of processes including erosion, weathering, sorting and aeolian activity has role in progressively changing the chemistry from source rock to catchments bed-load to Plains bed-load, active flood-plains and the older inter-fluvial sediments in the Ganga River system.

3. Pramod singh and Rajamani, 2001:

The flood plain sediments of the Kaveri river of southern India, originated from Archean gneissic and charnockite source. The sediments show inter-bedding of silty and sandy units. The geochemistry of silty beds is uniform at a location and over a lateral distance of nearly 250 km; the chemical concentration of sandy beds show more variable in the mineral composition. The geochemical evidence of silty sediments provide indication to the of source rocks and provide evidence of tectonic instability in the source region. The floodplain sediments contain all size grades (sand, silt, and clay), which may have resulted in minimizing the biases imposed on suspended and bedload sediments due to sorting. The low chemical index of alteration (CIA), shows lower % of the weathering of primary minerals formation which creates in lower percentage of smectite. This is possible if the region has undergone recent uplift to cause denudation of the surface from fresh Archean rock to the weathered sediments.

4. Nagarajan et al, 2007:

Petrographic, major, trace, and rare earth element compositions of quartz arenites, arkoses, and siltstones of Neoproterozoic Rabanpalli Formation of Bhima Basin have been investigated to understand the provenance. The quartz arenites, arkoses, and siltstones have large variations in major element concentrations. For example, quartz arenites and arkoses contain the higher SiO_2 (average with one standard deviation being 97±1,73±2, respectively) and lower Al_2O_3 (0.95±0.4, 9.6±0.9, respectively) concentrations than siltstones (SiO_2 = 64 ±4, Al_2O = 14±1), which is mainly due to the presence of quartz and absence of other Al-bearing minerals in relation with rock types. This is also supported by our petrography, since quartz arenites and arkoses contain significant amount of quartz relative to feldspar and lithic fragments. The observed low CIA values and A-CN-K diagram suggest that the sedimentary rocks of Rabanpalli Formation have undergone K-metasomatism.

5. Bakkiaraj, et al, 2010:

Major, trace and rare earth elements (REE) composition of sandstones from the Upper Cretaceous Sillakkudi Formation, Ariyalur Group, Cauvery Basin were studied to decipher their weathering and provenance history. Texturally, these sandstones are immature, poorly sorted and grain supported. Abundance of feldspars especially, plagioclase indicates rapid deposition of sediments from a nearby source rocks. Using the geochemical classification diagram the Sillakkudi sandstones are classified as Fe-rich sandstone, quartz arenite, litharenite, sub-litharenite, sub-arkose, arkose, and wacke types, which is also supported by the petrography study. The transition trace elements like Co, Ni, and V are higher in the Sillakkudi sandstones than upper continental crust (UCC) values.

6. Krishnaswami and Singh, 2005:

Rivers transport weathered materials from land to the ocean. The chemistry of river waters is dictated by supply of various elements from both natural and anthropogenic sources. Among the natural sources, chemical weathering of the drainage basin is the dominant component, a process which consumes atmospheric CO_2. On timescales of millions of years, atmospheric CO_2 balance and hence global climate is influenced by chemical weathering process, silicate weathering in particular. The suggestion that silicate weathering in the Himalaya may be a driver of global cooling during the Cenezoic era and has prompted many studies on rivers draining the Himalaya, especially the source waters of the Ganga– Brahmaputra.

7. Das, et al, 2004:

Rates of chemical and silicate weathering of the Deccan Trap basalts, India, have been determined through major ion measurements in the headwaters of the Krishna and the Bhima rivers, their tributaries, and the west flowing streams of the Western Ghats, all of which flow almost entirely through the Deccan basalts. The Ca/Mg and Na/Mg in these rivers, after correcting for rain input, are quite similar to those in average basalts of the region, suggesting near congruent release of Ca, Mg, and Na from basalts to rivers. Comparison of calculated and measured silicate-Ca in these rivers indicates that at most 30% of Ca can be of nonsilicate origin, a likely source being carbonates in basalts and sediments. The chemical and silicate weathering rates of the west flowing rivers of the Deccan are four times higher than the east flowing rivers. This difference is due to the correspondingly higher rainfall and runoff in the western region and thus re-emphasises the dominant role of runoff in regulating weathering rates.

8. Sarin et al. : 2007:

The Ganga-Brahmaputra, one of the world's largest river systems, is first in terms of sediment transport and fourth in terms of water discharge. A detailed and systematic study of the major ion chemistry of these rivers and their tributaries, as well as the clay mineral composition of the bed sediments has been conducted. The chemistry of the Highland Rivers are all dominated by carbonate weathering; (Ca + Mg) and HCO_3 account for about 80% of the cations and anions. In the lowland rivers (the Chambal, the Betwa and the Ken), HCO_3 excess over (Ca + Mg) and a relatively high contribution of (Na + K) to the total cations indicate that silicate weathering and/or contributions from alkaline/saline soils and groundwater could be important sources of major ions to these waters. The chemistry of the Ganga and the Yamuna in the lower reaches is by and largely determined by the chemistry of their tributaries and their mixing proportions. Illite is the dominant clay mineral (about 80%) in the bedload sediments of the highland rivers. Kaolinite and chlorite together constitute the remaining 20% of the clays.

9. Rashid et al, 2014:

Climate shows a vital role in weathering of rocks, and a rich record of climatic change is preserved in rocks and sediments. The physical and chemical weathering also largely depend on the prevailing paleo-climate in the area, apart from other factors. In an attempt to understand the dominance of physical over chemical weathering processes, the textural and geochemical studies of Wular Lake sediments from Jammu and Kashmir, northern India, have been taken up in the present study. These sediments documented several attention-grabbing processes that operated during weathering, transportation, and deposition. Investigations have revealed that physical weathering dominated over chemical weathering, resulting in enhanced rates of erosion and consequent deposition of large detritus into the lake. Lake sediments and source rock chemistry are comparable, indicating low to moderate chemical weathering history of the source region which is consistent with cold regions and steep slope areas. Unusual enrichment of Cr values in source rocks compared with sediments signify a process of sediment–water interaction where Cr is removed from water and preferentially adsorbed onto clay fraction of sediments.

10. Das et al, 2006:

The sediment geochemistry, including REE, of surface and core samples from Mansar Lake, along with mineralogical investigations, have been carried out in order to understand the provenance, source area weathering, hydrolic sorting and tectonic setting of the basin. The geochemical signatures preserved in these sediments have been exploited as proxies in order to delineate these different parameters.The major element log values (Fe_2O_3/K_2O) vs (SiO_2/Al_2O_3) and (Na_2O/K_2O) vs (SiO_2/Al_2O_3) demarcate a lithology remarkably similar to that exposed in the catchment area. The higher Zr/Th and Zr/Yb ratios in coarse sediments and PAAS compared to finer grained detritus indicate sedimentary sorting. Plots of the geochemical data on tectonic discrimination diagrams suggest that the sediments derived from the lower Siwalik were originated within a cratonic interior and later deposited along a passive margin basinal setting. It therefore reveals lower Siwalik depositional history.

11. Ahmad and Chandra, 2012:

Middle to Late Pleistocene loess-paleosol sediments of Kashmir Valley, India, was analyzed for major, trace and REE elements in order to determine their chemical composition, provenance and intensity of palaeo-weathering of the source rocks. These sediments are generally enriched with Fe_2O_3, MgO, MnO, TiO_2, Y, Ni, Cu, Zn, Th, U, Sc, V and Co while contents of SiO_2, K_2O, Na_2O, P_2O_5, Sr, Nb and lack of prominent negative Eu anomaly ($Eu/Eu^* = 0.73–1.01$, average = 0.81). PAAS normalized REE are characterized by slightly higher LREE, depleted HREE and positive Eu anomaly. Various provenance discrimination diagrams reveal that the Kashmir Loess-Paleosol sediments are derived from the mixed source rocks suggesting large provenance with variable geological settings, which apparently have undergone weak to moderate recycling processes. Weathering indices such as CIA, CIW and PIA values (71.87, 83.83 and 80.57 respectively) and A-CN-K diagram imply weak to moderate weathering of the source material.

12. Das and Haake, 2003:

Major, trace and rare earth element (REE) chemistry of fresh-water lake sediments, stituated in the middle Siwalik Formation (Pliocene), have been investigated. The log (Fe_2O_3/K_2O) vs log (SiO_2/Al_2O_3) plot of sediments discriminate the rock types of the catchment which are remarkably similar to those observed in thin sections. The Chemical Index of Alteration (CIA) between 75.2 to 78.1 and Chemical Index of Weathering (CIW) between 79.5 to 89.8 are higher than Post-Archean Australian Shale (PAAS), indicating moderate to high weathering at source area. The PAAS normalized REE patterns are similar and differentiate the major rock types on the basis of abundance of REEs in accordance to clay minerals, grain size, with the highest concentration in the finest grain sediments. It also indicates poor mixing of sediments. The consistency of REEs in sediments with those of rock types illustrate almost unaltered, unmodified transport of these from the provenance to the detritus deposited in the basin and also shows that the REEs are enriched in phyllosilicates. The major elements, Fe_2O_3, TiO_2, MgO, K_2O show strong positive correlation with Al_2O_3 and follow the trend of the latter, and REEs also indicate same characteristics, hence phyllosilicates are likely to be the promising host for REEs. The negative correlation of La, Y band Y with Zr and positive correlation with REEs and Al_2O_3 do not indicate Zr control on REE distribution in the present case.

<u>1.6 RESEARCH PROBLEM</u>:-

Sediments are deposited in various form associated with river that are river bed load, suspended load. Geochemical and mineralogical study of bed load sediments will help to understand the weathering process, the intensity of weathering and the denudation in various environmental conditions, origin, mode of occurrence, biological and physic-chemical processes, mobilization and transport of various elements. River draining a single lithology helps to study above parameter of the catchment area. SO here Gumani river draing Rajmahal basalt was selected as there is no report or literature available from this catchment to understand the weathering process in its water shade.

1.7 OBJECTIVE:-

The objective of my project is

a) To deducing the mineral composition of river bed load sediments

b) Geochemical composition to address the weathering trends along with their intensity in distance manner of this catchments.

Chapter-2

Study Area

2.1. STUDY AREA:-

The study area comes under the Sahebganj district in the N-E part of the Indian state of Jharkhand. This districtis surrounded by small part of Bhagalpur in the north, Kathiar district of Bihar state and east by West-Bengal. Where as in the Jharkhand, south by Pakur district and west by Godda district. The study area is situated between 24°50'52.08" and 25°10'59.8"N latitude and 87°33'16.16"and 87°42'36.8"E Longitude.

2.2 PHYSIOGRAPHIC APPERANCE: -

(a) Rainfall in this area by south-west monsoon. Rainy season held in the middle of June and lasts till September. The normal average rainfall in the district is 1575mm.

