Boletín de la Sociedad Geológica Mexicana
Volumen 65, núm. 1, 2013, p. 201-205

Short Note

Evidences for Extreme Wave Events in Velanganni Coast, Southeast of India

S.M. Hussain[1], P. Elakkiya[1], K. Elumalai[1], M.P. Jonathan[2,*], R. Nagarajan[3]

[1] Department of Geology, School of Earth & Atmospheric Sciences, University of Madras, Guindy Campus, Chennai, India, 600 025.
[2] Centro Interdisciplinario de Investigaciones y Estudios sobre Medio Ambiente y Desarrollo (CIIEMAD), Instituto Politécnico Nacional (IPN), Calle 30 de Junio de 1520, Barrio la Laguna Ticomán, Del. Gustavo A. Madero, México D.F., México, C.P. 07340.
[3] Department of Applied Geology, School of Engineering and Science, Curtin University, Miri, Sarawak, Malaysia, CDT 250, 98009.

[*] mpjonathan7@yahoo.com

Abstract

The present study focuses on sediment grain size, microfossil content and heavy minerals present in the sediments collected from a trench in the southeast coast of India in order to identify the frequent extreme wave events (*e.g*. storm surge, cyclone, tsunami, *etc*.). Two different depositional events were identified at different depths with distinct sedimentological, mineralogical and microfossil characteristics. These geological features further improve the understanding of depositional sequences in this region.

Keywords: ostracoda, foraminifera, trench sample, Velanganni, southeast coast of India.

Resumen

El presente estudio se enfoca en el tamaño de grano, contenido de microfósiles y minerales pesados de los sedimentos colectados en una trinchera en la costa sureste de la India para poder identificar los eventos frecuentes de alta energía (p.e. tormenta costera, ciclón, tsunami etc.). Se identificaron dos diferentes eventos de depositación a diferentes profundidades con distintas características sedimentológicas, mineralógicas y de microfósiles. Estas firmas geológicas mejoran la comprensión de las secuencias de depositación en esta región.

Palabras Clave: ostracoda, foraminíferos, muestra de trinchera, Velanganni, costa sureste de la India.

The evidences for extreme wave events that often occur in the coastal regions are very crucial in determining the type of deposition and its related characters. In recent years several researchers have taken different approaches supporting the idea of using multi-proxy tools to identify these events. Identification of such extreme events lies in the basic principles of lithostratigraphy, sedimentology, faunal assemblage, geochemistry and radio carbon dating (*e.g*. Chagué-Goff *et al*., 2002; Goff and McFadgen, 2002; Radtke *et al*., 2003; Ruiz *et al*., 2005). Studies to delimit different high energy events (*i.e*. tsunami, flood events) especially use foraminifera and ostracods to distinguish their nature (Clague *et al*., 1999; Nagendra *et al*., 2005, Ruiz *et al*., 2005; Kortekaas and Dawson, 2007; Ruiz *et al*., 2010).

The present study documents the evidences of extreme wave events in the Velanganni coast in the southeastern part of India based on micropaleontological, sedimentological and mineralogical tools. The regional map (Figure 1) indicates the regions that were flooded during the 2004 December Indian Ocean tsunami as well as the areas that could possibly be inundated during high energy waves. As part of a larger investigation for high energy events,

