

Impact of the 2004-tsunami on the geology of Car Nicobar Island

The historic tsunami of 2004 in the northern Indian Ocean severely affected the eastern coastal areas of peninsular India and Andaman–Nicobar Islands, besides the neighbouring countries. The Andaman–Nicobar Islands experienced intense damage to the coastline, at places reaching several hundred metres deep into the island with loss of human lives. Car Nicobar is one such area badly affected by the tsunami in a broad belt running along the shore (Figure 1), killing about 600 inhabitants.

One of us (V.S.) who visited Car Nicobar in 1967–1968 for detailed geo-

logical study made a visit to the island again in October 2008, to examine the impact of the tsunami. The island has an extensive span of sea on all sides and was the worst hit area in the Andaman–Nicobar Islands. The present work is the result of observations made in the late sixties and after the 2004 tsunami.

Car Nicobar Island, being the type area of Neogene stratigraphic units and one of the earliest studied areas for detailed micropalaeontological work, occupies a distinct place in the geology of Andaman–Nicobar Islands located in the northeastern Indian Ocean. The stra-

totype sections of Sawai Bay Formation as well the Sawaian Stage are located at Car Nicobar. Geological work on Car Nicobar dates back to the *Novara* expedition. Hochsetetter, the geologist on-board, collected samples from Car Nicobar, Java and New Zealand, which were studied by various workers, C. Schwager being one of them. Schwager¹, who studied foraminifera from Car Nicobar, described the presence of ‘two layers’ on the island, without naming the lithology. Jacob and Sastri² reported two lithological units at Sawai Bay: the ‘nodular clay’ and the overlying ‘arenaceous limestone’.

The first detailed stratigraphic classification of Car Nicobar was presented by Srinivasan and Sharma³, who identified two mappable lithological units, viz. Sawai Bay Formation and Malacca Limestone Formation (Table 1). The Sawai Bay Formation was further subdivided into Sawai Bay Mudstone Member and Sawai Bay Limestone Member³. Later, the ranks of these two members were elevated and the lithostratigraphic units were named ‘Sawai Bay Formation’ and ‘Guitar Formation’⁴. The Malacca Limestone Formation was placed within the Neill West Coast Formation⁴. A brief description of the various lithological units present in Car Nicobar, as described in Sharma and Srinivasan⁷, is presented in the following section.

The Sawai Bay Formation consists of moderately hard, highly calcareous, light to bluish-grey mudstone with calcareous concretions and occasional thin sandstone bands, particularly in the section at Sawai Bay, where it is well developed. The formation is exposed from the Abbeville Point northwards to Mus Jetty and beyond at Sawai Bay and along the road cutting at Passa Bridge. Also, a small outcrop of the Sawai Bay Formation is seen east of the village Kakana at the southeastern tip of the island. Car Nicobar was designated the type area and Sawai Bay section as the type section of the formation.

Conformably overlying mudstone of the Sawai Bay Formation is the Guitar Formation, comprising limestone which varies from sandy (at Mus Jetty) to coarse-grained, shelly variety containing fragments of bivalves, gastropods, etc. (at Abbeville Point, Sawai Bay) and

