# Chapter-I

# Introduction

*I do not know what it may appear to the world; but to myself I seem to have been only like a boy playing on the seashore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me.....* Isaac Newton (1855).

## Introduction

The scope the Geological Science starts by analyzing the stone sphere beneath the one's feet called 'crust' vis-à-vis inter-relative analysis of the outer- and inner spheres around the mother earth. The outer sphere contributes mainly degradation while the inner sphere recycles the crust by adding and digestion.

The geological sciences have evolved with the civilization through Stone-, Copper-, Bronze- and Iron Ages that have made the man master of techniques. May it be the field of agriculture and fertilizers, forestry, transportation, infrastructure, atomic energy, space technology or environment monitoring the man has gained masterly skills in the last 300 years.

The geology is concerned with the study of different processes, mechanics and rocks of the Earth as a whole. The domains of geological studies include analysis of minerals, rocks, fossils, processes of degeneration (weathering) and regeneration (sedimentation) may it be taking place at lofty mountains or its foothills and from beaches to oceanic depths.

Petrology is the study of rocks in a systematic manner which consists of the way of arrangement of individual mineral i.e. petrography *vis â vis* the genesis of the rock as a composite of minerals. There are three branches in petrology *viz* igneous, metamorphic and sedimentary. Igneous petrology deals with the differential studies of primary rocks or rocks directly formed by the igneous processes, whereas metamorphic petrology defines recrystallization of pre-existing rocks by the effect of different physical and chemical factors. Sedimentary petrology is working in the field of study of sediment formation, all type of variation in sediments, transportation, deposition and formation of sedimentary rocks.

## 1.1 Sedimentology

As quoted by Lucretius- " .....do you not see that stone even are conquered by time, that tall turrets do fall and rocks do crumble?' so as the rocks broken down and made available to deposit again is the process of formation of sedimentary rock". Sedimentary Petrology connotes something more then near description of rock types based on microscopic analysis, and in its wider sense embraces comprehensive investigations of their nature, origin, mode of deposition, inherent structures, mineralogical composition, mechanical constitutions, textural analysis, various physical and chemical properties, in short, all data leading to an understanding of the natural history of the formations under review" (Krumbein and Pettijohn, 1938).

Sedimentation includes that portion of the metamorphic cycle from the destruction of the parent rocks, no matter what its origin or constitution, to

the consolidation of the products derived from that destruction (with any addition from other sources) into another rock.

Sediments deposit as a solid material (or material in transportation which may be a deposit) made from any medium on the earth's surface, or in its outer crust under conditions of temperature approximating those normal to the surface.

Sedimentology is perhaps a comprehensive and coherent study of rocks of secondary origin. Apart from this, the hidden history of the nature accompanied by the intense activities caused the production of sediments and the processes of deposition are the scope of sedimentary petrology.

> *On the pure academic side, the tendency was at first towards study of the subject for its own sake, with little or no regards for its broader possibilities: sampling a particular sediment, segregation of its 'heavier' and more stable constituents and their ultimate mineralogical analysis, formed a welcome change from routine investigation of thin section of consolidated rocks, one follow mainly because it was indeed a new, departure in experimental petrology.* ..... **Henry B. Milner, 1962**

The sedimentological studies of the recent time have the domains over the sedimentary particles through; textural analysis; size analysis; graphic presentation of particle size distribution; heavy mineral analysis and provenance study.

Sedimentary deposits are assemblages of individual grains or particles. They compose the framework of mode of sedimentation at coastal areas, such as a beach or a point bar that upon consolidation gives a sedimentary rock. The purposes of sedimentology to introduce the various kinds of

particles that are commonly occur in sedimentary rocks. Depending on their kind, they could be an excellent indicator of the 'nature' or the 'source' (or both) from which they were derived and subsequently the environment in which they evolved and accumulated.

A careful study of sediment texture reveals valuable information about the processes that remained operative to transport and deposit particles. The textural attributes of sedimentary deposit/rocks include 'particle size', 'shape', 'surface', 'texture arrangement' (packing and fabric). Such an exercise is formulated unravel sediment texture.

By studying mineralogy in more detail we learn much more about the history of sediment, and also which rock type or types served as the parent or source material of the sediment. The source material or source area is known as provenance. Different igneous, sedimentary and metamorphic rocks have different and often distinct or even unique, groups are heavy minerals.

## 1.2 Beach sediments

Beach portrays annual sum of the seasonal products including skeletal parts of fauna and flora of the near shore zones. They are considered valuable from sedimentological, palaeontological and economical point of views and are the most productive sources of heavy minerals in the world.

Beach formation, types of beaches and sand describe the process in which beaches are formed when the suspended sediments in sea water are transported by the long shore current. River sediments are the source of 80

to 90% of the beach sand; some beaches are built to great widths by sediments washed to the sea by episodic floods.