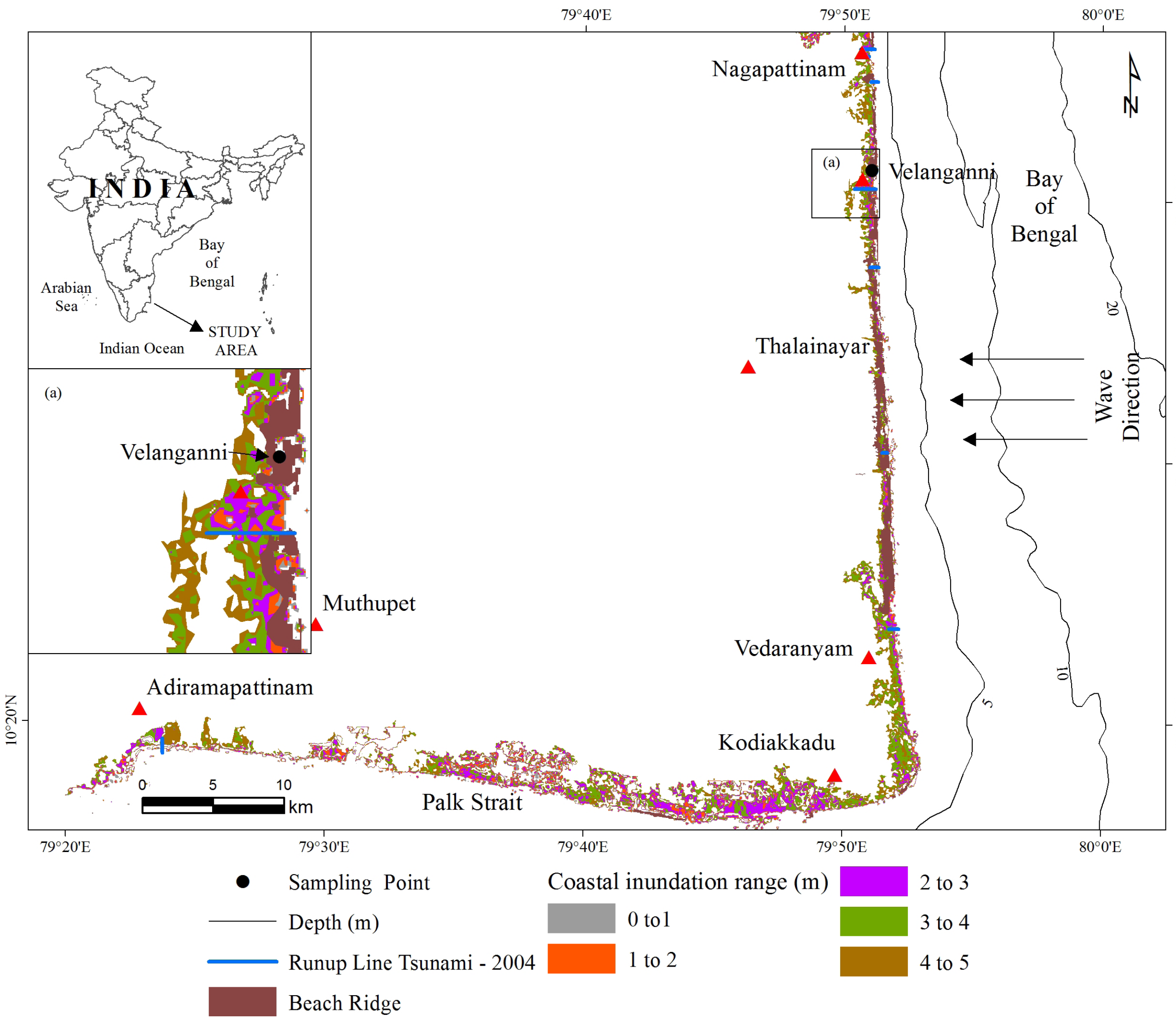

Figure 1: Study area and trench location (see inset a) in the southeast coast of India. The geomorphological features in the study area are also shown in order to understand the local topographic settings in the region. The map was produced as part of larger investigations to understand the areas that were affected during the 2004 Indian Ocean tsunami.

many studies have been initiated by the researchers of the Department of Geology from the University of Madras, Anna University and the Earth System Sciences Group in Chennai (India) all along the coastal regions in south India. Earlier studies in this region have already focused on the microfossil assemblages (Nagendra *et al*., 2005; Hussain *et al*., 2010). A 1.2 × 1.2 m vertical trench was excavated to identify the depositional sequence in this region where the mean sea level (m.s.l.) is almost equal to that of the present day sea level. In the litho-section, samples were selected based on the colour of the soil and grain size distribution (by direct eye observation). Overall, 12 sediment samples were collected at: 0-10 cm (loose sand with grass roots), 11-22 cm (red sand), 23-31 cm (white sand), 32-37 cm (light yellow sand), 38-63 cm (light yellow sand), 64-71 cm (coarse red sand), 72-81 cm (fine grained red sand), 82-93 cm (black sand), 94-99 cm (white sand), 100-111 cm (coarse river sand), 112-130 cm (black sand) and 131-135 cm (fine white sand) (Figure 2).