(b) The climate in this area is under humid to sub humid climate. The hot climate from March to middle of June. Rainy season from middle June to end to September. Winter starts from the middle November to till the end of February. The heat summer from March to May. Maximum tempreture-44.4°c and minimum tempreture 6.8°c.

(c)The geomorphology of Sahibganj district is mainly drained by the Ganges, Gumani and Morang rivers. Except the Ganges River all these rivers are seasonal in nature. During monsoon the Gumani and Morang River contribute to the major surface run-off. The main geomorphological features of the district are scarp of the northern part of the area, flat alluvial terrain in the eastern fringe of the district and resistant lava plateau of Rajmahal which occupies major part of the district.

(d) The major soil type found in the Sahibganj district is the Rajmahal type soil which is derived from the basaltic lava. The other soil types which are found in this district are Tal soil, eroded scarp soil, foothill soils, red soil and alluvial soil. Near the Sahibganj plains the clayey loam type alluvial soil also found.

(e) The structure of the Gumani river basins are leaf shaped. This structure is stretched along the main river course and opened in broad like structure and lower part is compressed and opens out like narrow band and mixed with Ganga river. (Shodhganga. Inflibnet.ac.in)

2.3 LITHOLOGY AND LITHOSTATIGRAPHY:-

The study area Gumani river basin composed of two group or formations are Rajmahal formation having thickness 600m and Dubrajpur formation having thickness 122 to 137m. The lithology of this area coarse sandstone, shale, clay beds, pebbly sandstone, fossiliferous siltstone, baked sandstone, siltstone, laterite, soil alluvium etc. (Mahadevan, 2002, Geology of Bihar and Jharkhand)

1.Dubrajpur formation: - It is situated between the underlying Barakar and the overlying Rajmahal trap. It contains conglomerate, ferruginous sandstone, coarse pink felspathic sandstone, red and brown siltstone and clay. It occurs as narrow discontinuous bands which striking the Rajmahal formation along the western margin of the Rajmahal hills. Three major exposure of Dubrajpur formation by Sengupta (1985):-

(i) The saravanpahar located 3.35km ENE of Nargraj.

(ii) Section of Katangi hill, 380m south of Kharikasol.

(iii) Chaparia pahar section, 4.8km north of Narganj.

2. Rajmahal formation: -It is placed above the Dubrajpur formation and it contact with the Barakar onto the crystalline basement along the western margin. It has maximum thickness 330m and thins 100m towards near the eastern of the Raniganj basin. The lithology beds of the sandstone, carbonaceous shale, grey shale and tuff are mainly lithology found in this Rajmahalarea. TheRajmahal formation may be divided into four major successive zones such as:

a) Basalt lower trap flows with unfossiliferousintertrappean beds

b) Successive lava flows with highly fossilifeorusintertrappean beds

c) Overlying lava flows with scarcely fossilifeorusintertrappean bed

d) Lava flows with no intertrappean beds

Table-1 -Lithostatigraphy of Rajmahal formations (simplified from Sengupta,1988) ((T.M Mahadevan,2002, Geology of Bihar and Jharkhand)

FORMATION	LITHOLOGY	AGE
Rajmahal formation	Soil, Alluvium	Cretaceous
	Laterite	
	D. Upper trap flows with and without intertrappean scarcely fossiliferous	
	C. Upper trap flows with fossiliferous intertrappean bed 8 with Taeniopteris spatulata-Brachyphyllum rhombicum. Assemblage zone 3	Lower cretaceous
	B. Lower trap flows(4 to 6) with fossiliferous intertrappean beds(4 to 7) with Cladophlebis indica-Dictyozamites indicus assemblage zone 2	Middle Jurassic
	A. Lower trap flows (1 to 3)with unfossiliferous intertrappean beds(1 to 2)	
	IGNEOUS CONTACT	
Dubrajpur formation	Baked sandstone, siltstone	Lower Jurassic
	Fossiliferous siltstone with Ptylophyllum acutifolium and Gleichenites gleichenoides Assembly zone-1	
	Pebbly sandstone	
	Coarse sandstone, shale and clay beds	Triassic

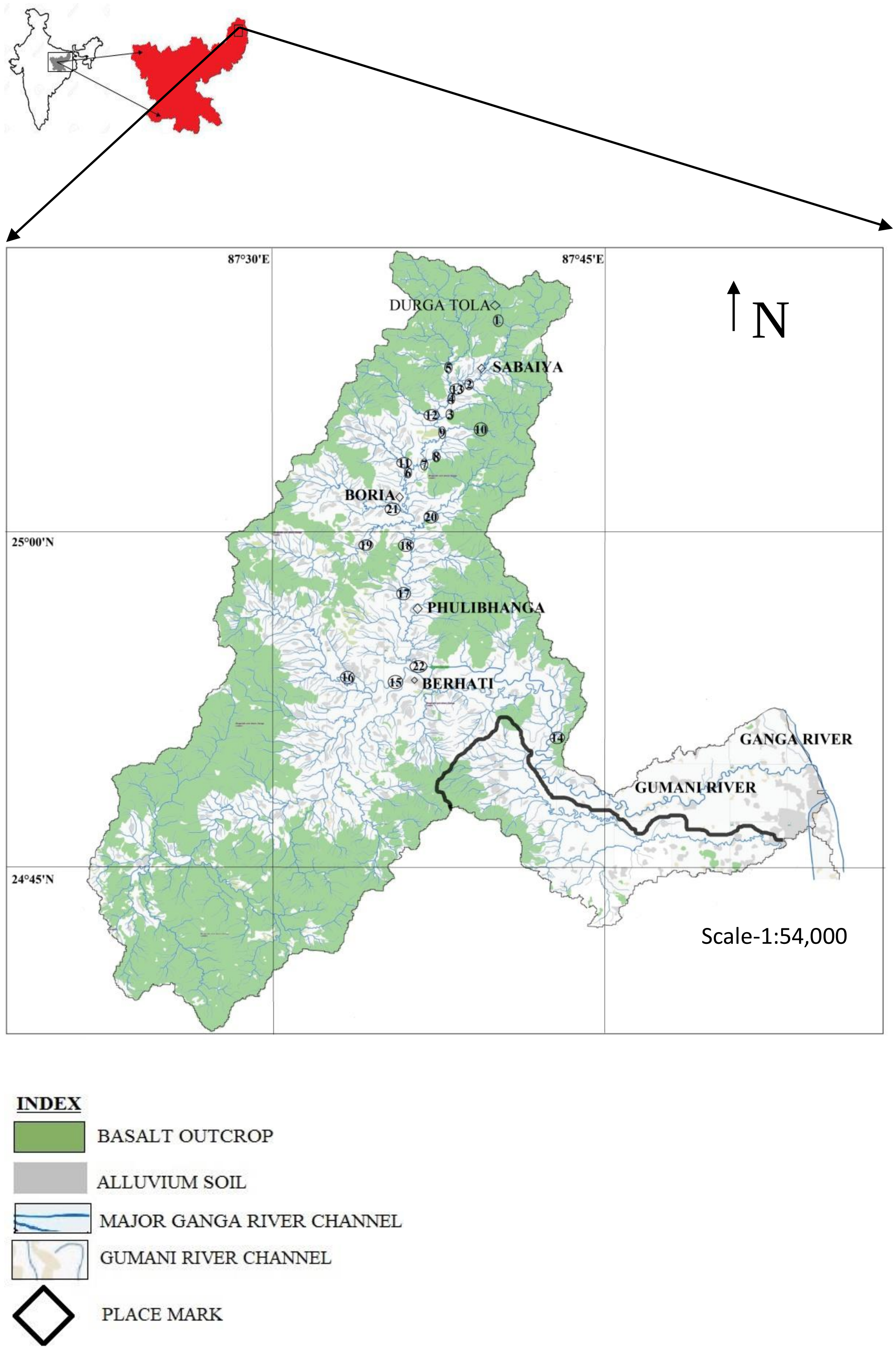


Figure 1 Geological Map of Study Area of Sahebganj (source- Bhuvan portal-watershed)

CHAPTER- 3

Material and Methods

3.1. Sampling:-

The 22 river sediments samples are collected from different region of the catchment region of the Gumani River in Sahebganj district. The distance between the samples collected area of river sediments are collected 32 km to 102.50 km etc. The total length of the sample collected area about 128.38 km. The samples are collected from inside the catchment region of the river. All the sampling data like latitude, longitude, altitude, sample collected area and their sample location distance.

Table:-2(Sampling location table of the river bed sediments)

Sample no.	Latitude	Longitude	Altitude In (m)	Sample location name	Distance (Km)
Loc1	25° 10' 59.8"	87° 40' 1.3"	149	Durgatola	102.50
Loc2	25°07' 07"	87° 38' 51.2"	90	Sabaiya	94
Loc3	25 °05.701'	87° 37.911'	81	Dighi	88.19
Loc4	25 °06 .508'	87° 37.974'	82	Turua	90.19
Loc5	25° 07.8223'	87° 37.862'	89	Kordhia	88.6
Loc6	25° 01.9858'	87° 36.124'	67	Chapgawan	78
Loc7	25° 03.483'	87° 36.87'	72	Simra	80.194
Loc8	25° 03.787'	87° 37.312'	73	Gorda	81.19
Loc9	25° 04' 59.6"	87° 37' 38.4"	77	Majhauna	85.19
Loc10	25° 07.329'	87° 39.198'	104	Bhurkunda	90.19
Loc11	25° 03' 31.25	87° 35' 49.98	72	Chhotakusma	78.45
Loc12	25° 05' 43.2"	87° 37' 08.30	82	Matia	88.19
Loc13	25° 06' 52.99	87° 38' 22.48	85	Sabaiya	92
Loc14	24° 50' 52.08	87° 42' 36.8"	38	Amjhor	32
Loc15	24° 53' 37.67	87° 33' 16.16	56	Simaldhab	54
Loc16	24° 57' 24.64	87° 35' 46.82	60	Phuibhanga	60
Loc17	24°59' 42.14"	87° 36' 1.93"	54	Bara beyasi	60
Loc18	24° 59' 59.6"	87°34' 23.36"	64	Chasganwan	66
Loc19	25° 0.01' 0.3"	87° 36' 59"	76	Rampur	75
Loc20	25°1'2.40"	87° 35 21.40	69	Bansjori	71
Loc21	25° 01' 21.3"	87° 35' 21.4"	67	Kalkha	73
Loc22	24° 54' 11"	87° 36' 32.7"	51	Paharpur	50

3.2 <u>Analytical methods</u>:-

This part was divided into two different processes one was sample processing and another one was sample analyzing. Sample processing was divided into some steps and analytical process table and their weight of the sediments after sieving and grinding sample given in following table:-

(Table3.- Analytical process and weight (gm) of river bed sediments)

Sample name	**Dry Sample**	**After sieving**	**After Sieving**	**After Cone &quartering**	**After cone & Quartering**
	(g)	**Sample ≤2mm (g)**	**waste (g)**	**Coarse Particle remaining (g)**	**Grinded sample (g)**
Loc1	176	164	11	82	81
Loc2	299	212	86	105	107
Loc3	245	137	106	59	78
Loc4	278	234	34	114	121
Loc5	247	123	125	60	61
Loc6	145	143	2	67	75
Loc7	276	52	224	-	51
Loc8	239	208	24	102	104
Loc9	289	139	150	65	73
Loc10	220	154	67	68	82
Loc11	300	222	74	107	113
Loc12	320	102	219	28	71
Loc13	181	168	12	80	87
Loc14	306	285	19	139	140
Loc15	145	134	11	64	65
Loc16	123	111	13	54	54
Loc17	200	174	25	85	88
Loc18	475	306	171	174	132
Loc19	253	119	132	47	70
Loc20	255	121	134	49	69
Loc21	303	88	213	27	59
Loc22	175	156	19	72	84

<u>1st step</u>

Sample drying: All the 22 samples were dried in hot air oven at 50° temperature till the samples are well dried.

