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Heavy Mineral Studies of Beach Sands of Vagathor, North Goa, India

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Abstract: *Vagator beach is situated 22 km away from panjim on the northern side Bardez taluk approachable via Candolim are Mapusa by road. The beach is projected on both the sides by promontories. The beach is in arcuate shape, the area included with survey of India toposheet No 48/E/14 which is bounded by latitudes 15º35'N 15º38'N and longitude 78º43'E. The Chapora river and its tributaries drain the entire region that is the Vagator beach. It flows from North-East to South-West direction. The drainage pattern is structurally controlled; the Chapora River has its source in the Ramghat hills of Belgaum district in Karnataka then it flows through the Thilari ghat and enters Goa. Its length in Goa is about 31 km and the mouth of the river bank, mud bank and mangroves swamps are common.*

In laboratory techniques heavy mineral separation are based mass separation in a liquid with specific gravity and magnetic separation using hand magnet and Frantz isodynamic separator at different volts. X-ray analysis was carried out by using RIGAKU ALTIMA IV copper target on the basis of Bragg's law. The non magnetic sand grains was observed under optical microscope to identify diagnostic properties of minerals.

The heavy mineral shoot comprises of opaque (magnetite and illmenite) and transparent heavy minerals like hornblende, epidote, garnet, rutile, zircon, enstatite and minor amounts of tourmaline. The light minerals are mainly quartz and feldspars. The magnetite concentration ranges between 2.01 to 56.86% and Ilmenite between 2.83 to 41.04% and non mangnetics between 1.18 to 44.81%. X ray diffraction studies and SEM (Scanning electron microscope) studies were employed to study the mineralogical composition of beach sands of Vagator and detailed investigations are dealt in the paper.

I. Introduction

Throughout the human history, oceans have serve as a source of food and valuable minerals helps in trade and commerce. Beaches are interfaces of oceans and land, dynamic landforms altered continuously by wind and waves undergo creation and erosion. Beach formation begins with the accumulation of eroded continental material like sand, gravel and cobble fragments. River and stream action process result the deposition. Most of the sediments is suspended in sea water and transported along the coast by the long shore current. A stream of water flowing parallel to the beach that is created by the action of waves breaking at an angle to shore

A beach is a geological land form along the shoreline of an ocean usually consists of loose particle often composed of rock such as sand, gravel, shingle, pebbles, cobblestones among them are economically important heavy mineral placers. Most of the placers are exploited as commercial use and these deposits have been formed by mechanical concentration of detrital mineral particles in subaqueous environments. The term beach may refer to small system the rock material moves onshore, offshore or along the shore by forces of waves and currents or geological units of considerable size. These geomorphic features composed of beach profile, it can changes in wave energy experienced during seasonal variations. The drift line is one of the potential demarcations which significant wind movement of sand occur and move inland under assault by storm waves. The shape of the beach depends on whether constructive or destructive may be sand or shingle. The present study of Vagator beach situated along southern part of Chapora river mouth contains appreciable quantities of heavy mineral sand with high specific gravity.

II. The Aim Of The Study Is To Investigate

1. To determine the grain size characters, Mineralogy and grain morphology to understand the environment of deposition and the nature of sediments in the area.
2. To quantify the various mineral components with special emphasis on heavy mineral content.
3. To estimate the heavy mineral resources of the area.
4. To decipher the source of these minerals through mineralogy and transportation history of surficial textures.

The Chapora river and its tributaries drain the entire region of the Vagator beach. It flows east to south direction. The drainage is well developed and structurally controlled and the length of the river in about in Goa is 31 km running through Pernem and Bardez talukas of North Goa, at the estuary of Vagator beach in the Morjim village. At the mouth of the river bank mud banks and mangroves swamps are common (Iyer and Wagle, 1987).