The elongated deposit of siliceous beach-sands, heavy minerals and economic minerals on the exposed littoral zone (between the maximum sea level and minimum sea level) along the junction of ocean and land (shore) is the representative of continental and shelf lithology. The recordable long and wide deposits of sand present in between foreshore and backshore, are sorted time and again to provide well pronounced data regarding the pre-existing environment and history of sedimentation along with the record of change in the physiography and morphology of coast. The presence of beach along the coast is only subjected to presence of low gradient topography generally at a width of about 0.5 to 1 km. The beach deposit perhaps a temporary deposit, which is alternately deposited and removed in 'beach-cycles'.

Morphologically, the upper beach is located in backshore zone while the lower beach is at foreshore zone. Shepard and Young (1961) classified the beaches in to three types

a. A beach situated in a foreshore section whose gradient decreases seaward;
b. A beach situated in a foreshore and the backshore section consisting of a berm or a practically horizontal beach terrace, the foreshore section being similar in profile to that in the first type; and
c. A beach that may or may not have a backshore marked by a berm but it has a foreshore with a low tide terrace;

Sea waves create force to break down the coastal rock into pieces and allow them to move 'back and forth' in beach building. When the sea wave reaches

the continent along the shoreline the force of the wave makes the debris move up and with its retreat it brings the debris down the slope. By the effect of physical obstruction, the load of debris reaches to the shore obliquely. The transport of material along the shore is called 'long shore drift'. The long shore drift is an important process in the development of the beach. Under the force of the prevalent wind carried particles of the wave strike to shore. Due to maximum slope of the shore carried particles are brought down by backwash or return of the sea water. A zigzag fashion is formed by long shore drifting and carried sediments of the waves move considerable distance along the shore zone.

## 1.3 Objectives of the study

Study of sediments all over the world has assumed importance in the recent years. Several significant as well as economical aspects are: concentration of trace metals, distribution of phosphate, granulometric studies of beach sediments, evaluation of environment, evolution of beaches, sediment dynamics at beaches, and sedimentological parameters.

The sedimentary regimes of the west coast of India seems to be more affected by industrial pollution compared to those of the east coast, which rather reflect, to some extent, effect sediments of the Ganga on its geomorphic and oceanographic activities, and also on the flora and fauna that greatly differs from those of the west coast.

In India, the study of beach sediments and other littoral sediment remained neglected till 1970's. After that lot of work has been done on the sedimentological aspects of the beach- and dune-sands along both the coasts

of India. However, the east coast of India still has lot of scope of such studies. Therefore, in view of the potential, economic and academic importance of this subject the proposed study of exposed littoral sediments from Puri to Kanniyakumari covering a coastal stretch of about 2300 km has been carried out. This included visits to the exposed littoral-zone at sixteen stations (Puri, Gopalpur, Kalingapatnam, Vishakhapatnam, Kakinada, Chirala, Madras, Pondicherry, Nagapattinam, Vedaranniyam, Kottipattinam, Tondi, Rameshswaram, Mandapam, Tuticorin and Kanniyakumari) as shown in the Map 1.1, to study the beach characteristics and collection of sediment-samples for analysis.

Sedimentological, mineralogical and isotopic study may prove to be helpful indirectly in coastal management, fisheries, monitoring of environment pollution etc.

The present research project has been taken-up to study valuable contents of sediments/minerals including gold, monazite, gem stones invariably released from the igneous and metamorphic suites like khondalites, kodurites, charnockites and granitoids or from the Gondawana and Cretaceous sediments under fluvial/oceanic influence.

The present study may also be found useful to understand processes like transgression and regression of the sea transgression, tusnamic or plaeotsunamic sediments along the east coast of India, in future.

## 1.4 Historical résumé

The bibliography on the studies of different aspects of littoral sediments, in the world is vast. In general, the beaches of the east coast of

India have been considered to have derived their sand from the rivers to the south and from shore erosion (Fairbridge, 1966) with their heavier minerals settled near river mouths in the south whereas the lighter ones are driven north by littoral drifts prominently directed from south to north.

The concentrations of detrital heavy minerals occur as beach placers and in dunes in high-stand barriers of the Quaternary age.

During the last 40 year much attention has been directed towards the usefulness of the size parameter in recognition of depositional environment (Folk and Ward, 1957; Harris, 1958; Shepard and Yong, 1961; Friedman, 1967; Duane, 1984; Subba Rao, 1964; Chakravarti, 1977; Chouhan, 1992; Pattan Shetty *et al.*, 1993; and many others).

