Recently, graphitic carbon was shown to catalyse aerial oxidation[9] and this may correlate the role of nanosized carbon black affecting neurotransmitter levels and pro-inflammatory expressions[3]. In case of graphitic carbon, its nonavailability in nanosize form indoors prevents its inhalation. This is not valid for SFCNT as they readily float in the air, according to our present observation. This study showed that indoor spider webs within days collect matter by trapping considerable amount of floating particulates inside a room which are potent materials for uptake by effortless human breathing. The catalytic action of SFCNT in generating superoxide radical strongly suggests that these may trigger direct inflammasome type activation[2]. Thus, these abiotic SFCNT may imitate impulsive pseudo phagocytosis.

Degradation of SFCNT is difficult and its size may not allow ready precipitation causing its gradual accumulation in indoor aerosols which on exceeding a threshold may lead to catastrophic consequences.

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Impact of the 2004 earthquake on the limestone caves in North and Middle Andaman Islands

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We evaluated the effects of the great earthquake of December 2004 on 43 inland caves in the Andaman and Nicobar Islands. Data was collected before and after the earthquake. The number and size of fallen rocks within the caves were taken as a measure of physical damage to the caves. Rockfall was greater in caves located above ground ($Z = -3.543$, $P = 0.000$) and in larger caves ($\chi^2 = 18.545$, $df = 3$, $P = 0.000$), indicating significantly higher damage to these caves. The impact of damage to the microclimate and ecosystem inside the caves is also discussed.

Keywords: Andaman and Nicobar Islands, habitat aulteration, limestone caves, rockfall, tsunami.

THE Arakan Yoma arc through Myanmar, Andaman and Nicobar Islands to Sumatra and beyond is a seismically active zone[1]. Geologically, the Andaman island arc can be separated into two concentric arcs: the outer arc is sedimentary and includes the main chain of islands, whereas the inner arc which includes Barren and Narcondam Islands is volcanic. The rocks occurring in these islands are mainly marine deposits from Cretaceous to Recent[1–3].

Caves can form only in lithified rocks, i.e. the rocks formed by aggregation of particulate matter[4] and their location is controlled by the original sediment character and diagenetic history, i.e. changes that result from the sedimentary processes during the transformation of the sediments into rock[5,6]. The Andaman and Nicobar Islands, located between 6°45′N–13°41′N and 92°12′E–93°57′E, have several caves and cave complexes. Most caves in the Andaman and Nicobar Islands fall into two broad categories: (a) those formed by underground drainage and erosion in Limestone Formations, the channels thus formed have been later cut into by sub-aerial erosion and exposed, and (b) those formed in sea cliffs by marine erosion of rocks[6].

Of the several caves in the Andaman and Nicobar Islands, Sankaran[4] located and mapped 384 caves, of which 61.5% (236) were inland (located within the forest) and the rest coastal (located on the shore). Among the 236 inland caves, 86% were underground, of which 1% was located at the origin of a stream. Fourteen per cent of

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the caves seen above ground were sub-divided into those located on inland cliffs (3%) and those seen on inland hills (97%; Figures 1 and 2). Caves were also categorized by their size as small, medium, big and very big.

A subduction of the Indo-Burma plate occurred due to the M 9.15 earthquake of 26 December 2004, the epicentre of which was located 150 km off the west coast of northern Sumatra Island in Indonesia. It led to significant ground deformation in the Andaman and Nicobar region. The Andaman and Nicobar Islands lie within the subduction zone of the Burma plate, north of the epicentre, and was the most affected region in India[7–10]. In the subsequent months after the major earthquake, a series of aftershocks were also experienced.

Cave ecosystems are amongst the most fragile ecosystems on earth, as cave fauna are very sensitive to microclimatic factors such as light, temperature and humidity[10]. Caves are unique in several ways. They are sites of speciation and endemism and the fauna of caves often have characteristic adaptations such as low or no pigmentation, poor or no sight and ability to survive with low oxygen. Although considerable information exists on the impact of the earthquake and tsunami on people, habitations and coastal ecosystems, their effects on caves have not been documented. In this paper, we document the impact of the 2004 earthquake on the caves in the North and Middle Andaman Islands.

