CHAPTER 3

METHODOLOGY

The locations were surveyed using GPS and the topography was marked for both 2004-tsunami deposits & washover deposits. 2004-tsunami deposits were studied at and around Velankanni and Vedaranyam District along the east coast of Tamil Nadu. Additionally, eyewitness accounts were considered in mapping the tsunami deposits. Faces for 2004-tsunami deposits involved digging numerous pits and number of transects method.

Geomorphology mapping is done form Vanagiri to Pushpavanam along Cavery Delta Coast of Tamil Nadu, India and washover deposit sites are identified in paleo beach ridge landforms. The area contain beach rides, paleo-lagoons, paleo-tidal flats and paleo barriers (beach ridges). Faces are hand excavated with a shovel and 'cleaned' with a small trowel and brush to expose contacts and yield minimal disturbance to the stratigraphy.

Faces were excavated to investigate the subsurface stratigraphy for all the identified sites. The excavated faces allow for detailed facies analysis. Excavated faces also allowed collection of samples. Samples were collected at 1 cm, 2cm and 5cm interval from each pit. Small pits were dug at approximately 50-m intervals perpendicular to the coastline and augmented by additional trenches wherever necessary to trace the layer. The samples were analysed for sedimentoligical techniques, micromorphological studies and geochronological dating using OSL technique. Heavy minerals were also separated from the sample and they were identified.

Textural studies on the sediments were performed for sand, silt and clay distributions (Ingram 1970). Determination of calcium carbonate ($CaCO_3$) was performed following the procedure of Loring and Rantala (1992). Grain-size analysis was done with the mechanical sieve shaker using a set of sieves with mesh size ranging from 18 – 325 ASTM. In microns it ranges from 1000 to 44microns. The grain size statistics, median, mode, sorting, skewness and kurtosis, were calculated using the logarithmic method of moments and the division into different sediment types was done using Folk and Ward (1957) classification (Table 3.1).

Based on the above studies done for 2004 tsunami deposits, stratigraphic and sedimentological characteristics are identified. These characteristics are set as criteria to assess the washover deposit samples. Similar studies are done for washover deposit samples. The results are compared with the set criteria to identify the origin of washover deposits. A detailed methodology chart is given in the Figure 3.1.

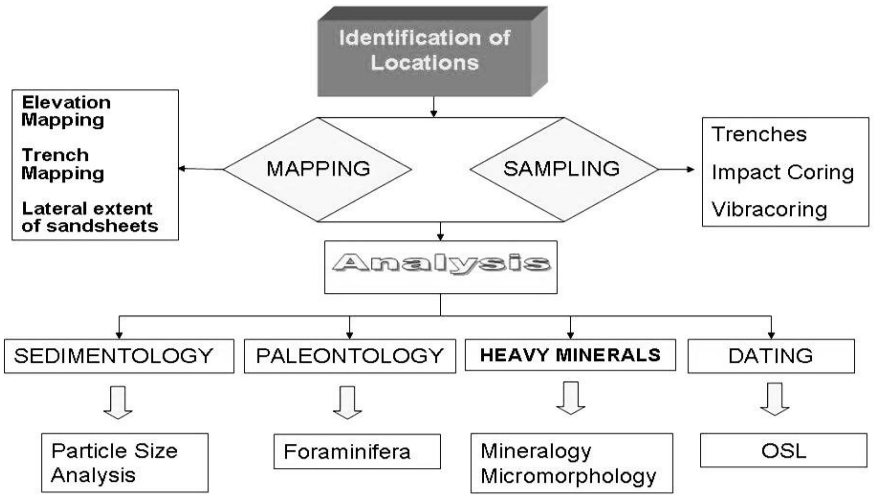


Figure 3.1 Schematic representation of Methodology used in this study

3.1 SAMPLING

The sample was taken by making pits on the surface. The depth of the pit varies according to the area and the layers found. One or two samples are taken from each layer for analysis**.** Collected samples are stored in polythene bag and then they were labeled according to the sampling location which was measured by hand held GPS.

3.2 PREPARATION OF SAMPLES

The samples were dried in hot air oven at 60°C to remove the moisture. From the dried samples, 100 gm of the samples were taken by repeated coning and quartering to ensure the uniformity and avoid errors in analyses of heavy mineral separation.