<u>2nd step</u>

Then separated the big pebble size fragment and wastage material like root of dead plant and fossil like snails etc then theaccumulated sediments are separated by the help of agate pastel mortar.

<u>3rd step</u>

To separate the ≤2mm size of the bed sediments for the grinding by use of the 2mm size of sieving and collector. Then ≤2mm grain size particles are moved into cone and quartering method.

Cone and quartering: This method is applied to homogenize the sample and avoid biasness. Procedure of cone and quartering method:

• The ≤2mm sediment samples are mixed and poured into the conical pile or by the help of the butter sheet paper.

• The pile are made due to the homogenizing the sample.Then spread sample over the butter sheet paper having cone or disc shaped.

• Then disc is divided into quarters. From this, two quarters which are opposite to one another are choose out while the remaining are combined and comprise the reduced sample.

• This process is continued until the desired sample amount is obtained.

But in case of the less amount of samples the cone and quartering method or homogenize the samples by the help of theupdown of the four corner of the butter sheet paper at least five times to homogenize the sample.

<u>4th step</u>

Then the bedsediments samples of the one part of the cone and quarteredmethod moved into the grinding miller having agate bowl (Retch 200) to convert the sediment into fine powdered particles. Then the 3 - 5gm of fine sediments were sent for XRD and XRF analysis.

3.3 XRD analysis:-

It stands for X-ray powder diffraction (XRD). It is mainly used for identifying the phase of different minerals. It also used for the identifying different crystalline materials. This technique is now mainly used for the study of the different crystal structures as well as atomic spacing. Now a day, it is a faster tool for geo-researcher to identifying minerals.During the process from the cathode ray tube the X rays are generated and then these rays are filtered to produce the monochromatic radiation, then it collimated and directed towards the samples. Then a detector detected the X-ray signal electronically or by micro processor which converted the signal to count rate. This principle is on the basis of Bragg's law ($n\lambda=2d \sin \theta$) where n is the integer, λ is the wavelength of X-ray, d is spacing between the interplanar spacing between the crystal and θ is the angle of incidence X-rays beam. (J.K. Flohr, 1997)

Figure 2 Schematic diagram of basic principle of XRD

3.4 XRF ANALYSIS:-

XRF is the analytical method to know the chemical composition the all kind of materials like in solid, liquid and powered form. And it sometimes used to determine the thickness of mineral and coated of the mineral. The method is fast, non destructive, accurate value and requires only a minimum sample preparation and its applications are broad metal, cement, oil, polymer, plastic, and food industries. Spectrometre system are generally two types 1.WDXRF- detected (Be- U)and 2. EDXRF detected (Na- U).

Figure3 Image of XRF (source-
https://serc.carleton.edu/research_education/geochemsheets/techniques/XRF.html

Chapter-4

Result and Discussion

4.1 XRD and XRF analysis-

From above methodology and analytical method, it is noticed that the semi-quantification percentage of the minerals from sample loc 1 to loc 22 from the XRD data which help to identified the varying in mineralogical composition according to their distance of the sample collected locations. And also found thatthe percentage of SiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, CaO, Na_2O, K_2O varied. The value of Chemical index of alteration and index of lateirtization varied along the weathering trend direction and their provenance of the river bed sediments, hich is also evident in ternary plots of A-C-NK&A-CN-KFM. The d-spacing [A] and 2Theta [deg] value of the particular mineral were identified by the help of ICDD library for each spectrum. And from the bivariant plot between the (SiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, CaO, Na_2O, K_2O) vs. river bed sediments collection distance, Chemical index of alteration vs. distance of sample collection and of each to understand the mineralogical distribution from upper region to lower part of the river mouth.

All the data of XRD and XRF are discussed below:-

(Table-4- Semi-quantification percentage of the mineral from XRD data)

SAMPL E NO.	Qu art z	Feld spa r	Mic a	Sti- bit e	Pyr- xene	cla y	Gibb -site	Ana- cime	Goeth -ite, syn	Carb onat e	Ot- ers
LOC-1	27	13	15	2	11	18	9	2	3		
LOC-2	10	7	11	1	5	45	17	1	2		
LOC-3	31	16	23		9	7	8	3	2	1	
LOC-4	43	6	34		3	9	2	1	1	1	1
LOC-5	36	5	7	2	28	13	5	1	2	2	
LOC-6	40	8	33		9	4	2	1	1		2
LOC-7	25	25	11	7	8	16	3	2	2		
LOC-8	26	12	43	3	5	7	2	1	1		
LOC-9	23	28	23	1	6	10	4	2	3		
LOC-10	25	13	8	2	11	10	21	4	4	2	
LOC-11	58	7	4	2	19		3	1	1	2	4
LOC-12	15	29	19	4	11	9	6	2	2	3	
LOC-13	31	2	42		17		1		1	1	
LOC-14	27	14	43	1	5	6	3	1	1	1	
LOC-15	26	33	26		4	7	2	1	1		
LOC-16	36	23	13		11	10	2	1	1	1	1
LOC-17	15	21			19	29	4	2	2		7
LOC-18	37	8	38	1	5	7	3	1	1	1	
LOC-19	11	26	35	2	8	9	4	1	3		1
LOC-20	12	8		7	3	40	17	2	4	2	
LOC-21	46	19		1	9	13	5	1	2	3	
LOC-22	35	7	45	1	4	5	2		1		

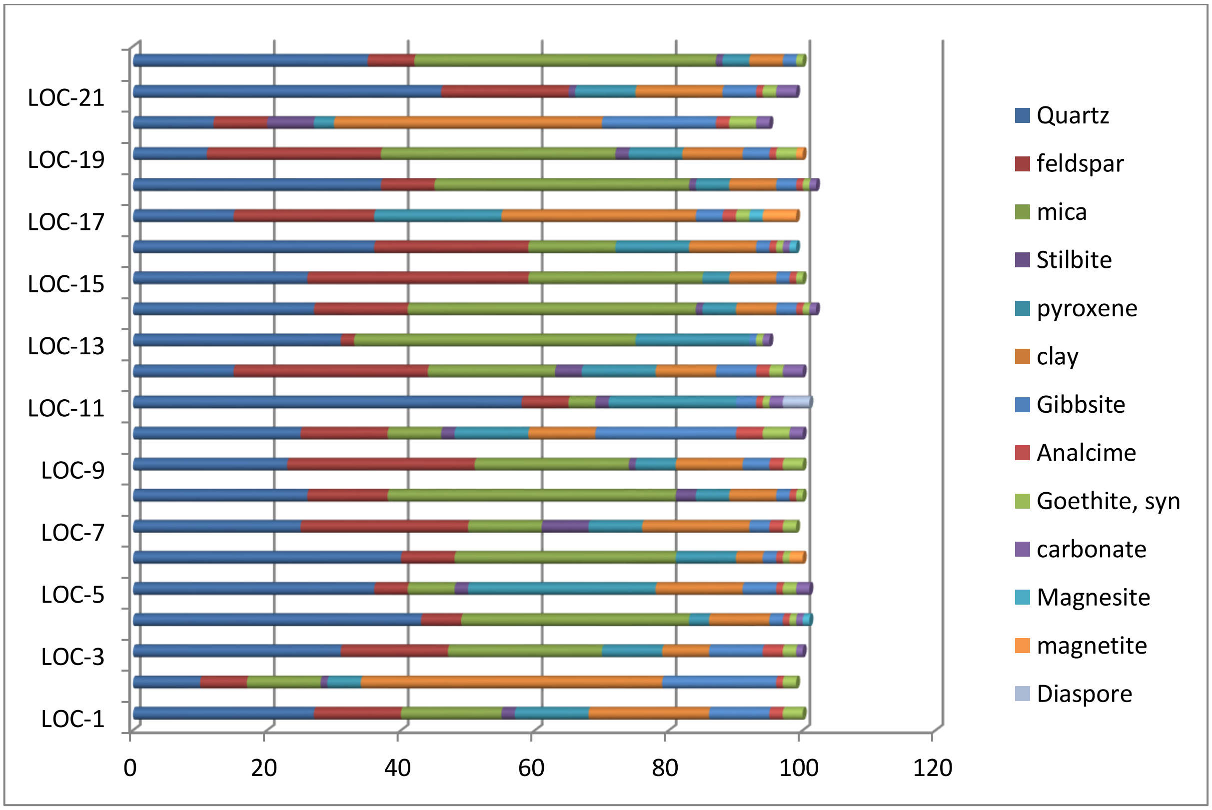
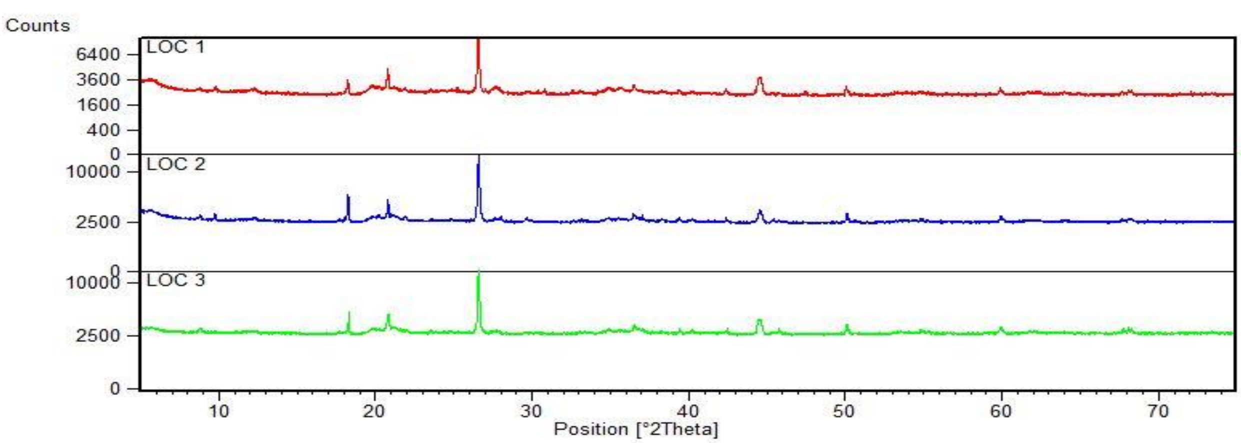