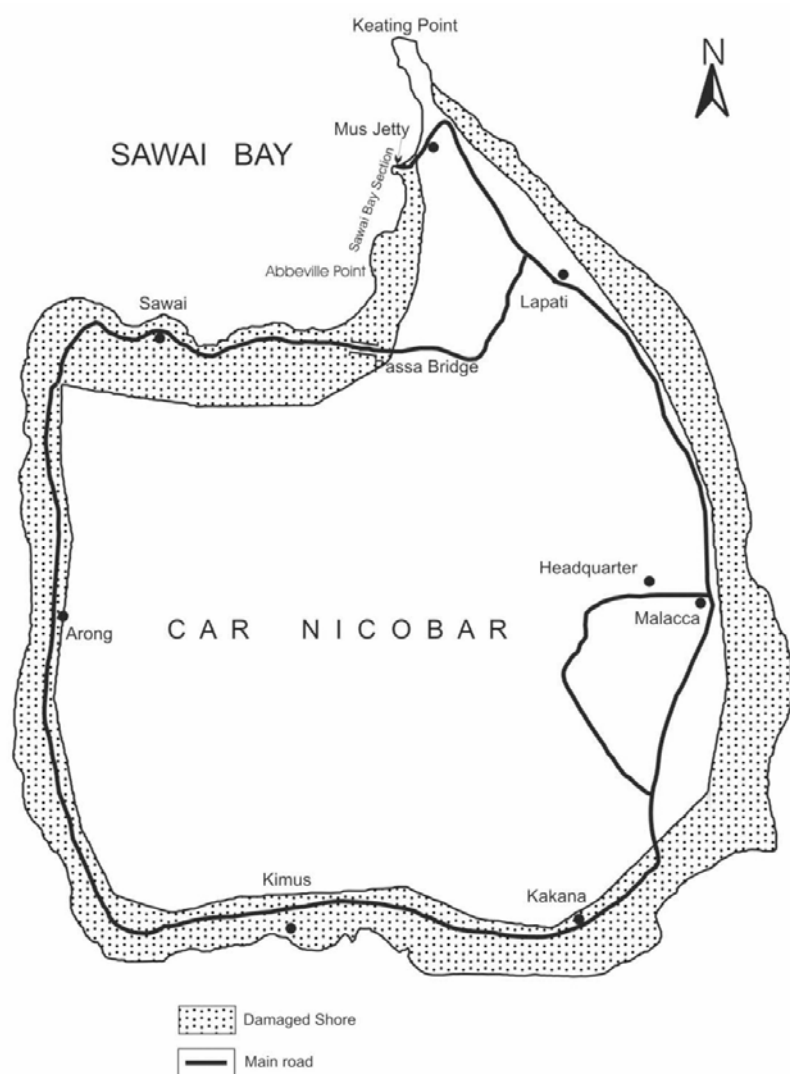


Figure 1. Map of Car Nicobar, showing coastline damaged by the 2004 tsunami (courtesy: Andaman–Nicobar Administration). Original map simplified to show only the damaged shore. Places marked on the map are pre-tsunami locations; presently (post-tsunami) most locations are shifted towards the interior of the island.

SCIENTIFIC CORRESPONDENCE

Table 1. Pre-tsunami and post-tsunami lithologic succession of Car Nicobar

Car Nicobar (pre-tsunami) ³		Car Nicobar (post-tsunami) (Present work)	Lithology
Archipelago Group			
Malacca limestone Formation	(= Neill West Coast Formation ⁴)	Neill West Coast Formation	White, hard, compact, semicrystalline foraminiferal limestone
	Unconformity	Unconformity	
Sawai Bay Formation			
Sawai Bay Limestone Member	(= Guitar Formation ⁴)	Guitar Formation	Sandy to coarse-grained shelly limestone
Sawai Bay Mudstone Member	(= Sawai Bay Formation ⁴)	Sawai Bay Formation	Moderately hard, highly calcareous, grey to bluish-grey mudstone
		Unconformity	
Base obscure		Long Formation	Dirty-white, soft to moderately hard, calcareous sandstone

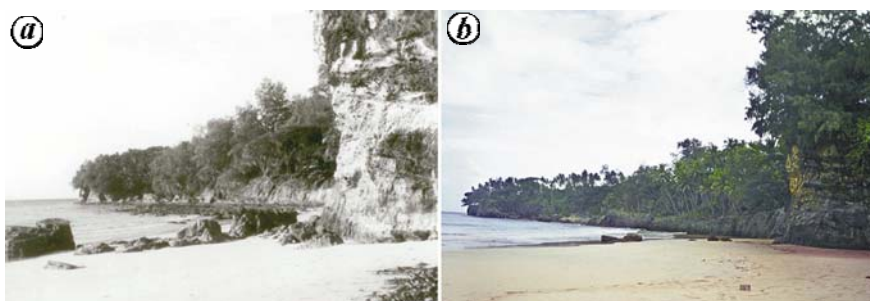


Figure 2. Two views of the Sawai Bay section located in the northern part of Car Nicobar. *a*, Photograph taken in 1967. *b*, Photograph taken after the 2004-tsunami, in 2008. Note that huge boulders in the foreground have almost vanished.

occupying a large area on Car Nicobar Island.