The samples were oven dried to 40 °C and used for the identification of foraminifera and ostracod species. The microfossils were subsequently photographed using a scanning electron microscope (JEOL-JSM 6360). Likewise, heavy minerals were identified after the sample was sieved and separated using bromoform. Microfossils were subsequently identified under an optical microscope to obtain the total abundance in each sample (Milner, 1962a, 1962b). Granulometric analysis suggested the presence of dominant sand size sediment.

In this study, we focus on the sediment present at depths of 37-63 cm and 111-130 cm. Both layers present an upward fining sequence with fine sand at the base and increasing the abundance of silty sand and clay towards the top. The sediments at depths of 37-63 cm showed the presence of the foraminifers *Ammonia beccarii*, *Elphidium norvangi* and *Quinqueloculina lamarckiana*. The ostracod taxa comprised *Neomonoceratina iniqua* and *Tanella gracilis* (Figure 3a-g, 4). The sediment at 111-130 cm depth yielded the foraminifers *Ammonia beccarii*, *Quinqueloculina lamarckiana*, *Q. seminulum*, *Q.* sp., *Elphidium* sp., *Parallina hispidula* and ostracod species such as *Neomonoceratina iniqua* and *Caudites javana* (Figure 3a-g). Earlier reports suggest that these microfossils are often found in the inner shelf regions (Ruiz *et al*., 2004; Nagendra *et al*., 2005; Hussain *et al*., 2006) and that they are brought into the continental area during transportation or movement of high velocity waves. The ostracod carapace-valve ratio of 60.28 % in adult and juvenile shells in the present study also supports the fact that these deposits belong to extreme wave events (*e.g*. McKenzie and Guha, 1987; Ahmad *et al*., 1991; Hussain and Rajeshwara, 1996; Srinivasalu *et al*., 2007). The taxonomic features of these microfossils indicated that many are broken or many are complete with both shells retained; this might be due to their transportation during different extreme events in the coastal region indicating abrupt changes from normal conditions.

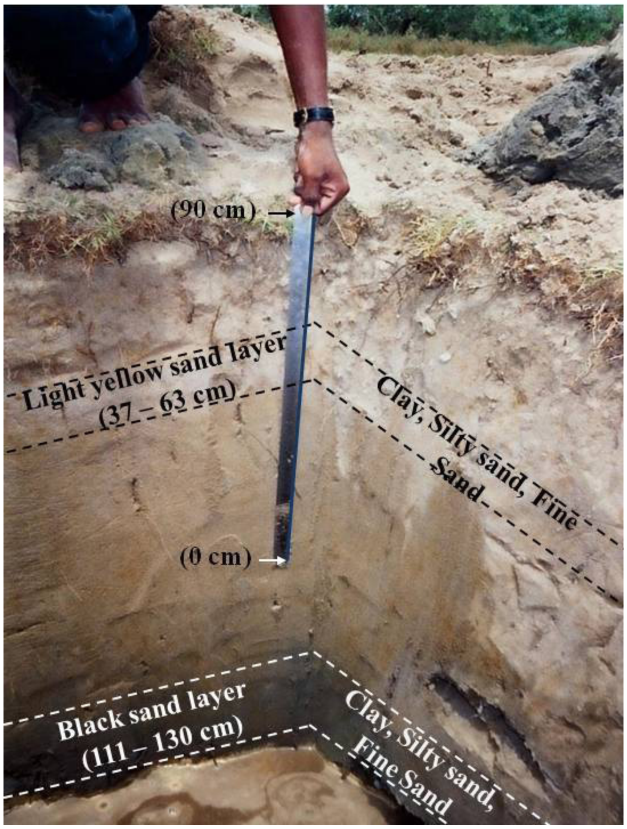

Figure 2. Vertical trench excavated at the study area in the southeast coast of India.