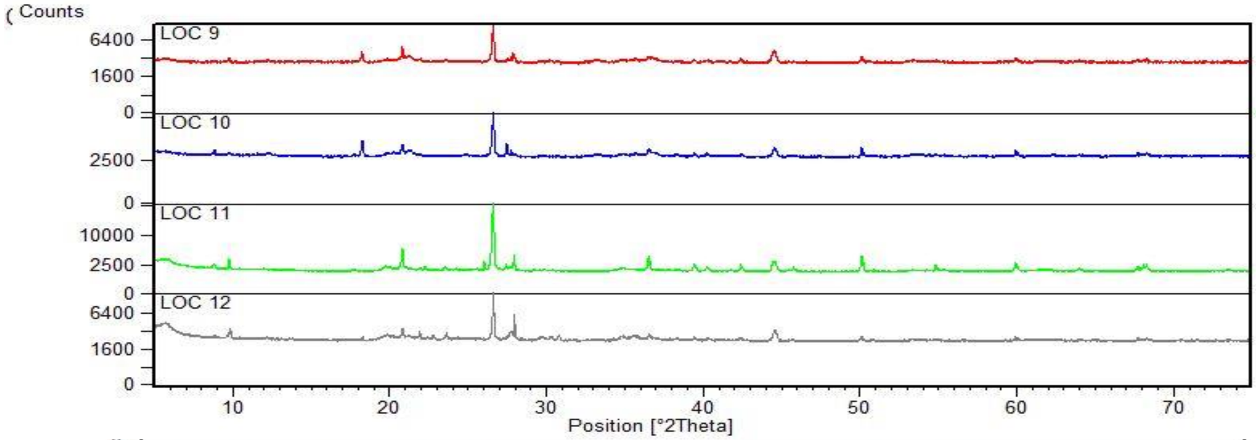
Fig-4 Graph plot of XRD mineral percentage

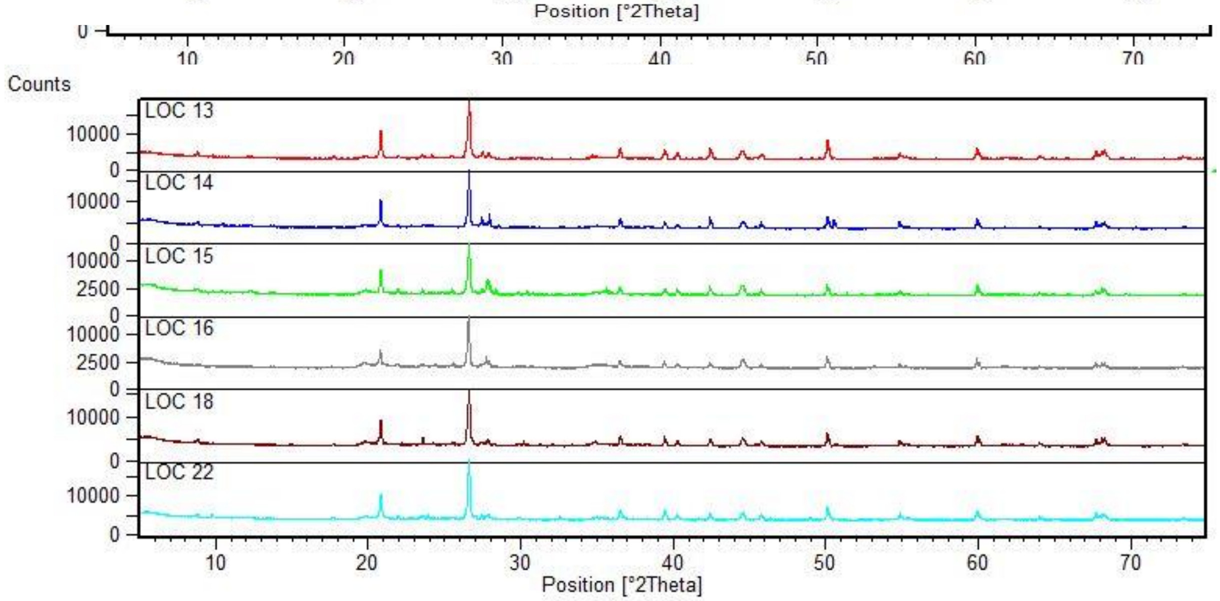
4.2 Comparison of XRD spectrum:-

(a)



(b)





(e)

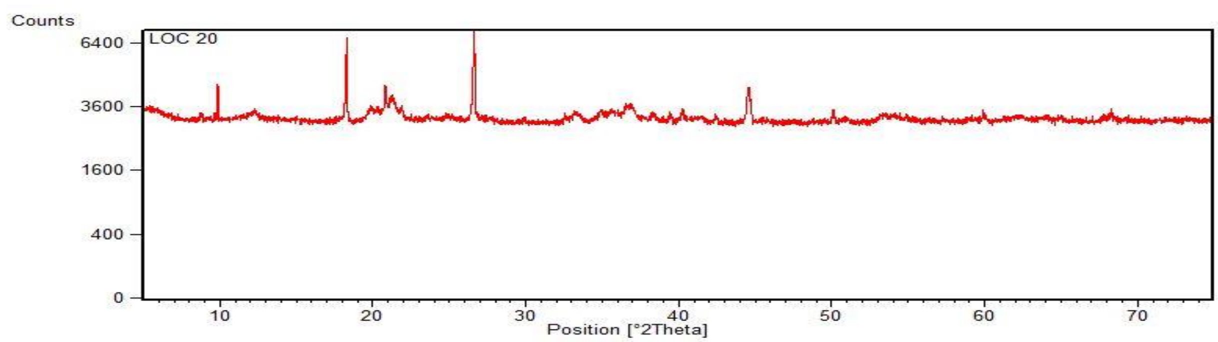


Fig-5.- (a) XRD spectrum comparison loc1-loc3, (b) XRD spectrum comparison loc-4,5,6,7,8,21 (c) XRD spectrum comparison loc-9,10,11,12 (d) spectrum comparison loc-13,14,15,16,18,22 (e) XRD spectrum loc-2

Table-5 XRD d[A] spacing and 2 Theta[degree]

LOC-1	d [A]	2Theta[deg]
Quartz	3.34924	26.593
Albite low	3.18802	27.965
Phlogopite (Fe-rich)	10.0192	8.819
Biotite	10.0788	8.767
Stilbite-Ca	9.0785	9.735
Clinoenstatite	3.00066	29.75
Kaolinite #1\ITA\RG	7.13149	12.402
Gibbsite	4.85273	18.267
Analcime	3.43	25.956
Goethite, syn	4.18964	21.189
Illite-1\ITM\RG [NR]	4.43	20.027

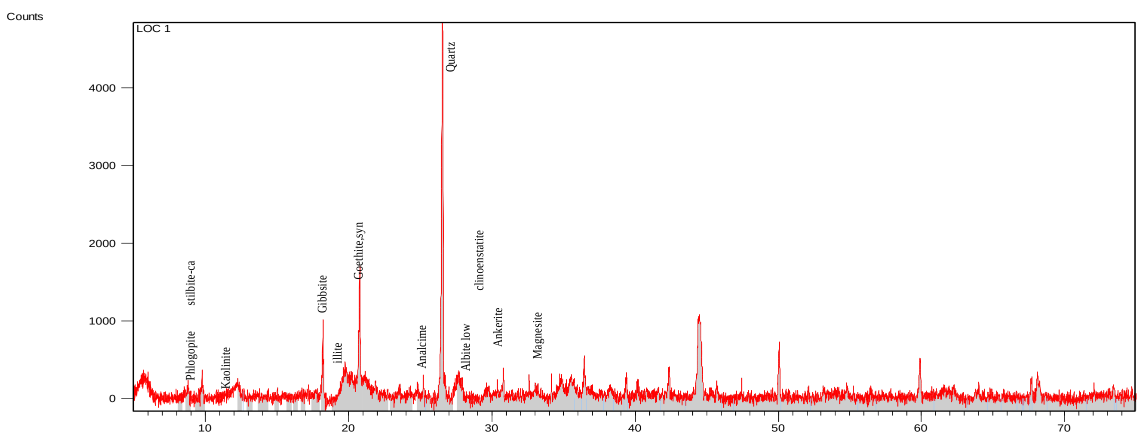


Fig-6 -XRD spectrum with their I=100% minerals peak value

Table- 6 XRF normalize value and adding some oxide minerals

Sample No.	K_2O	Al_2O_3	$CaO+Na_2O$	Fe_2O_3+MgO	Al_2O_3	$CaO+Na_2O+K_2O$
Loc 1	5.4187	75.8621	18.7192	39.403	45.9701	14.6269
Loc 5	7.3446	76.2712	16.3842	39.7959	45.9184	14.2857
Loc 10	4.5977	81.0345	14.3678	47.432	42.5982	9.9698
Loc 14	12.0567	67.3759	20.5674	31.5534	46.1165	22.3301
Loc 18	11.0465	75	13.9535	30.9237	51.8072	17.2691
Loc 20	4.3956	79.6703	15.9341	47.7011	41.6667	10.6322
LOC 20 RPT	4.3011	80.1075	15.5914	47.4576	42.0904	10.452

Table- 7 semi-quantity % of clay mineral

SAMPLE NO.	clay(%)
LOC-1	18
LOC-2	45
LOC-3	7
LOC-4	9
LOC-5	13
LOC-6	4
LOC-7	16
LOC-8	7
LOC-9	10
LOC-10	10
LOC-11	
LOC-12	9
LOC-13	
LOC-14	6
LOC-15	7
LOC-16	10
LOC-17	29
LOC-18	7
LOC-19	9
LOC-20	40
LOC-21	13
LOC-22	5