Goa is dominantly covered by the rocks of the Goa group belongs to the Dharwar super group of Archean – proterozoic age, except a narrow strip along the north eastern corner occupied by the Deccan traps of Upper cretaceous to lower Eocene age. The Goa group consisting of green schist facies of metamorphic rocks and divided into the Barcem formation, Sanvordem formation, Bicholim – Rivona formation comprises basic and acid metavolcanics associated with Meta – tuffs of Meta sediments. The Sanvordem formation made up of meta-greywacke, tilloids and argillites, the Bicholim – Rivona formation representing metapyroclasts and tuffs with calcareous, manganiferrous and ferruginous chemical precipitates. The Vageri formations consist of meta greywacke and meta basalts. The early Proterozoic included acid and basic intrusive, the Goa group of rocks have been intruded by granite, felpathic gneiss, hornblende granite and basic intrusive and over laid by Deccan traps represented by massive and vesicular metabasalt in the north eastern corner of the area.

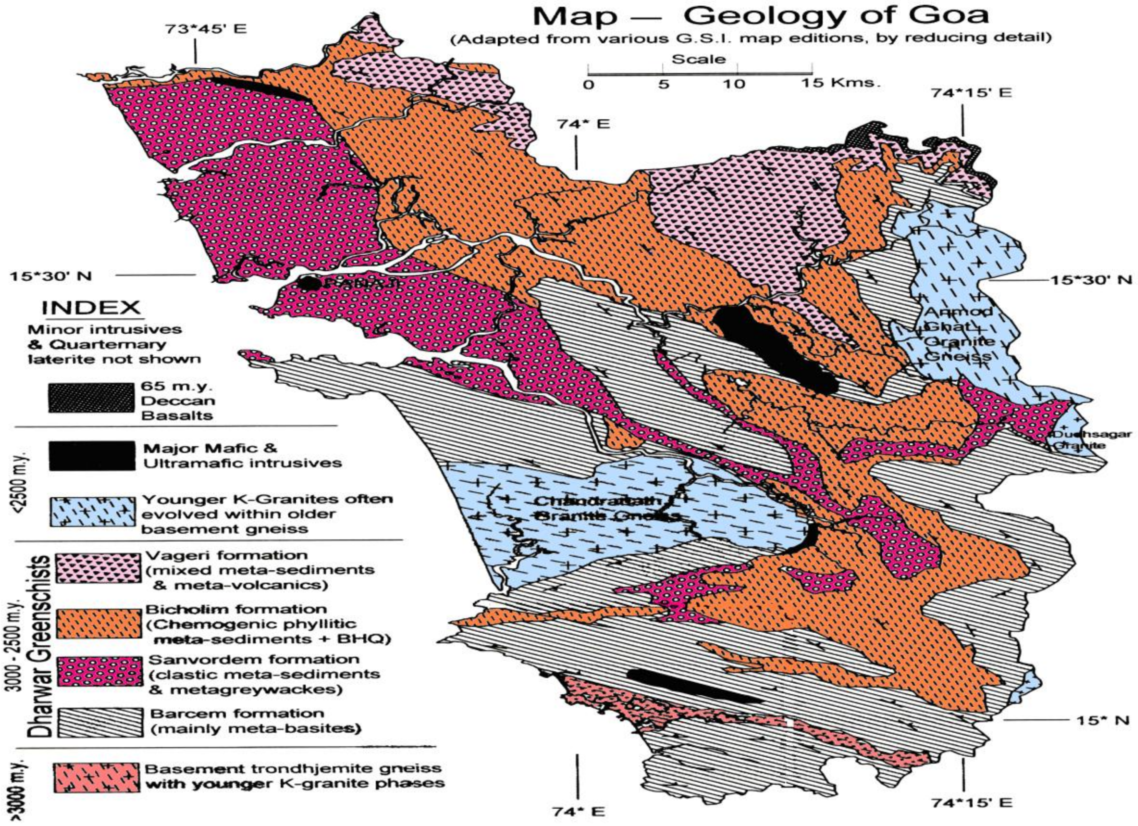
Fig.1 Satellite imagery of study area, Chapora-Vagator, Goa