Heavy minerals are more abundant in sediment collected at depths of 37-63 cm (27.06 %) and 111-130 cm (23.16 %). The heavy mineral assemblage comprises tourmaline, zircon, rutile, garnet, magnetite, ilmenite and chlorite (Figure 4). Additionally, the presence of lighter mica flakes suggests that they possibly represent the final phase of deposition due to the higher specific gravity of the heavy mineral and micas are also dominant in the upper part of the sequence which is also finer-grained in nature. The lighter minerals float in the water column for some time before their deposition on the upper part of these layers.

Our results clearly suggest that the sediment present at depths of 37-63 cm and 111-130 cm represent two different phases of deposition during/after extreme wave events, where the sediment, heavy minerals assemblage and the microfossils are transported to the continental region and deposited subsequently. However, more studies are also needed in this region to ascertain the exact provenance of the sediment and further radiometric dating is required to know the age of these deposits.

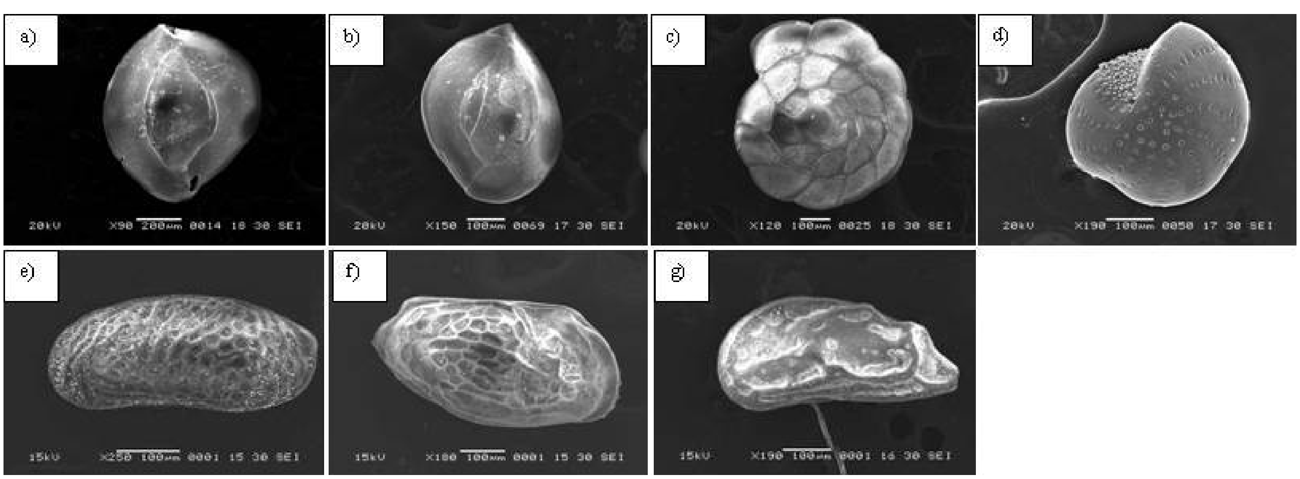

Figure 3. Microfossils present in the subsections of 37-63 cm and 111-130 cm: a) *Quinqueloculina lamarckiana*; b) *Quinqueloculina seminulum*; c) *Ammonia beccarii*; d) *Elphidium norvangi*; e) *Tanella gracilis*; f) *Neomonoceratina iniqua*; g) *Caudites javana*.