3.2.1 Pre treatment of samples for Particle size analysis

i) Clay fraction removal: The sample were soaked in water for over night, were the samples washed in water (+4.00 phi value) and to remove the clay fractions. The samples were dried and weighed and the weight loss was taken as the weight of clay.

ii) Organic matter removal: The sample was soaked in hydrogen peroxide for over night were the samples washed in water (+4.00 phi value) until a clear column of water, without any turbidity was obtained. The samples were dried and weighed and the weight loss was taken as the weight of OM.

iii) Carbonate removal: The samples were treated with 1:9 HCl to dissolve and remove the calcareous shelly fragments present in the sediments. After proper washing and drying, the

samples were weighed and the weight loss was taken as the weight of carbonates.

iv) Sieving: Though the grain size may influence heavy mineral composition, usually fine to medium grained sands yield the optimum heavy mineral assemblages. Sieving was carried out in ASTM at ½Φ interval. The sieve sets, stacked in descending order of their sizes, were shaken using mechanical sieve shaker continuously for about 20 minutes. During sieving proper attention was paid to minimize the sand loss from the sieve sets. The sieve materials were collected separately for weighing. Weight of individual fractions was tabulated for further granulometric studies. The sieved sands of 80,100, and 120 meshs were separately kept for heavy mineral studies.

It is a fundamental premise of sedimentology that every sedimentary unit is formed as a result of its response to a certain set of environmental conditions (Blatt et al 1980). In order to investigate the depositional environments of the samples collected for this study, all samples were investigated using a number of basic physical sedimentology techniques. These techniques were used to characterise the sediments into basic lithological facies, e.g. wash over sands, shelly beach face sands or lagoonal muds. In many cases this initial facies description then dictated the analysis of that facies and further division into subfacies.

Furthermore, an understanding and comparison of the textural and compositional characteristics (mineralogy) of sediments from various depositional environments within a particular sedimentary system, such as an estuary or lagoon, can allow the interpretation of sediment transport pathways and allow one to distinguish source environments (Gao and Collins 1992).

The average grain size is given by the **mean value (M),** which is computed from particle sizes spread through the grain size range.

The standard deviation (σ): Represents the sorting of the sediment. It is a measure of the dispersion or scatter of the grain size distribution. Well sorted sediments have a low standard deviation, while poorly sorted sediment shows a high standard deviation.

Skewness (Sk): Is a measure of the deviation from a normal, bell-shaped distribution. It shows the asymmetry of the grain size distribution. The Skewness has a positive value when more fine material is present and a negative value when the distribution shows a coarse grained tail. A normal distribution curve has a Skewness of 0.

Kurtosis (K) : Reflects the peakedness of the grain size distribution. It is related to both the dispersion and the normality of the distribution. Poorly sorted sediments or sediments with a bimodal grain size distribution have flat curves and are called platykurtic. Whereas peaked curves with a very good sorting of the central part of the distribution are leptokurtic and normal distributions are mesokurtic (McManus 1988).

The values of mean, standard deviation, Skewness and kurtosis are calculated using the formulas as given below

Table 3.1 Grain size parameters, formulas and suggested descriptive terminology using the graphical method of logarithmic (phi) values of Folk and Ward (1957).

Mean	Standard deviation
$M_G = \exp \frac{\ln P_{16} + \ln P_{50} + \ln P_{84}}{3}$	$\sigma_G = \exp\left(\frac{\ln P_{16} - \ln P_{84}}{4} + \frac{\ln P_5 - \ln P_{95}}{6{\cdot}6}\right)$
Skewness	**Kurtosis**
$Sk_G = \frac{\ln P_{16} + \ln P_{84} - 2(\ln P_{50})}{2(\ln P_{84} - \ln P_{16})} + \frac{\ln P_5 + \ln P_{95} - 2(\ln P_{50})}{2(\ln P_{25} - \ln P_5)}$	$K_G = \frac{\ln P_5 - \ln P_{95}}{2{\cdot}44(\ln P_{25} - \ln P_{75})}$