Era			Formation	Rock types
Sub-recent to recent				Sea sand, alluvium, laterite
Sub cretaceous to lower Eocene			Deccan Trap	Basalt
Proterozoic			Basic Intrusive	Dolerite, Gabbro
			Acidic Intrusive	Pegmatite vein, Quartz, Porphyritic Granite, Hornblende Granite, Felspathic Granite, Granite Gneiss
ARCHEAN TO PROTEROZOIC	DHARWAR SUPER GROUP	GOA GROUP	Vageri Formation	Metabasalt, Metagreywacke.
			Bicholim Formation	Banded ferruginous Quartzite, Manganiferous Chert, Breccias with Pink ferruginous Phyllite, Limestone, Pink ferruginous phyllite, Quartz-Chlorite-Amphibolite schist
			Sanvordem Formation	Argillite, Quartzite, Tilloid Metagreywacke.
			Barcem Formation	Metagabbro, Peridotite, Talc – chlorite schist, Variegated phyllite, Quartz – chlorite schist, Red phyllite, Quartz porphyry, Massive Schistose and Vesicular & Metabasalt.
(>3000 Ma)	Basement Trondhjemite Gneiss			

Table.No.2. Chronostratigraphic sequence of Goa

III. Heavy Mineral Studies

Heavy minerals or placers are mineral deposits have been formed by the mechanical concentration of detrital mineral particles in subaqueous environments, occurs at river banks, lakes and ocean floor. They usually originate from primary igneous or vein minerals which are liberated from the breakdown of their parent rocks. Most of the placers are high specific gravity grater then 2.85 and are resistant to chemical breakdown otherwise they would not have survived the erosion, transportation and depositional processes that took place prior to their concentration. Important placer minerals include elements in their native state such as gold, platinum, and diamond and resistant minerals are cassiterite, ilmenite, rutile, zircon, monazite, garnet, magnetite and corundum (Dunham, 1969).



Despite their small amount of great value in studying provenance, transportation and weathering history of a sediment in correlation with paleosediment studies. They represent the accessory and varietal minerals of igneous and metamorphic rocks which are reduced in quantity as they passed into sediments because they are chemically unstable, considerably softer than quartz. The heavy minerals as a sediment is function of various factors like lithology of the region, stability of minerals during movement from the source rock. The Movement of heavy minerals from one place to another place along its course is dependent hydraulic factor, specific gravity, the amount of distance travelled from the source rock. During its movement the distribution of heavy mineral may lead to change in mineral ratio of the deposition is depending on the velocity of the water.

The concentration of heavy mineral occurs in river banks, beaches, offshore areas and river draining areas, the energy level in the river drops to allow the placers to settle. The formation of placer mineral deposits on beaches results essentially form the selective sorting of the intertidal zone by wave current action with the velocity of the backwash is sufficient to remove the light mineral and leave the heavy minerals. According to (Emery and Noakes 1968) modern beaches probably represent the optimum conditions of light and heavy minerals.

In the present studies using laboratory techniques for heavy mineral separation are based on mass separation in a liquid with specific gravity between the specific gravity of the light and heavy minerals. It is based on the principal of gravity settling and bromoform is used with a specific gravity of 2.89. The other heavy liquids are tetrabromoethane, methylene iodide and clerici solution. The sample is washed, treated with HCL and sieved accurately into three size fractions. Each sample is poured into a separating funnel which contains bromoform. The heavy minerals settle to the bottom while the lighter ones float, they collected separately on a filter paper, (Rubbey 1933) showed that the grains of heavy minerals are hydraulically equivalent to light mineral grains of some larger size depending upon the specific gravity of the heavy minerals and heavy mineral suits therefore vary in composition with grain size of the sample.

IV. Methodology

- The heavy minerals were separated using bromoform at Sp.Gr 2.89 using procedure (Milner 1962) each fraction of sample along with bromoform was pored in to a separating funnel. After the heavy and light mineral separated the sediment was released by opening the cock of the funnel in to filter paper (Whatman .1).
- The sample was washed with methanol and kept for air drying, weighed and the percentage were tabulated.
- Separated heavy minerals were subjected to magnetic separation using hand magnet and Frantz isodynamic separator.
- Magnetite was first separated with a hand magnet and the strongly magnetic minerals were separated first, later the remaining magnetite was separated by isodynamic separator at 0.05 volts.
- The ilmenite is later separated at 0.22 volts. The amperage as given by Rosenblum (1958) and (1959). The separated ilmenite and magnetite weighed their percentage were calculated.
- The separated fractions of ilmenite and magnetite were confirmed by X-Ray diffraction method.