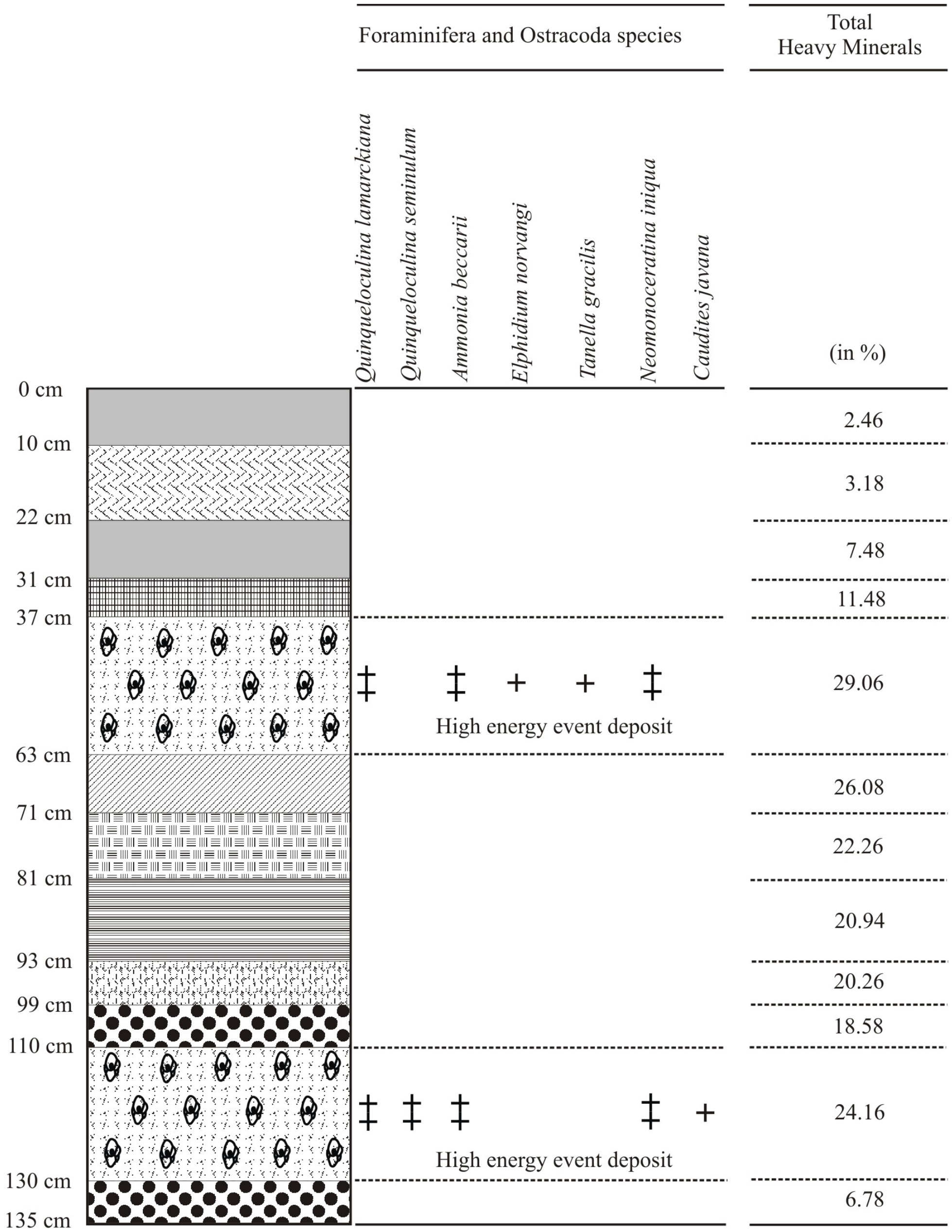

Figure 4. Lithological section indicates the presence of microfossils (+ rare; ‡ abundant) and heavy mineral distributions.

Acknowledgments

SMH wishes to thank the Indian National Centre for Ocean Information Services (INCOIS), Hyderabad for providing the financial assistance and Dr. A.K. Singhvi for encouragement to carry out this work. We are grateful to Prof. S. P. Mohan, Head, Department of Geology, University of Madras, Chennai for his constant support and encouragement. MPJ wishes to express his thanks to SNI, CONACyT, IPN (COFAA, EDI), México. This short note is the 57th contribution from the Earth System Sciences Group (ESSG), Chennai, India.

References

Ahmad, M., Neale, J.W., Siddiqui, Q.A., 1991, Tertiary Ostracoda from the Lindi area, Tanzania: London, The British Museum, Bulletin of the British Museum (Natural History) Geology, 46, 175-270.

Chagué-Goff, C., Dawson, S., Goff, J.R., Zachariasen, J., Berryman, K.R., Garnett, D.L., Waldron, H.M., Mildenhall, D.C., 2002, A tsunami (*ca*. 6300 years BP) and other Holocene environmental changes, northern Hawke's Bay, New Zealand: Sedimentary Geology, 150, 89-102.