Sorting (σ_G)		Skewness (Sk_G)		Kurtosis (K_G)	
Very well sorted	<1·27	Very fine skewed	$^{-}$0·3 to $^{-}$1·0	Very platykurtic	<0·67
Well sorted	1·27–1·41	Fine skewed	$^{-}$0·1 to $^{-}$0·3	Platykurtic	0·67–0·90
Moderately well sorted	1·41–1·62	Symmetrical	$^{-}$0·1 to $^{+}$0·1	Mesokurtic	0·90–1·11
Moderately sorted	1·62–2·00	Coarse skewed	$^{+}$0·1 to $^{+}$0·3	Leptokurtic	1·11–1·50
Poorly sorted	2·00–4·00	Very coarse skewed	$^{+}$0·3 to $^{+}$1·0	Very leptokurtic	1·50–3·00
Very poorly sorted	4·00–16·00			Extremely leptokurtic	>3·00
Extremely poorly sorted	>16·00				

3.3 HEAVY MINERAL SEPARATION

3.3.1 General Considerations

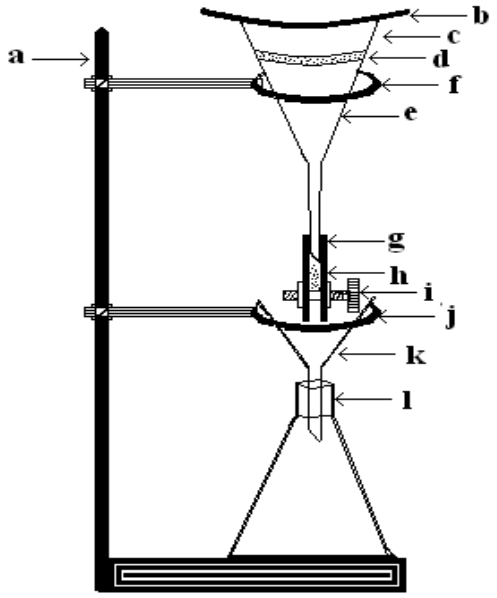
The separation of heavy mineral is performed by means of high-density liquids. There is a considerable difference in densities between the lighter and heavier minerals. According to this density variation, the higher density (heavy mineral) will sink and the lower density (lighter mineral) will float. Various heavy liquids were used for heavy mineral separation. They are Bromoform (2.89 gm/cc), Tetrabromomethane (2.96) Mehelene iodide (3.32) and cleric solution (4.24). These heavy liquids are of high density and highly toxic. There is also non-toxic sodium polytungstate used as heavy liquid for heavy mineral separation. The washing liquids suitable for removing heavy liquids from the grains are carbon tetra chloride, benzene alcohol and acetone.

3.3.2 Apparatus and Chemicals Required

Bromoform (2.89), acetone, distilled water, funnel, conical flask, stand to hold the separating funnel, pinch clip, rubber tube, watch class and filter paper.

3.3.3 Procedure (Milner 1962)

The equipment used for separation by gravity settling was arranged as illustrated in Figure 3.2. The heavy liquid was filled in the separating funnel, the dry and weighed sample of 5 gm was then added to the liquid that should be stirred to ensure that the grains are thoroughly wetted. Grains adhering to the stirring rod or the side of the funnel are removed using heavy liquid. Heavy minerals get accumulated in the bottom of the funnel above the pinch clip. After few minutes (normally 10 to 20 minutes) when no more grains sink further, the pinch clip was opened slowly, thus allowing the heavy fraction to pour onto the filter paper in the lower funnel. Then the pinch clip was closed, leaving a layer of clear liquid below the light fraction. A new funnel, with filter paper, was placed under the separating funnel. The fraction was then drained into the new funnel. Subsequently, the wall of the separating funnel was rinsed with acetone and distilled water, and also both fractions are washed thoroughly, and set aside to dry. The used heavy liquid and washings are collected. The heavy liquid can be re-used. Both the fractions were dried at 60ºC in the oven. After that the heavy fraction was weighed and collected in polythene covers.



(a) Retort stands, (b) Watch glass, (c) Separating funnel, (d) Position of light fraction, (e) Heavy liquid, (f) Funnel support, (g) Rubber tube, (h) Position of heavy residue, (i) Pinch clip, (j) Filter funnel support, (k) Filter funnel, and (l) Collecting conical flask.

Figure 3.2 Shows the arrangement of equipment for heavy mineral separation by gravity settling.

The photographs of heavies are taken using scanning electron microscope and there characters are studied in detail to understand the environment.

3.4 FORAMINIFERAL ANALYSIS

3.4.1 Micropalentological Analysis (Floating method – CCl_4)

The sediment samples were analyzed for foraminiferal assemblage. The samples were washed through an ASTM 230 mesh sieve (opening 0. 063 mm) to remove the finer (silt and clay) particles. The residue which included

sand and foraminifera were collected in a china dish and dried in an oven at 50ºC to 60ºC and treated for the floating method using CCl_4.