V. X-Ray Analysis

X-ray analysis of the samples was carried out by using RIGAKU ALTIMA IV by copper target (Fig.1), the X-ray diffraction is based on the elastic scattering of X-rays from the electron clouds of the individual atoms in the system. The most comprehensive description of scattering from crystals is given by the dynamical theory of diffraction. In this study the powder diffraction is a scientific technique by X-ray, neutron or electron diffraction on powder or microcrystalline samples for structural characterization of materials. RIGAKU a machine used to carry out the procedure which is based the Bragg's law the formula $n\lambda = (hkl) \sin Ø$ where

λ= the true lattice spacing for planes (hkl)
Ø = glancing angle of reflection
λ = wavelength of X-ray
n= order of reflection

A reflection on a given set of planes only occurs when a certain glancing angle Ø results for fixed wavelengths, a variation of Ø is obtained in the powder method by exposing a very fine grained powder whose crystals have random orientation. A crystal plane (hkl) then reflects at the angle Ø according to above relationship Anon (1980). Analysis of sample is powdered on agate mortar to the size of -230 mesh i.e. 64 microns, the powder was mounted on a X-ray machine holder and the machine operated for specific degrees of light fraction - 20º - 60º, Ilmenite - 20º - 71º, magnetite 17º - 65º, non- magnetite - 3º - 70º to obtain the required X-ray diffractograms. The data is subjected to RIGAKU software programme to obtain desired X-ray diffractograms. Interpretation for identifying the different minerals was done according to Anon (1981).

The X-ray diffractograms of ilmenite, magnetite and light minerals show various peaks which are identified using JCPDS data, Anon (1981). The X-ray diffractograms of limonite shows the intergrowth of other minerals along with limonite. The minerals include ilmenorutile and titanite shows major peaks. The non-magnetic sand grains were mounted in Canada balsam and observed under optical microscope to identify diagnostic properties of the minerals.