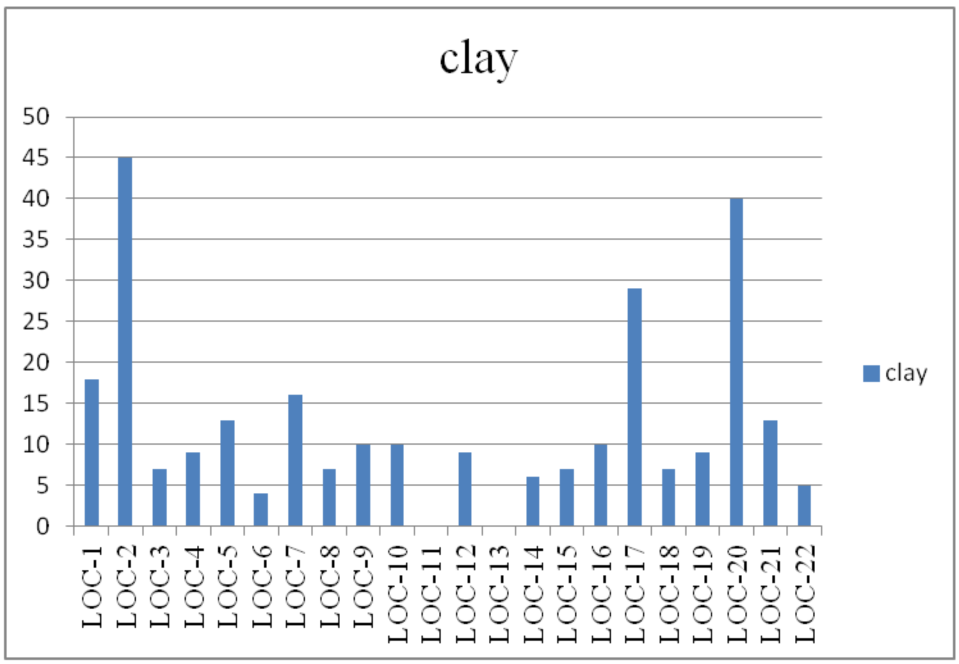


Fig-7 Graph plot of clays percentage

Table - 8- Value primary weight % of minerals and conversion of weight % to molar% value and CIA, CaO (%)+Na_2O, CaO(%)+Na_2O+K_2O, Fe_2O_3+MgO value

Sample Name	Loc 1	Loc 5	Loc 10	Loc 14	Loc 18	Loc 20	LOC 20 RPT	mole	sample name	Loc 1	Loc 5	Loc 10	Loc 14	Loc 18	Loc 20	LOC 20 RPT
SiO_2 (%)	50.3	53.8	44.37	62.22	59.76	45.234	45.63	60.08	SiO_2 (%)molar%	0.836	0.895	0.738	1.035	0.994	0.75	0.759
Al_2O_3 (%)	15.7	13.8	14.4	9.771	13.25	14.854	15.228	101.96	Al_2O_3 (%)molar%	0.154	0.135	0.141	0.095	0.129	0.145	0.149
Fe_2O_3 (%)	16.9	15.4	24.31	6.829	7.189	25.685	25.75	159.69	Fe_2O_3 (%)molar%	0.105	0.096	0.152	0.042	0.045	0.16	0.161
MnO (%)	0.17	0.37	0.66	0.1	0.14	0.63	0.63	70.937	MnO (%)molar%	0.002	0.005	0.009	0.001	0.001	0.008	0.008
MgO (%)	1.12	0.87	0.225	0.946	1.317	0.281	0.292	40.3044	MgO (%)molar%	0.027	0.021	0.005	0.023	0.032	0.006	0.007
CaO (%)	1.98	1.44	1.311	1.256	1.108	1.562	1.563	56.0774	CaO (%)molar%	0.035	0.025	0.023	0.022	0.019	0.027	0.027
Na_2O (%)	0.21	0.27	0.158	0.446	0.336	0.145	0.15	61.978	Na_2O (%)molar%	0.003	0.004	0.002	0.007	0.005	0.002	0.002
K_2O (%)	1.1	1.26	0.77	1.68	1.799	0.809	0.816	94.2	K_2O (%)molar%	0.011	0.013	0.008	0.017	0.019	0.008	0.008
									CIA	75.862	76.271	81.034	67.375	75	79.67	80.107
									CaO (%)+Na_2O	0.038	0.029	0.025	0.029	0.024	0.029	0.029
									CaO(%)+Na_2O+K_2O	0.049	0.042	0.033	0.046	0.043	0.037	0.037
									Fe_2O_3+MgO	0.132	0.117	0.157	0.065	0.077	0.166	0.168

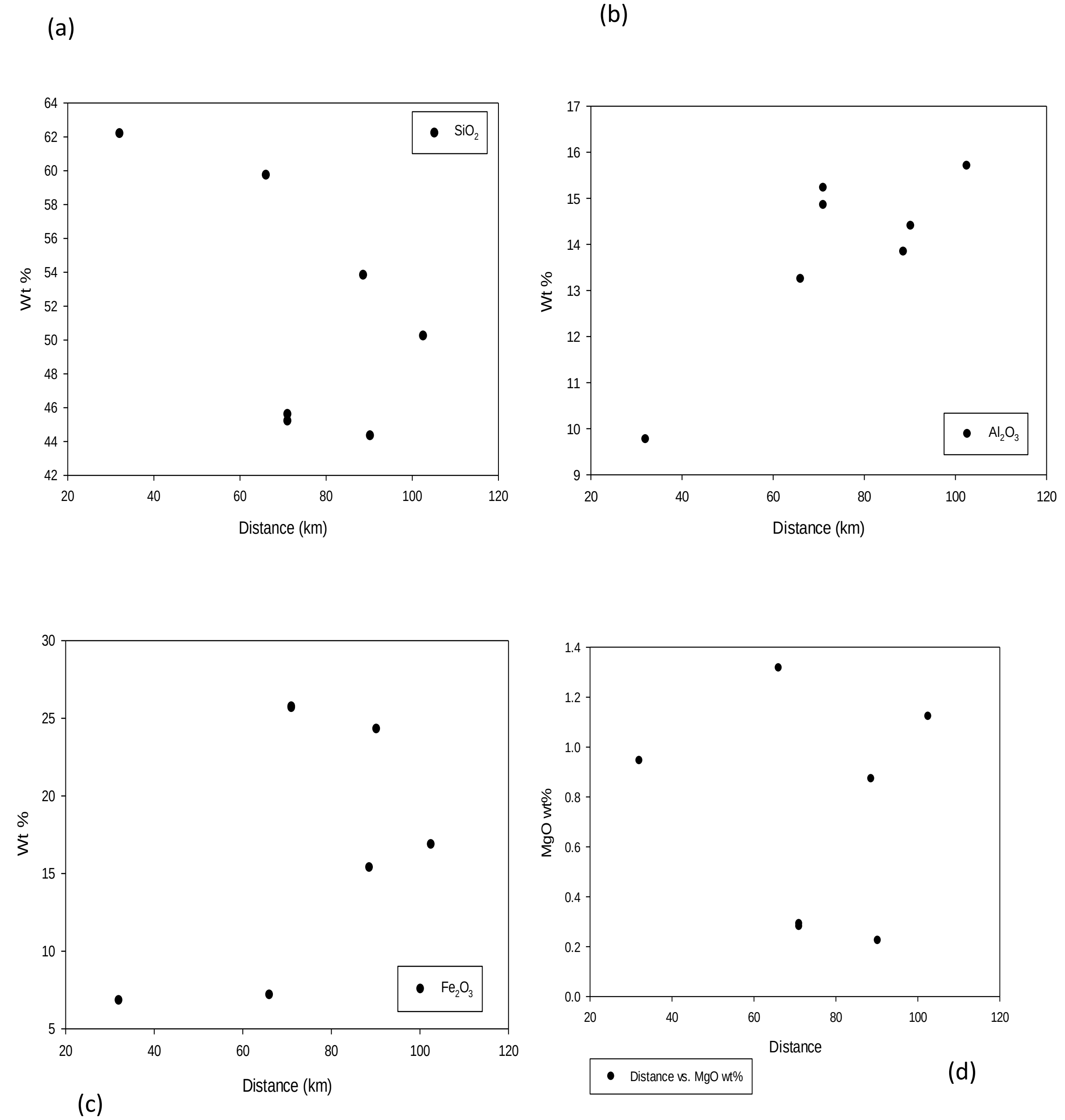


Fig-8 Bivariate scattered plot between Distance (km) vs..(a) SiO_2,(b) Al_2O_3, (c)Fe_2O_3, (d)MgO

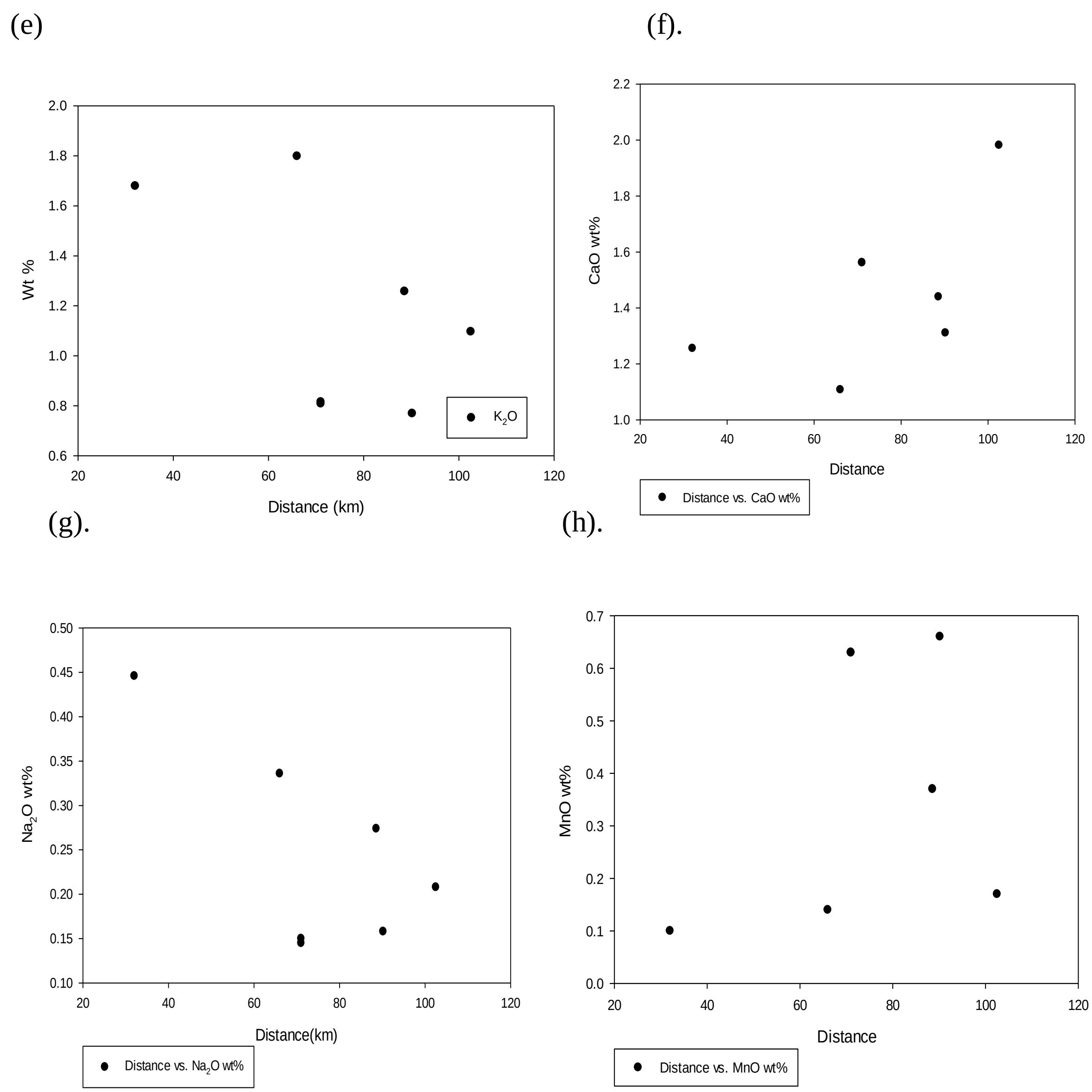


Fig- 9 Bivariate scatter graph plot between distance(km) vs.(e)K_2O,(f)CaO,(g)Na_2O,(h)MnO