The youngest lithostratigraphic unit at Car Nicobar belongs to Neill West Coast Formation that is a white, hard, compact, semicrystalline limestone and which lies over the Guitar Formation probably with an unconformity.

The great Indian Ocean earthquake of 2004 resulted in significant ground deformation (uplift and subsidence) in the Andaman–Nicobar Islands, including Car Nicobar^{5,6}. The ensuing tsunami, which devastated the coastline of Car Nicobar, washed away huge boulders lying on the shore at Sawai Bay section in the northern part of the island (Figure 2). It also exposed relationship, hitherto unknown, among the rock formations. The rock boulders which were covering the exposures and obscuring the relationship among different strata were completely washed away due to the impact of the tsunami, revealing the relationship between the mudstone of the Sawai Bay Formation and the rock formation below it.

The purpose of this correspondence is to amend the stratigraphy of Car Nicobar in the light of the recent discovery of relationship, until now undescribed, between the mudstone of the Sawai Bay Formation and the underlying rock unit. The updated stratigraphy of Car Nicobar is, thus, based on the stratigraphic classification as described in Sharma and Srinivasan⁷, and on the recent finding by one of us (V.S.). The mudstone of the Sawai Bay Formation, which was so far considered the oldest exposed lithologic unit in the stratigraphy of Car Nicobar, is found underlain unconformably by calcareous sandstone (Figure 3). The sandstone is dirty-white, soft to moderately hard, sometimes friable enough to crumble between fingers. Petrographically, it is almost wholly composed of carbonates in the form of grains of calcite and numerous tests of planktic and benthic foraminifera and a few mica flakes. It shows dense packing and has locally developed porosity due to removal of foraminiferal tests. The outcrop of the

rock is seen at Abbeville Point of the Sawai Bay Section. However, since the work of Schwager¹, every subsequent authors^{2–4} has reported two lithological units in this section, viz. mudstone overlain by a limestone. And, obviously, they were unaware of the relationship of the mudstone with the calcareous sandstone due to the presence of rolled blocks and dense vegetation.

Lithology and stratigraphic disposition of the calcareous sandstone suggest that it can be assigned to the Long Formation. The Long Formation is comprised of calcareous sandstone to silty mudstone, siliceous chalk and limestone, and spans from Middle to Late Miocene (*Praeorbulina glomerata* Zone to *Globorotalia pleiotumida* Zone)⁴. However, facies variant of the formation has been reported⁷ from Havelock (silty mudstone with interbedded hard calcareous bands), Nancowry–Kamorta (silty mudstone) and Little Andaman (calcareous mudstone) islands. At Long Island (the type locality of Long Formation), soft calcareous silty mudstone belonging to the Long Formation is overlain by Sawai Bay Formation comprising grey, calcareous mudstone⁸. The exact nature of the contact between the two formations is, however, not clear as it is marked by a ‘no exposure zone’. At Guitar Island, the silty mudstone of Long Formation is overlain unconformably by the limestone belonging to the Guitar Formation⁹.

The calcareous sandstone has yielded both planktic and benthic foraminifera. However, the fossils are poorly preserved. From a large number of picked specimens of planktic foraminifera (about 1200), the following species have been identified:

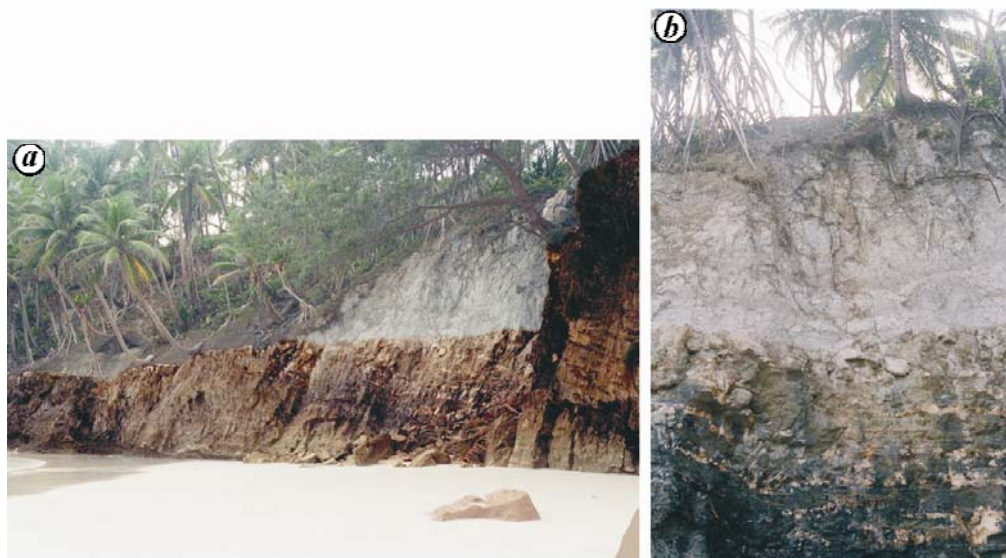


Figure 3. *a*, Photograph showing Early Pliocene Sawai Bay mudstone unconformably underlain by the Late Middle Miocene calcareous sandstone. *b*, A closer view of the two lithologic units. Photographs taken in 2008.

Globigerinoides quadrilobatus, *Globigerinoides sacculifer*, *Globigerinoides obliquus*, *Globigerinoides triloba*, *Globoquadrina venezuelana*, *Orbulina universa*, *Dentoglobigerina altispira* and *Globigerinella aequilateralis*. No specimens referable to *Globorotalia* (*Fohsella*) lineage are encountered, nor does the assemblage show the presence of *Neogloboquadrina acostaensis*. Based on the assemblage, the rock can be assigned a late Middle Miocene age, falling within the *Globorotalia siakensis*–*Globorotalia menardii* zones (N13–N15). Thus, in the Car Nicobar sequence, which spans from Late Middle Miocene to Plio-Pleistocene, the strata of Late Miocene are absent.

1. Schwager, C., *Geol. Theil.*, 1866, **2**, 187–268.
2. Jacob, K. and Sastri, V. V., *Sci. Cult.*, 1951, **17**, 181–182.

3. Srinivasan, M. S. and Sharma, V., *J. Geol. Soc. India*, 1973, **14**, 1–11.
4. Srinivasan, M. S. and Azmi, R. J., In Proc. VI Indian Colloquium on Micropaleontology and Stratigraphy, Varanasi, 1976, pp. 302–327.
5. Rajendran, C. P., Rajendran, K., Earnest, A., Anu, R., Machado, T. and Freymeuller, F., *Bull. Seismol. Soc. Am.*, 2007, **97**, S174–S191.
6. Rajendran, K., Rajendran, C. P., Earnest, A., Ravi Prasad, G. V., Dutta, K., Ray, D. K. and Anu, R., *Tectonophysics*, 2008, **455**, 53–60.
7. Sharma, V. and Srinivasan, M. S., *Geology of Andaman–Nicobar: The Neogene*, Capital Publ. Co, New Delhi, 2007, p. 163.
8. Srinivasan, M. S. and Srivastava, S. S., *Micropaleontol. Spec. Publ.*, 1975, **1**, 124–161.
9. Azmi, R. J. and Srinivasan, M. S., In Proc. VI Indian Colloquium on Micropaleontology and Stratigraphy, Dehradun, 1974, pp. 55–58.

ACKNOWLEDGEMENTS. We thank the officials of Andaman–Nicobar Administration

for permitting one of us (V.S.) to visit Car Nicobar, a reserved area in the Andaman–Nicobar Islands. We also thank Prof. M. S. Srinivasan, Department of Geology, Banaras Hindu University, Varanasi for providing useful suggestions that helped improve the manuscript. Mr S. K. Dass, Department of Botany, University of Delhi, helped with the photographs.

Received 26 October 2010; revised accepted 3 January 2011

V. SHARMA*
SHILPA BAJPAI

*Centre of Advanced Study for Geology,
Department of Geology,
University of Delhi,
Delhi 110 007, India*

**For correspondence.*

e-mail: vsharma752004@yahoo.co.in