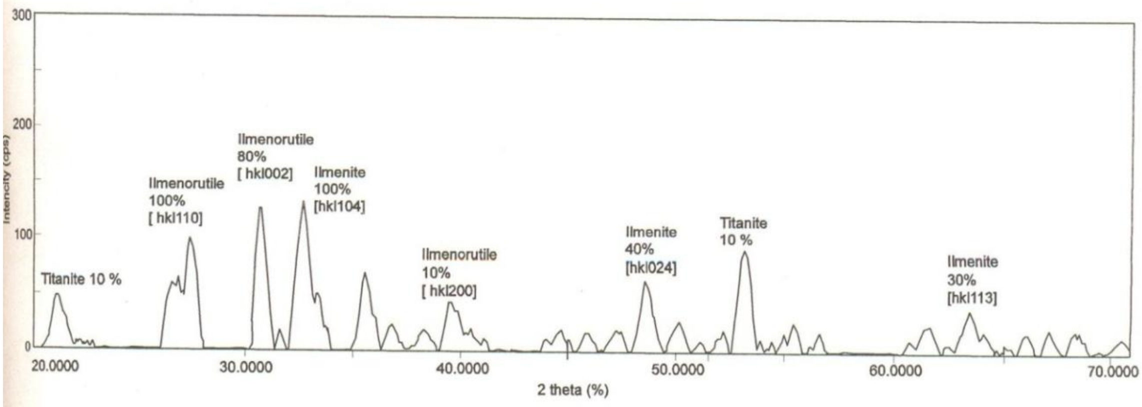


Fig . 1 X-ray diffractogram of ilmenite, Vagator, Goa

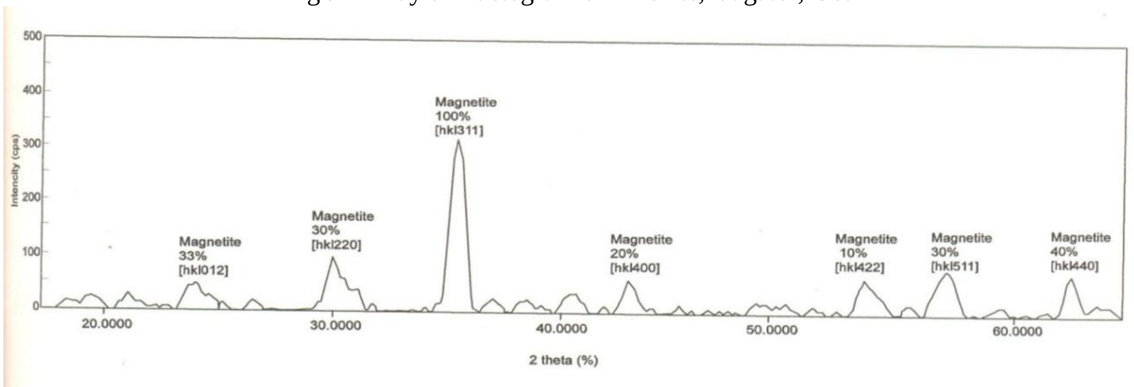


Fig. 2. X-ray diffractogram of Magnetite, Vagator, Goa

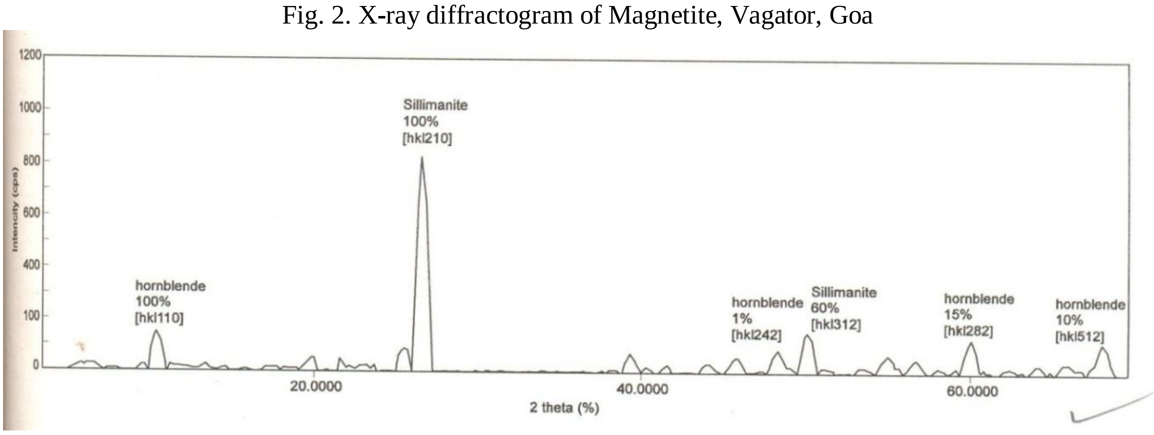


Fig.3. X-ray diffractograms of Non-magnetite, Vagator, Goa

VI. Scanning Electron Microscopy (SEM)

Krinsley and Doornkamp (1973) used the surface textures of quartz grains in order to achieve an understanding the post depositional history of the sediments. During the process of transportation and deposition the sand grains are exposed to continuous mechanical and chemical action. As a result various micro features are developed on the surface of the grains, This study of the magnetite, ilmenite and quartz grains under the scanning electron microscope, observed the micro textures developed on quartz grains and its significance in understanding the action of transportation and depositional environments. In this study the methodology is used the sediment sample from different locations were selected, washed and treated with 10%HCL. Dried samples were separated for light and heavy minerals by using bromoform (Sp.Gr. 2.89) following standard procedures (Hutchinson 1974). A few grains of magnetite, ilmenite and quartz grains were taken in to SEM study. The grains were mounted on SEM brass stub, and coated with gold in a vacuum evaporator and slowly rotated. The grains were studies in detail and typical micrographs were plotted by using Joel JSM-5800 SEM.