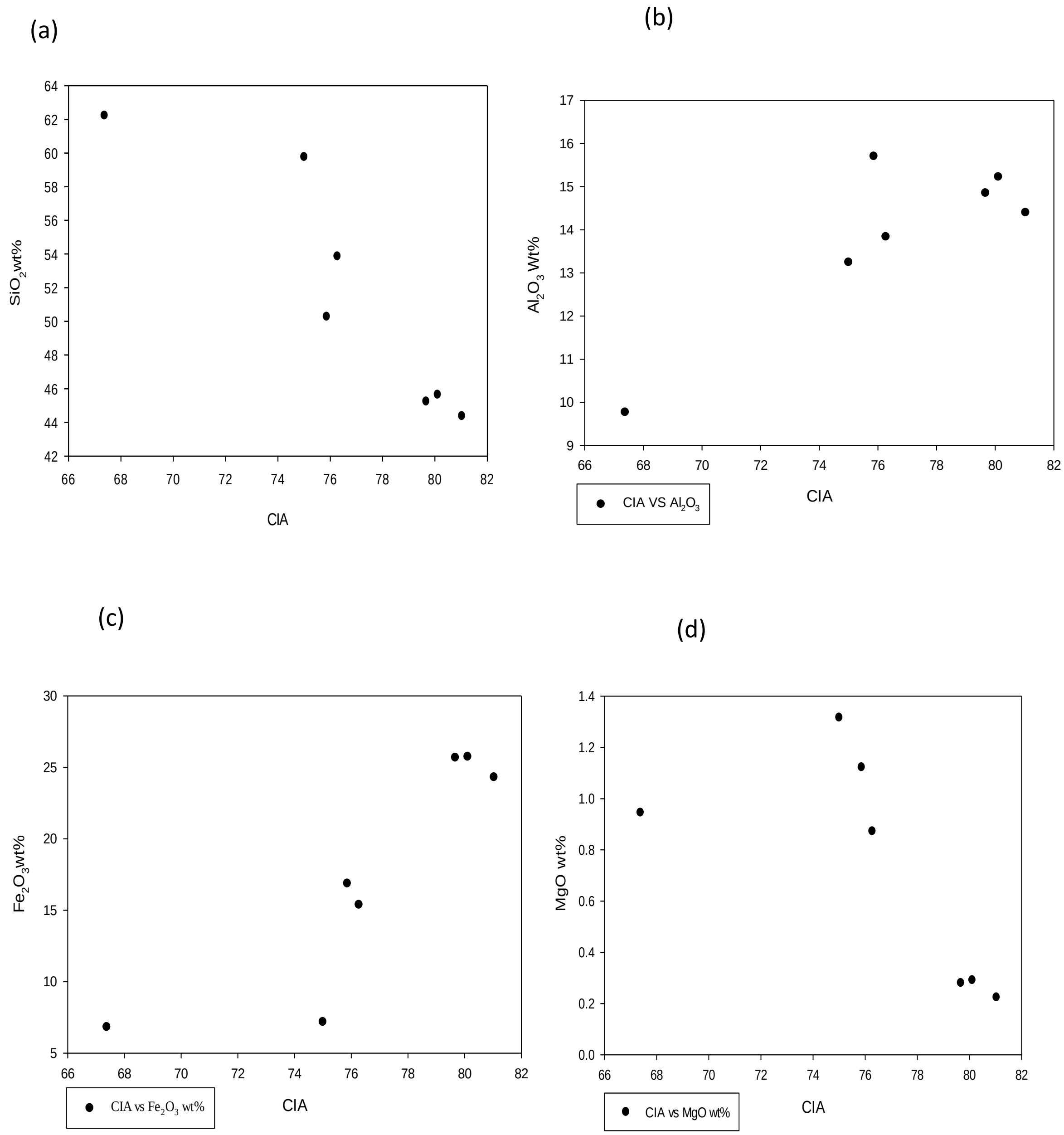


Fig- 10-Bivariate scatter graph plot between Chemical index of alteration (CIA) vs.(a) SiO_2,(b) Al_2O_3, (c)Fe_2O_3, (d)MgO

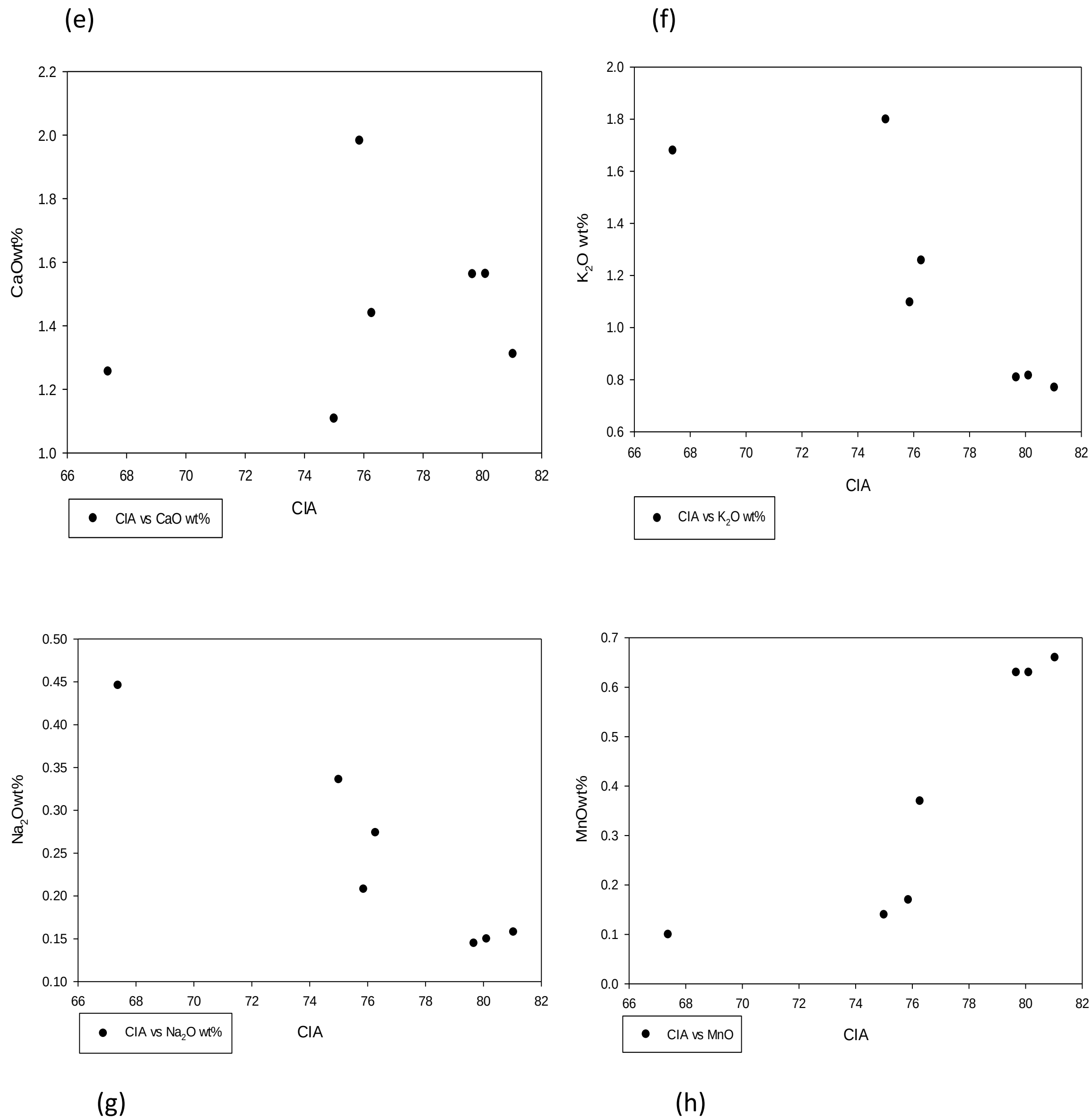
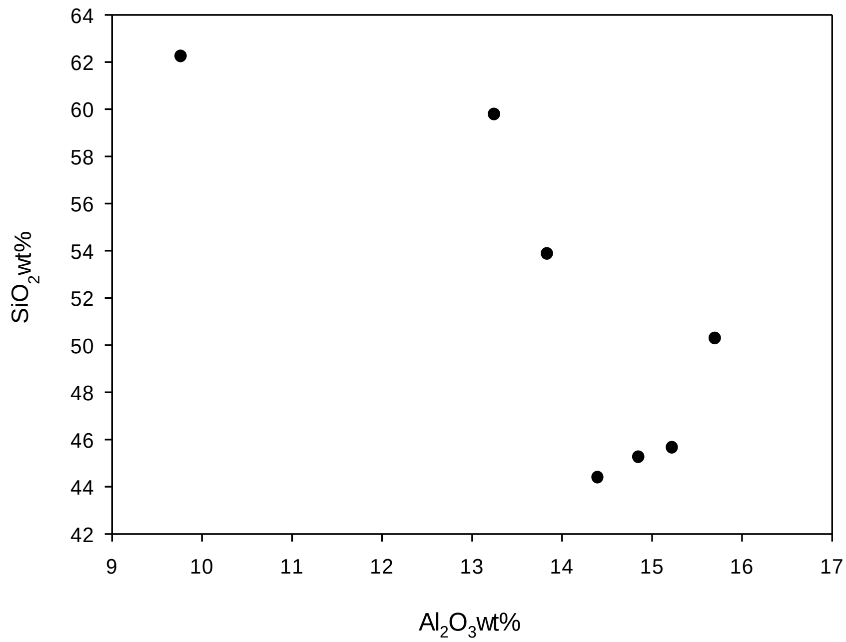


Fig- 11 Bivariate scatter graph plot between Chemical index of alteration (CIA) vs. (e) CaO, (f)K_2O, (g) Na_2O, (h) MnO

(a)



(b)