In India, the coastal areas has been remained a curious topic of the workers of different fields. Workers have studied various aspects in early sixties and seventies: oceanography of the Bay of Bengal (LaFond, 1957); evolutionary history of Vishakhapatnam beach (Prasad Rao and Mahadevan, 1968); and mathematical prediction of shore line changes (Chandramohan & Narsimha Rao, 1984). Many geographers studied the evolution of beach (Prasada Rao & Mahadevan, 1968); regional geomorphology of the continental slope of north-western India; near shore processes (Chandramohan *et al.,* 1984); climatic variation during late Pleistocene-Holocene in eastern Bay of Bengal (Chouhan *et al.,* 1993) and; quantification of changes on seabed topography of Hanstal Creek, Gulf of Kachchh, India (Pattanshetti *et al.*, 1993). Others have studied the east coast with different perspectives. The tectonic evolutionary history of the east coast of India was

well defined by various workers using the geo-physical methods like magnetic and seismic methods.

Significant studies have been carried out on aspects like sediment size, foraminifera, sediment units off Santapilli-Vishakhapatnam coast, (Subba Rao,1964); geochemistry of sediments off the continental shelf (Mascarenhas *et al.,* 1985); variation in the mean size as indicators at Puri and Konark beaches (Chouhan *et al.*, 1988). Monsoon induced changes in beach morphology and associated sediment dynamics (Chouhan, 1995); Dissolved and particulate trace metal in the western Bay of Bengal (Rajendra *et al.,* 1981); and laminae and grain size measures in beach sediments, east coast beaches, India (Chouhan, 1992 a).

Various studies resulted in finding heavy mineral deposits in littoral zone or beaches along the east coast of India: mainly in the southern most beaches of the east coast near Kanniyakumari (Nambiar, 2000 a; Angusamy and Rajamanickam, 2000 and others).

Evolutionary history of quaternary sediments of Vedaranniyam and Rameshwarm coasts studied by Nambiar, 2000 b and Mohan *et al.* (2000). The study of shelf sediments (Madhusudana Rao and Murty, 1968); depositional environment and the mineralogical studies of the Channai coast was the prime attraction of the workers (Shetty and Rajamanickam, 1972; Mohan, 1995; Vijaykumar and Vaz, 1995; Mohan and Rajamanickam, 1998 and others), which was further accentuated by finding atomic minerals and *diamonds*. Coastal erosion around Pondicherry and Ennore coast (Anbarasu and Rajamanickam, 2002); buried placer mineral deposit along Chennai and Pondicherry coasts (Mohan and Rajamanickam, 2001) and Xenotime

in Narasapur beach placers (Subrahmanyam *et al.*, 2004). Grain size characteristics and chemical composition of white sand of Chirala coast was analysed to understand the environment of deposition and their industrial importance (Rao and Pitchaiah, 1985). Distribution of clay minerals in shelf sediments of Bhimunipatnam-Kalingapatnam coast was performed by Purnachandra Rao and Rao (1993).

Rare metal study in beach sands of Chattrapur (Sahu *et al.*, 1984), textural and dynamical studies of beach sediments of Puri and Konark beaches was taken up by (Chouhan *et al.*, 1988; and Chouhan, 1992).

From the mid 80s to mid 90s Vishakhapatnam beach received maximum attention on the different sedimentological aspects (Prasad Rao and Mahadevan, 1968; Chandramohan, *et al.*, 1981; Swamy, *et al.*, 1983; Chandramohan and Narashimha Rao, 1984; Raju *et al.*, 1993; Prasada Satyanarayan, *et al.*, 1993; Mohana Rao, and Rao, 1994; Murty, 1994; Lakshmipatiraju and Rinivaa Rao, 1996).

Foraminiferal studies covering the coast of India including the beaches incorporated in the present study has been dome by Kathal (2002 a & b). The first phase samples have been taken for the present study.

In the recent past, placer mineral deposits (Dhana Raju, 2002); formation of beach sand deposits (Gajapathi, 2002); heavy minerals at Gopalpur and Paradeep (Behera, 2003); and geochemical and ore mineralogical studies have been carried out on placer beach deposits from the Vishakhapatnam-Bhimunipatnam for ilmenite (Jagannath Rao *et al.*, 2005); micro- and macro-diamonds beaches at Kanniyakumari (Rau, 2006).

After the incidence of Tsunami (Dec, 2004) the mineralogical study of the beach sediments is an emerging trend for the sedimentologists (Satyanarayana *et al.*, 2007). At Gopalpur empirical orthogonal function of the beach sediment s has been performed by Ramana Murty *et al.* (2007). The tsunami sediments deposited along Karaikal to Nagapattinam beaches have been studied for foraminifera, grain size and clay mineralogy (Satyanarayna *et al.,* 2007).

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