The SEM study of all the grains of ilmenite, magnetite and quartz, shows variety of micro textures developed by mechanical and chemical processes acting in the coastal area. Mechanically formed grooves are predominant features followed by V marks and concoidal fractures. Rounded grains and smoothening of edges indicates high energy zones, etch V's and solution pits are dominant features by precipitation of chemical processes. Evaporation and exposure of grains in dry intervals increase the pH and aid etching process. In this observation of the sub rounded grains with high impact marks indicates high energy condition is a characteristic feature in coastal areas. V-Shaped triangular pits and etch V's indicates chemical action in pocket beaches. The mechanical breakage blocks indicate nearby source of sediments and arc shaped furrows are in fluvial environment. Development of precipitation indicates calm environment with low energy. The grains from offshore area show lines and pits and impact marks are observed in river samples at high energy environment.

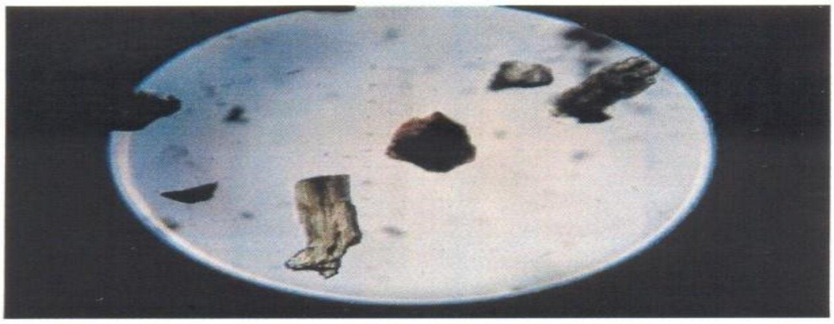


Fig. 4: Rutile and tourmaline

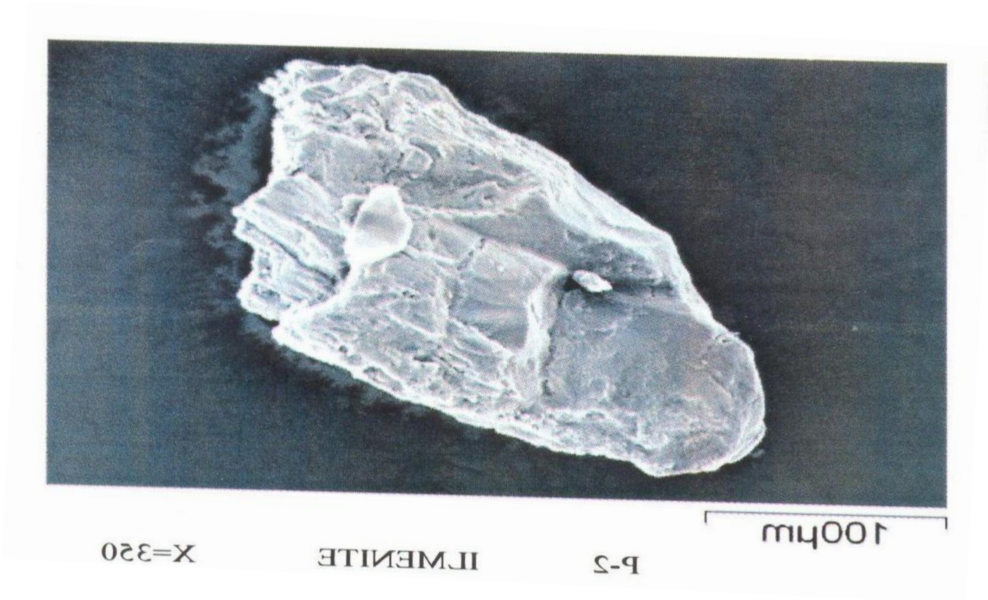
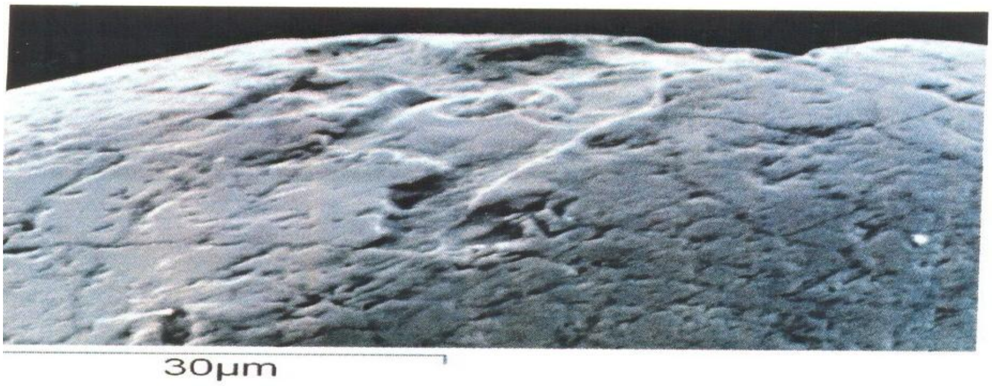
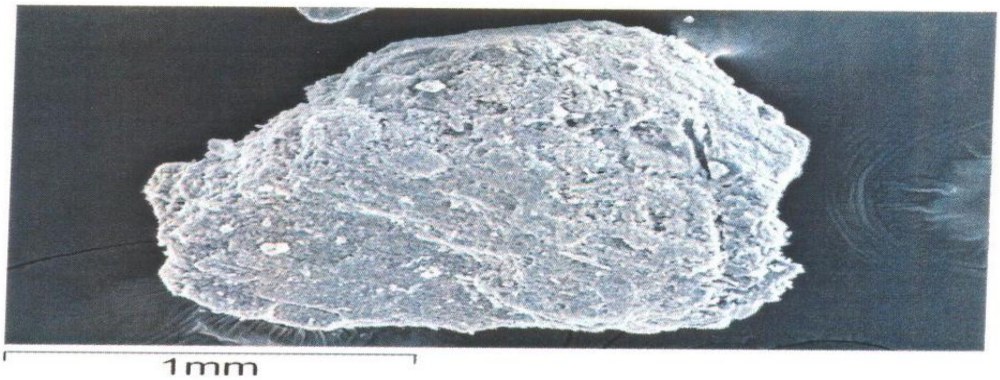