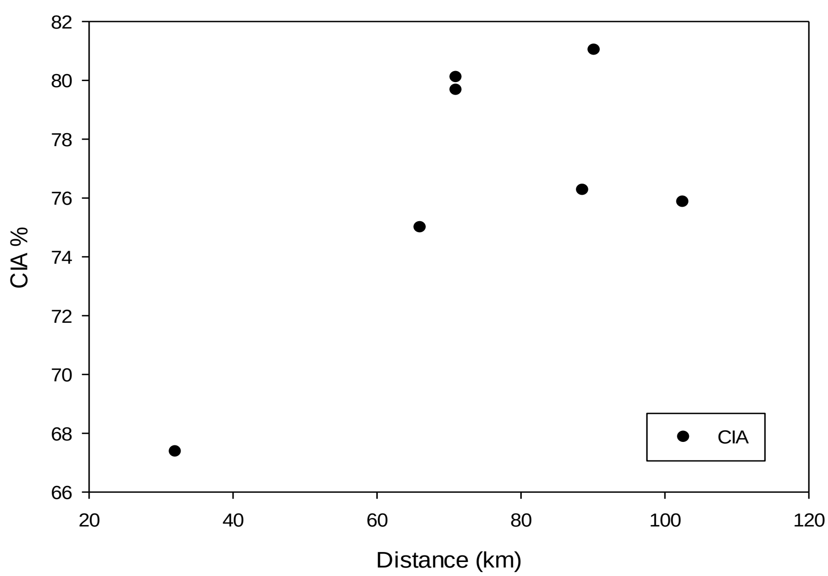


Fig- 12 Bivariate scatter graph plot between (a)Chemical index of alteration (CIA) vs. CIA% (b) CIA % vs. Distance(km)

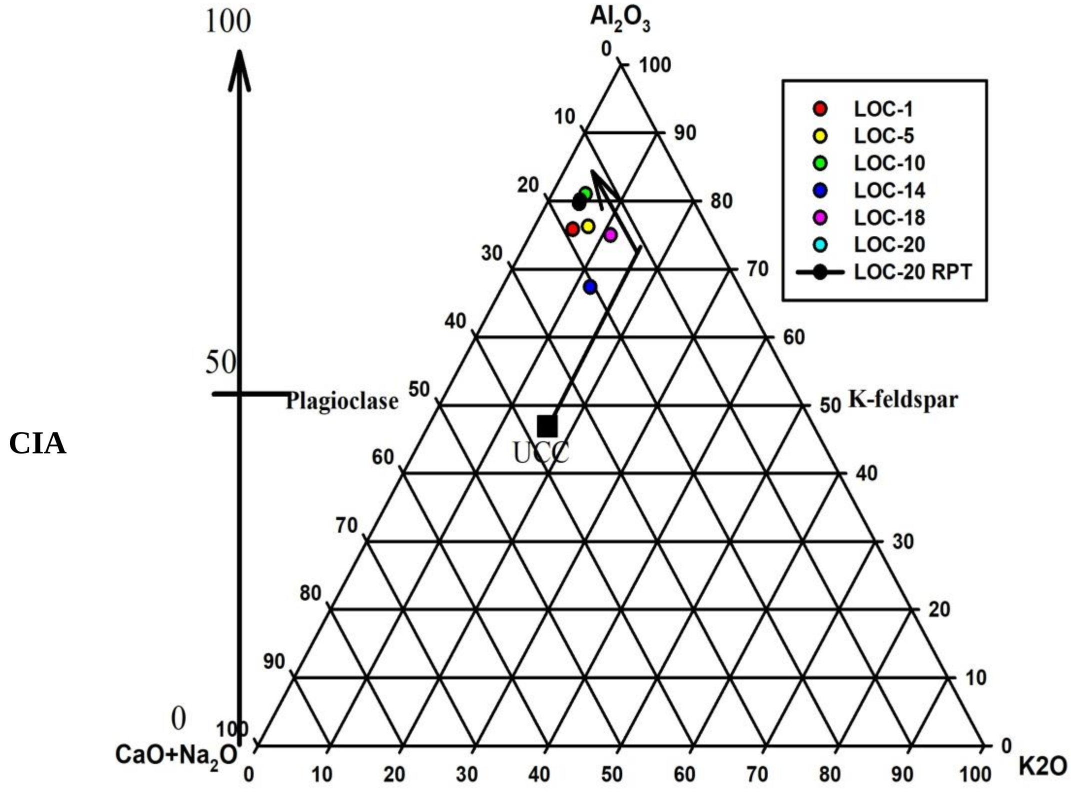


Fig-13 Ternary diagram of A-CN-K

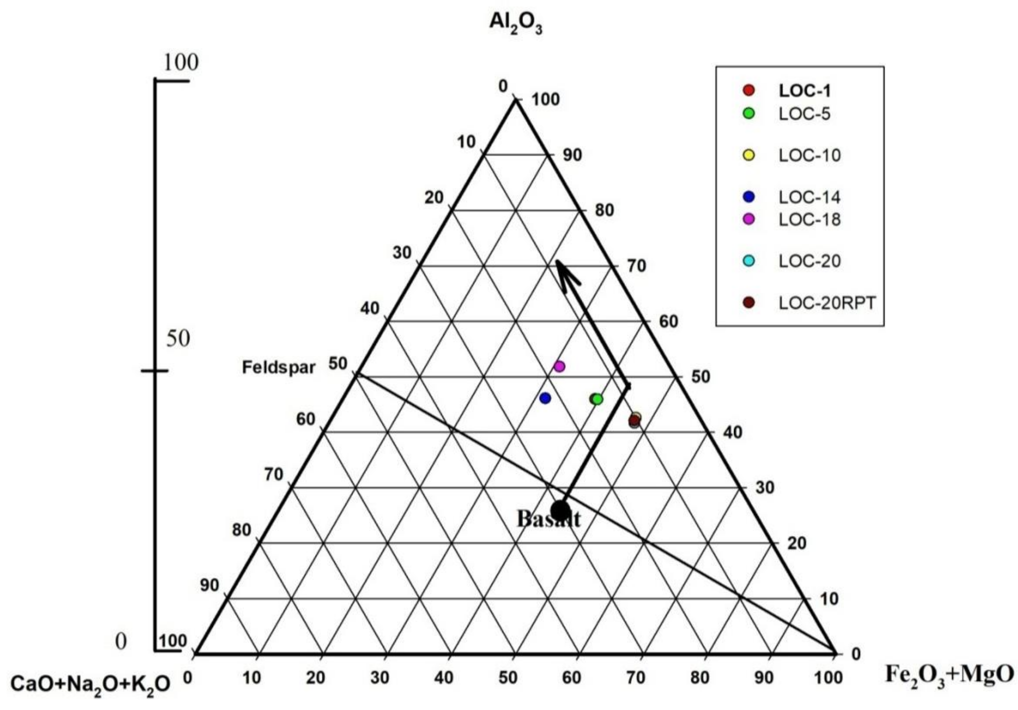


Fig- 14 Ternary diagram A-CNK-FM

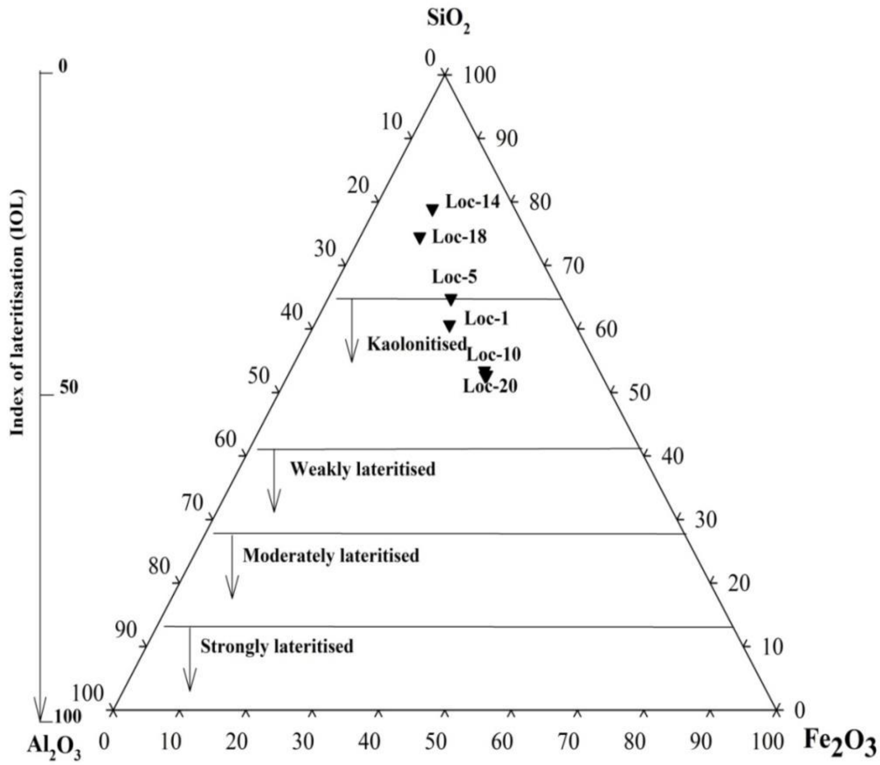


Fig- 15- Ternary diagram of Index of lateritization (IOL) between SiO_2, Al_2O_3, Fe_2O_3

6. Discussions:-

Homogenized powered sediment samples were analyzed as per the details given in the methodology sections. Using X-pert high score software XRD spectrums were analyzed to semi-quantify and to identify different mineral phase present in the samples. Using this method, precise quantification is not possible but it will provides estimates about minerals present in the sediments. From the above **table-4** the semi-quantification or the percentage of the minerals are indicated with the help of X-pert high score. Generally quartz, feldspar group mineral like albite, anorthite, orthoclase, pyroxene group minerals like enstatite, clinoenstatite, goethite synthetic, mica like muscovite, biotite, phlogopite, zeolite minerals like analcime, carbonate minerals ankerite, gibbsite, clay minerals kaolinite, iilite. Some magnetite, magnesite minerals were also identified. The XRD data of the bedload sediments are mainly rich in mineral likes kaolinite, pyroxene, stilbite, clinoenstatite, gibbsite and olivine. From the bedload sediments, the minerals are same the only difference in the quantity from weathering profile to bedload sediments. The clay minerals mainly formed by loss of silica from weathering profile that are rich in alumina silicates. Kaolinite formed by loss of silica and separation of Al and Fe from Feldspar. The further loss of silica converts the kaolinite to gibbsites.