We examined the impact of the earthquake on 27 of the 28 aboveground caves in the Chalis–Ek cave complex in a limestone hillock in North Andaman Island, and 16 below ground caves situated on the Interview Island (Table 1). We estimated the extent of damage within the caves by counting the number and size of fallen rocks. The fallen rocks were measured and categorized into size classes: boulder (big >1.5 m, medium 1–1.5 m and small 0.6–1 m), rocks (big 0.3–0.6 m, medium 0.15–0.30 m and small 0.10–0.15 m) and chips (<0.10 m). While the boulders and rocks were counted, the number of fallen chips was visually estimated as an approximate proportion to the total fallen rocks. Structural changes like the forma-

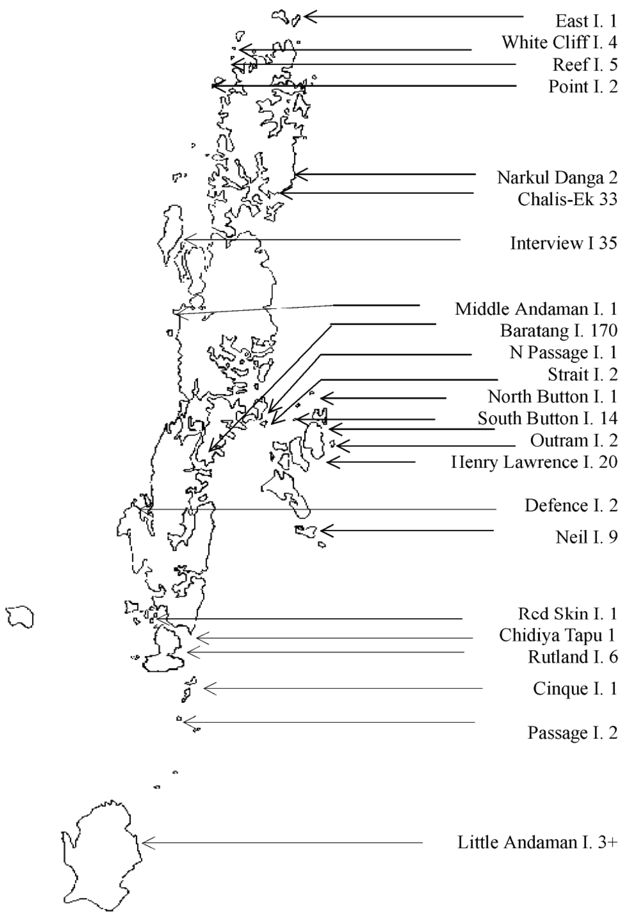

Figure 1. The location and number of the caves in the Andaman Islands[4].

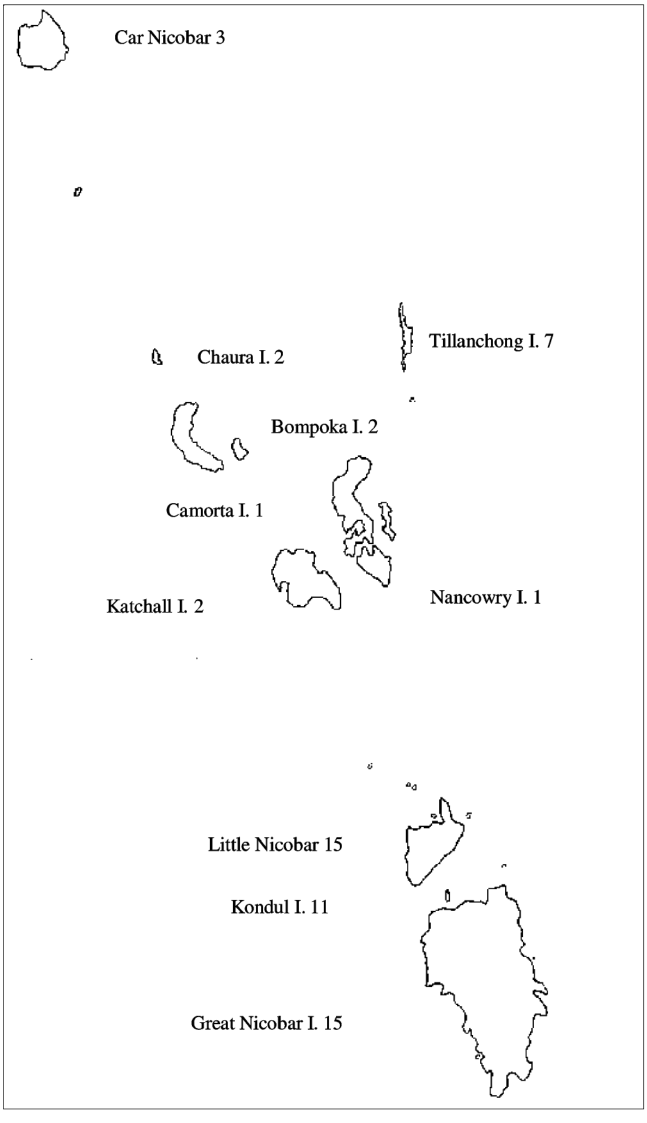

Figure 2. The location and number of the caves in the Nicobar Islands[4].