Fig 5: Elongated sub angular, sub rounded grains showing concoidal fractures, grooves, pits of limonite

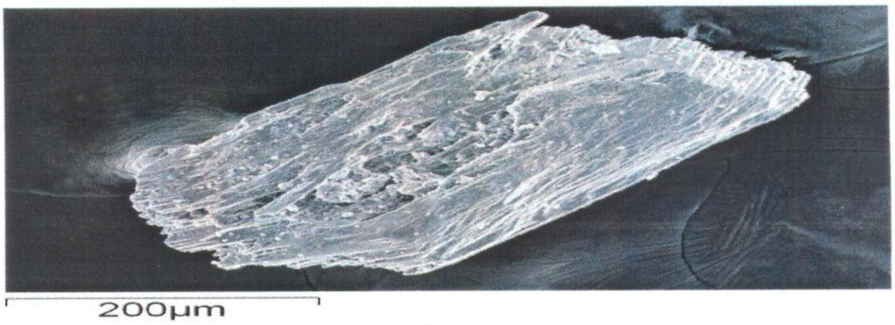


P-20 ILMENITE X=2000

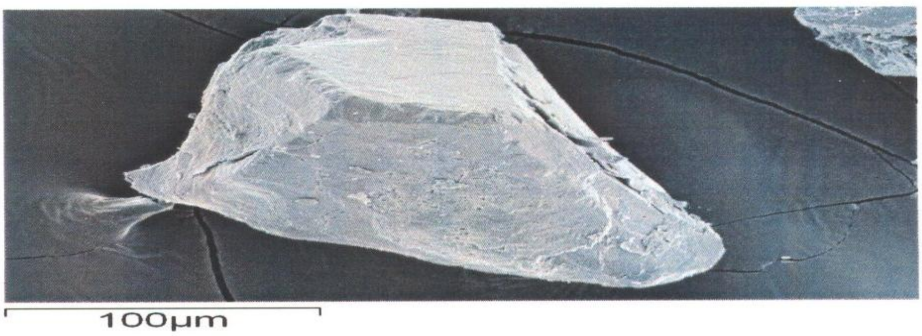


P-22 ILMENITE X=270

Fig. 6: The ilmenite showing irregular surface with more impact, rounded edges and sub rounded grains effect of chemical action,