3.5 OSL ANALYSIS

3.5.1 Introduction to Luminescence Dating

Luminescence dating is a form of geochronology that measures the energy of photons being released. In natural settings, ionizing radiation (U, Th, Rb, & K) is absorbed and stored by sediments in the crystal lattice. This stored radiation dose can be evicted with stimulation and released as luminescence. The calculated age is the time since the last exposure to sunlight or intense heat. The sunlight bleaches away the luminescence signal and resets the time 'clock'. As time passes, the luminescence signal increases through exposure to the ionizing radiation and cosmic rays. Luminescence dating is based on quantifying both the radiation dose received by a sample since its zeroing event, and the dose rate which it has experienced during the accumulation period. The principal minerals used in luminescence dating are quartz and potassium feldspar.OSL dating age range for various sediments are given in Table 3.2.

3.5.2 Applications of Luminescence

Table 3.2 OSL dating age range for various sediments

Deposit	Age Range (years)
Glass / Volcanic Ash	10-250,000
Loess	8,000-416,000
Fluvial	Modern-400,000
Colluvium / Alluvium	100-150,000
Eolian	10-70,000
Paleodischarge - A&C Horizons	3,000-190,000

3.5.3 Types of Luminescence Dating Techniques

- Photo-Transferred (PTTL)
- Thermal (TL)
- Optically Stimulated (OSL)
- Green Light (GSL) - Feldspar & Quartz
- Infrared (IRSL) - K-Spar
- Blue Light (BSL) - Quartz
- Red Light (RSL) - Volcanic Feldspar & Quartz

3.5.4 OSL Dating Principles

Luminescence dating is based on solid-state properties of mineral grains that allow them to record their exposure to radiation. The recorded radiation exposure can be measured by stimu-lating the sample with light of one wavelength and monitoring the emitted luminescence at another wave-length (optically stimulated luminescence, OSL). The intensity of luminescence is a function of the absorbed natural radiation dose. If the rate of natural irradiation of the grains is constant and can be determined, then dividing absorbed dose by dose rate gives a radiation exposure age, according to:

$$\text{Age}, T\ (\text{a}) = \frac{\text{Equivalent natural dose}, D_e\ (\text{Gy})}{\text{Annual dose rate}, R\ (\text{Gy/a})}$$

The equivalent natural dose (D_e) absorbed during burial may be determined from the response of the OSL signal to radiation. Most often the so-called sin-gle-aliquot regenerative-dose (SAR) procedure is used to determine the D_e. The technique of luminescence dating is well es-tablished

for age-dating sediments on Earth. There is an abundance of published examples throughout the terrestrial geologic literature describing successful applications of the technique.

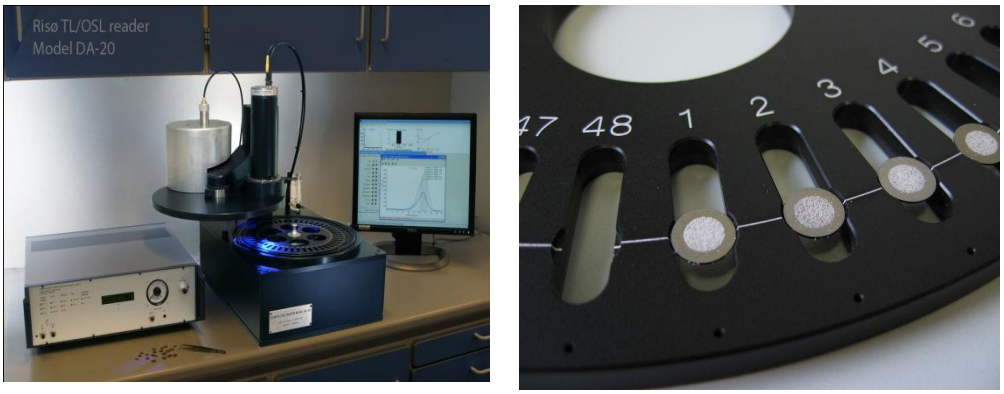


Figure 3.3 Instrument used for OSL dating

Thus the age of the sediments is more or less approximately identified using optically stimulated luminescence method. Instrument used for OSL dating is depicted in Figure 3.3.