Feldspar – *(loss of Si) →kaolinite – (loss of Si) →gibbsite(Al(OH)*$_3$)

The bedload sediments are also contain the same minerals as the above except Ankerite and stilbite. The clay mineral generally increases from profile to bed load sediments and their formations illustrated by reaction given below-

Metals in minerals are exchanged by H^+ with cations release as metal cations (K^+,Ca^{2+},Na^+. etc) and potential formation of a new clay mineral (kaolinite, smectite,etc.) retained from ions (Al^{3+},O^{2-},Si^{4+}).

$$\text{K-Feldspar} + H^+ = \text{Kaolinite} + K^+ + H_2SiO_4$$

Weathering of Na-feldspar (albite) to kaolinite*: albite + carbonic acid + water →* sodium ion + bicarbonate ion + silicic acid + kaolinite

$$2NaAlSi_3O_8 + 2H_2CO_3 + 9H_2O \rightarrow 2Na + 2HCO_3 + 4H_4SiO_4 + Al_2Si_2O_5\,(OH)_4$$

From the XRD data, for this study mainly indicated the clay minerals in the bed load sediments due to the weathering of the basalt outcrop in this region. Quartz mineral is mostly prominent, from loc1 to loc22 but the quartz percentage is high in loc-4, 6, 11, 21 is due to the intense weathering and the water flow speed in river. Zeolite, gibbsite, carbonate, stilbite, pyroxene, goethite minerals were less in quantity, due to the high intensity of weathering. But some location-2,10,21,17 , the gibbsite percentage is high, quartz (loc-4,6,11,21), feldspar, mica and clay minerals(loc-2,17,20) are high in percentage. Whereas pyroxene percentage is very less and some location (loc-5, 11, 13, 17) percentage is high due to the weathering intensity, speed of flow of water, water drained from different catchment region to different region.

From the XRD comparison data from **(fig-5)** the mineral assemblage associated with various locations are compared with one another to understand the variability in semi quantity (%) of the mineral changes from one location to another. From location 1-location 22 the clay minerals are prominent. Quartz is the dominant assemblage due to its high resistance to weathering. Due to the lateralization process some iron rich minerals like Goethite forms. Bedload sediment mainly rich in feldspar group of mineral which undergoes weathering to form kaolinite by loss of silica and whenever there is further loss of silica the alumina-silicate mineral like gibbsite are formed. As the provenance of the area is mainly basaltic nature, the mineral like enstatite, albite, anorthite are found in many. The comparison to total locations, the mineral like quartz, feldspar, clay, plagioclase are prominent with respect to their weathering index and some samples are rich in clay minerals which shows the action of weathering is higher in that location. XRD spectrum comparison **figure-5** (a),(b),(c),(d) and (e), the bedload sediments shows the variation in their mineralogical composition. The important minerals such as quartz, Na & Ca-plagioclase, k-feldspar, pyroxene, muscovite, phlogopite, clay minerals such as kaolinite, illite are identified from the river sediments. During the chemical weathering the least resistant minerals are weathered and resistant minerals found to be enriched in the sediments. However in the present study, minerals like Ca-rich plagioclase, pyroxene and the presence of clay minerals indicates the lower degree of chemical weathering in the catchment area.

Geochemical composition:-

From the table 7 and 8 indicates their compositions are in weight percentage and the component required for various ternary diagrams. With the help of sigma12 application, the bivariate plots and ternary diagram were drawn.

Figure 8 & 9**,** Bivariate plot between distance(in km) vs. different oxide weight % SiO_2, Al_2O_3, Fe_2O_3,MgO, K_2O, CaO, Na_2O, MnO. In the case of SiO_2 , it increased from upper bed load sediment to the lower bed load sediment, according to the increasing of the distance the quartz% is decreased due to the high resistance to the weathering. In Al_2O_3, the percentage is decreased from upper region of the stream bed load sediment to the lower region of the bed load sediment. It is due to its content of alumina-silicate mineral which is less resistance to weathering and alteration. The Fe_2O_3 and MgO weight percentage is decreased according to their distance of transportation of the stream bed load sediment from upper region to lower region of the river mouth.

The oxide % of the different elements mainly depends upon hydration and hydrolysis action of the chemical reagents like water with respects to the mineral abundance in the bed load sediments. In some cases the oxide % generally increases from higher regions to lower regions. In case of K_2O, it increased towards river mouth from upper regions, firstly K binds with clay minerals after some specific period, it released due to the action of rivers. CaO is weathered and decreased towards river mouth as the Ca rich minerals are highly susceptible to weathering. Clay minerals generally decreases in lower ridge and increases in upper ridge, this is mainly due to the action of river which is maximum in mouth as compare to the upper regions. At location 10 and 20 the clay % is high and Na_2O wt. % increases towards river mouth from the upper regions.

The CIA value shows that the significant variations in major elements concentration with distance from source, and these variations are related to weathering indices of the bed load sediments. The above graph indicates the variations of CIA with respects to the various oxide wt. %. Al_2O_3, Fe_2O_3, MnO. It increases with respects to their CIA and SiO_2, CaO, K2O,Na2O and MgO decreases with the increase in CIA value. At the upper part of the regions gibbsite and clay % is high, so CIA value higher in upper regions rather than the lower regions.

A-CN-K diagram, fig-13, the calcic, sodic and potash rich oxide weathered very fast in the upper continental crust. After certain point above UCC, the weathered sample comes in contact with feldspar which tends to decrease in silica to form clay rich mineral and after a certain extent it further loses silica to form the alumina silicate minerals which indicates the trend of weathering.

A-CNK-FM diagram, fig-14 the trend of weathering is towards alumina silicate minerals because the source rock of this area is mainly covered by basaltic rock type. The river sediments mainly contents the sediments that are draining from weathering profile which are covered by basaltic rock. Whenever basalt goes weathering, the loss of silica from feldspar leads to form alumina silicate assemblage.

SAF diagram, fig-15 and index of lateritisation (IOL) between SiO_2, Al_2O_3, and Fe2O3 shows the process of formation of lateritic assemblages. These samples overlies within the kaolinisation field. Some of them are below kaolinisation field. Only four samples are beyond this limit, which shows small decrease in silica at that site.

Chapter-5

Conclusion

Based on mineralogical and geochemical analysis of bed load sediments, following conclusions were drawn.

- The mineral compositions of the river bed load sediments from different locations shows quartz, plagioclase (albite-anorthite), pyroxene group minerals like enstatite, clinoenstatite clay minerals such as gibbsite, kaolinite, illite, goethite and clay micas, are dominating minerals whereas orthoclase, muscovite, biotite, phlogopite, zeolite minerals like analcime, carbonate minerals ankerite, magnetite are found in minor amount.
- Clay mineral percentage is higher in the upper reaches compare to thelower reach of the river.
- Clay mineral gibbsite and kaoline indicate the removal of silica is higher in the upper reach and shows kaolintization, latrtization and upto some degree of Bauxitization process is active in the upper reach.
- CIA value, A-CN-K, A-CNK-FM ternary diagram indicate the intensity of weathering is moderate to high at different location.
- The index of lateritization shows clear indication of kaolintization → latrtization → Bauxitization process.
- As the river is draining a mono lithological terrain the weathering type and its intensity shows the alteration of basaltic rock.

Future work – More geochemical work such as trace and rare earth element is required to understand the catchment scale denudation and type. In addition to bed load , suspended load and dissolved load needs to be analyzed for understanding catchment scale denudation.

REFERENCES:-

1. S.Sensarma, V.Rajamani, JayantK.Tripathi, 2008:Petrography and geochemical characteristics of the sediments of the small River Hemavati, Southern India: Implications for provenance and weathering processes.(111-124)

2. S. Krishnaswami, and Sunil K. Singh Physical Research Laboratory, Navrangpura, Ahmedabad 380 009,2005, India Chemical weathering in the river basins of the Himalaya, India(841-848)
3. D. Bakkiaraj, R. Nagendra, R. Nagarajan,John S. Armstrong-Altrin 2007 Geochemistry of sandstones from the Upper Cretaceous Sillakkudi Formation, Cauvery Basin, southern India: Implication for provenance
5. Sarin, M. M.; Krishnaswami, S.; Dilli, K.; Somayajulu, B. L. K.; Moore, W. S.,1 998 , Major ion chemistry of the Ganga-Brahmaputra river system: Weathering processes and fluxes to the Bay of Bengal.

6. Shaik A. Rashid , Javid A. Ganai, Ather Masoodi, Fareed A. Khan,2005; Geochemistry of Mansar Lake sediments, Jammu, India: Implication for source-area weathering, provenance, and tectonic setting

7. Brijraj K. Dasr ,Birgit-Gaye HaakeGeochemistry of Rewalsar Lake sediment, Lesser Himalaya, India: implications for source-area weathering, provenance and tectonic setting
8. Ishtiaq Ahmad, Rakesh Chandra,2012: Middle to Late Pleistocene loess-paleosol sediments of Kashmir Valley, India

9. Nath, B. N., Kunzendorf, H., Pluger, W.L., 2000. Influence of provenance, weathering and sedimentary process on the elemental ratios of the fine-grained fraction of the bedload sediments from the Vembanad Lake and the adjoining continental shelf., Southwest Coast of India. J.Sedi.Res.70, 1081-1094.

10. Nesbitt, H. W., Young, G. M., 1984. Prediction of some weathering trends of plutonic and volcanic rocks based on thermodynamic and kinetic considerations. GeochimcalCosmochim. Acta 8, 1523–1534.

11. Nesbitt, H.W., Young, G.M., 1996. Petrogenesis of sediments in the absence of chemical weathering: effects of abrasion and sorting on bulk composition and mineralogy. Sedimentology 43, 341–358.

12. Pandey, S., and Parcha, S.K., 2017. Provenance, Tectonic Setting and Source-Area Weathering of the Lower Cambrian sediments of the Parahio Valley in the Spiti Basin, India. J. Earth Syst. Sci. (2017) 126: 27. DOI 10.1007/s12040-017-0803-5.

13. Sari, A., Koca, D., 2012. An approach to provenance, tectonic and redox conditions of JurassicCretaceousAkkuyu Formation, Central Taurids, Turkey. Mineral Research Exploration Bulletin 144, 51-74.

14. Sharma,A, Sensarma,S, Kamlesh K, Khanna, PP, Saini, N.K,2013. Mineralogy and geochemistry of the Mahi River sediments in tectonically active western India: Implications for Deccan large igneous province source, weathering and mobility of elements in a semi-arid climate, GeochimicaetCosmochimicaActa 104 (2013) 63–83

15. Ramachandran, A., Madhavaraju, J., Ramasamy, S., Lee, Y.I., Rao, S., Chawngthu, D.L., Velmurugan, K., 2016. Geochemistry of the Proterozoic clastic rocks of KerurFormation of Kaladgi-Badami Basin, Northern Karnataka, South India: Implications for paleoweathering and provenance. Turkish Journal of Earth Sciences, 25, 1503-4.

16. Bhatia, M.R., Crook, K.A.W., 1986. Trace element characteristics of graywackes and tectonic setting discrimination of sedimentary basins. Contrib. Mineral. Petrol. 92, 181–193.

17. Borges, J.B., Huh, Y., Moon, S., Noh, H., 2008. Provenance and weathering control on river bed sediments of the eastern Tibetan Plateau and the Russian Far East. Chem. Geol. 254, 52–72.

18. Nichlos,2008, principle of Sedimentology and Statigraphy p.n 139

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