P-26 ILMENITE X=230



P-28 MAGNETITE X=70

Fig. 7: The magnetite shows elongated sub angular grain scratch marks, impact pits and effect of solution

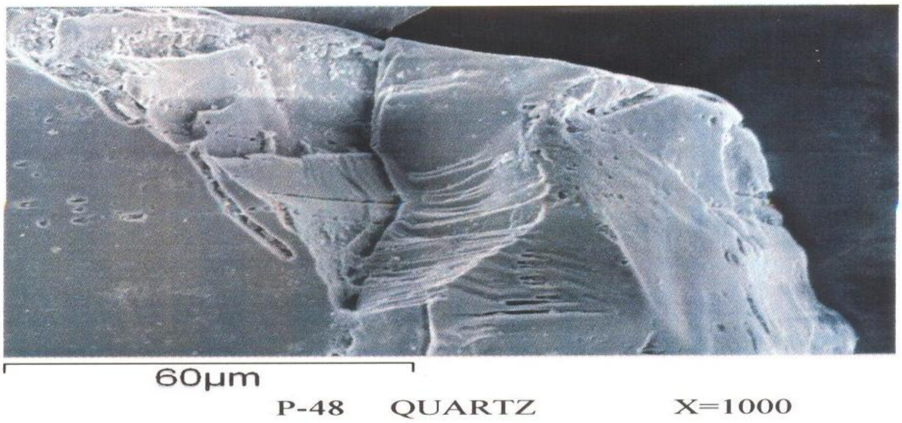


Fig. 8: The quartz shows step like grooves, secondary precipitation and sub concoidal fractured surface.

VII. Results and Discussion

From the above investigations the study of heavy minerals from beach sands of vagathor, North Goa reveals the following aspects regarding their genesis.

- The X-ray diffractogram of ilmenite shows the intergrowth of other minerals along with ilmenorutile and titanite major peaks.
- The heavy mineral suite comprises of opaque (magnetite and ilmenite) and transparent minerals like hornblende, epidote, garnet, rutile, zircon, enstatite and minor amounts of tourmaline.
- The light minerals mainly quartz and feldspars, magnetite concentration ranges between 2.01 to 56.86 percent, ilmenite between 2.83 to 41.04 percent and non magnetic between 1.18 to 44.81 percent.
- Mechanical process leads to form the concoidal fracture pitted surface, groves and furrows.
- Dissolution chemical process generates concavities, solution pits, etch V marks.
- A chemical process develops silica precipitation.
- The SEM study of all the grains of ilmenite, magnetite and quartz, shows variety of micro textures developed by mechanical and chemical processes acting in the coastal area.
- Mechanically formed grooves are predominant features followed by V marks and concoidal fractures. Rounded grains and smoothening of edges indicates high energy zones, etch V's and solution pits are dominant features by precipitation of chemical processes.
- Evaporation and exposure of grains in dry intervals increase the pH and aid etching process. In this observation of the sub rounded grains with high impact marks indicates high energy condition is a characteristic feature in coastal areas. V-Shaped triangular pits and etch V's indicates chemical action in pocket beaches.
- The mechanical breakage blocks indicate nearby source of sediments and arc shaped furrows are in fluvial environment. Development of precipitation indicates calm environment with low energy.
- The grains from offshore area show lines and pits and impact marks are observed in river samples at high energy environment.
- River sample is fresher then beach sample which are more weathered. They show primary features most of the beach sample overlapping by secondary precipitation.
- The highest concentration of heavy minerals in Vagator beach is in fine fractions, range of 16.58 to 97.49 percent. The heavy minerals concentration in left bank of Chapora River close to the low tide level of Vagator beach.
- The mineral with high specific gravity are winnowed by the retreating currents of the plunging waves.
- The non magnetic heavy mineral varies in degrees of transformation and size from euhedral to subhedral hornblende show elongated edges involving some chemical action in the depositional basin.
- Garnets seems to be undergone etching by the pits and depressions.
- The observed mineral assemblage on the surface features collectively suggest the derivation of source rocks like mixtures of igneous and metamorphic rocks, crystalline gneisses and schist's.

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