Clague, J.J., Hutchinson, I., Mathewes, R.W., Patterson, R.T., 1999, Evidence for late Holocene tsunamis at Catala Lake, British Columbia: Journal of Coastal Research, 15, 45-60.

Goff, J.R., McFadgen, B.G., 2002, Seismic driving of nationwide changes in geomorphology and prehistoric settlement–a 15th Century New Zealand sample: Quaternary Science Reviews, 21, 2229-2236.

Hussain, S.M., Rajeshwara, R.N., 1996, Faunal affinity, zoogeographic distribution and review of Recent Ostracoda from east and west coasts of India: Bulletin of Pure Applied Sciences, 15, 37-50.

Hussain, S.M., Krishnamurthy, R., Gandhi, M., Ilayaraja, K., Ganesan, P., Mohan, S.P., 2006, Micropalaeontological investigations of tsunamigenic sediments of Andaman Islands: Current Science, 91, 1655-1667.

Hussain, S.M., Mohan, S.P., Jonathan, M.P., 2010, Ostracoda as an aid in identifying 2004 tsunami sediments: a report from SE coast of India: Natural Hazards, 55, 513-522.

Kortekaas, S., Dawson, A.G., 2007, Distinguishing tsunami and storm deposits: An example from Martinhal, SW Portugal: Sedimentary Geology, 200, 208-221.

McKenzie, K.G., Guha, D.K., 1987, A comparative analysis of Eocene/Oligocene boundary Ostracoda from south-eastern Australia and India with respect to their usefulness as indicators of petroleum potential: Transactions of Royal Society South Australia, 111, 15-23.

Milner, H.B, 1962a, Sedimentary Petrography: London, George Allen and Unwin Ltd, Vol.1, 643 p.

Milner, H.B, 1962b, Sedimentary Petrography: London, George Allen and Unwin Ltd, Vol. 2, 715 p.

Nagendra, R., Kamal Kanna, B.V., Sajith C., Sen, G., Reddy, A.N., Srinivasalu, S., 2005, A record of foraminiferal assemblage in tsunamigenic sediments along Nagapattinam coast, Tamil Nadu: Current Science, 89, 1947-1952.

Radtke, U., Schellmann, G., Scheffers, A., Kelletat, D., Kromer, B., Kasper, H.U., 2003, Electron spin resonance and radio carbon dating of coral deposited by Holocene tsunami events on Curaçao, Bonaire and Aruba (Netherlands Antilles): Quaternary Science Reviews, 22, 1309-1315.

Ruiz, F., Rodríguez-Ramírez, A., Cáceres, L.M., Rodriguez Vidal, J.R., Carretero, M.I., Clemente, L., Muñoz, J.M., Yáñez, C., Abad, M., 2004, Late Holocene evolution of the southwestern Doñana National Park (Guadalquivir Estuary, SW Spain): a multivariate approach: Palaeogeography, Palaeoclimatology, Palaeoecology, 204, 47-64.

Ruiz, F., Rodríguez-Ramírez, A., Cáceres, L.M., Vidal, J.R., Carretero, M.I., Abad, M., Pozo, O.M., 2005, Evidence of high-energy events in the geological record: Mid-Holocene evolution of the southwestern Doñana National Park (SW Spain): Palaeogeography, Palaeoclimatology, Palaeoecology, 229, 212-229.

Ruiz, F., Abad, M., Cáceres, L.M., Vidal, J.R., Carretero, M.I., Pozo, M., González-Regalado, M.L., 2010, Ostracods as tsunami traces in Holocene sequences: Quaternary Research, 73, 130-135.

Srinivasalu, S., Thangadurai, N., Switzer, A.D., Ram Mohan, V., Ayyamperumal, T., 2007, Erosion and sedimentation in Kalpakkam (N Tamil Nadu, India) from the 26th December 2004 tsunami: Marine Geology, 240, 65-75.

Manuscript received: January 2, 2012.
Corrected manuscript received: September 14, 2012.
Manuscript accepted: September 20, 2012.