Table 1. The extent of damage in different type and size of caves in North and Middle Andaman Islands

Cave code no.	Cave size	Cave type	No. of openings pre-earthquake	No. of openings post-earthquake	Extent of damage
Caves at Chalis–Ek, Pattilevel, North Andaman					
1	Small	Above ground	1	1	Nil
2	Medium	Above ground	2	2	Medium
3			Not studied		
4	Big	Above ground	3	3	High
5	Medium	Above ground	1	1	Low
6	Big	Above ground	3	3	Low
7	Medium	Above ground	1	1	High
8	Very big	Above ground	2	1	High
9	Medium	Above ground	2	2	Medium
10	Big	Above ground	2	2	Low
11	Small	Above ground	1	1	High
12	Small	Above ground	1	1	Nil
13	Small	Above ground	1	1	High
14	Small	Above ground	1	1	Nil
15	Small	Above ground	1	1	Nil
16	Medium	Above ground	2	2	Low
17	Very big	Above ground	2	2	High
18	Small	Above ground	1	1	High
19	Small	Above ground	1	1	Nil
20	Small	Above ground	1	1	Nil
21	Small	Above ground	1	1	Nil
22	Very big	Above ground	1	1	Low
23	Small	Above ground	1	1	Low
24	Very big	Above ground	2	2	High
25	Medium	Above ground	1	1	Nil
26	Small	Above ground	1	1	Nil
27	Small	Above ground	1	1	Nil
28	Small	Above ground	1	1	Nil
Caves at Interview Island Wildlife Sanctuary, Middle Andaman					
2	Very big	Below ground	1	1	Nil
3	Small	Below ground	1	1	Nil
4	Medium	Below ground	1	1	Nil
5	Medium	Below ground	1	1	Nil
7	Small	Below ground	1	1	Nil
8	Small	Below ground	1	1	Nil
9	Small	Below ground	1	1	Nil
10	Small	Below ground	1	1	Nil
11	Small	Below ground	1	1	Nil
12	Small	Below ground	1	1	Nil
13	Small	Below ground	1	1	Nil
14	Small	Below ground	1	1	Nil
15	Medium	Below ground	1	1	Nil
16	Small	Below ground	1	1	Nil
17	Big	Below ground	2	2	Nil
18	Small	Below ground	1	1	Nil

tion of new openings or the closure of existing ones were also recorded. The damage to the cave was qualitatively categorized as high, medium, low and nil. We also analysed the extent of and size of rockfall and the overall damage to caves according to cave type and size[11].

Visible damages due to the earthquake included: (1) widening, narrowing, partial or complete closure of existing cave mouths, (2) fallen rocks within caves, and (3) development of cracks and fissures. Damage that was not visible included shift in position of the rocks, loosening of rocks and development of internal cracks. Sixteen of the 43 caves (37%) were damaged whereas 27 caves (63%) had no apparent signs of damage. The cave mouths were induced in five (31%) of the caves with damages. In the case of one cave the mouth was narrowed, partially or completely closed (6%). Rock-fall within the caves had occurred in 15 caves (35%). One cave had developed only cracks (2%).

Rock-fall differed significantly between the below ground and above ground caves (Mann–Whitney test, $Z = -3.543$, $P = 0.000$). There was zero or negligible rockfall in caves that were below ground, whereas in 15 of the 27 caves above ground (56%), there was rockfall. The amount of rockfall varied significantly with the size of the cave and was least in the small caves and highest in very big caves ($\chi^2 = 18.545$, $df = 3$, $P = 0.000$). In terms of the overall extent of damage inside caves, categorized according to the amount of rock-fall and other visible signs of damage, eight caves were highly damaged, two were moderately damaged and six less damaged. The damage was least in the small caves and increased with cave size (Figure 3; Table 1). The proportion of the size of the fallen rocks to the total fallen rocks varied between caves ($\chi^2 = 43.325$, $df = 6$, $P = 0.000$), but showed no difference with respect to cave size (Figure 4).

The most significant finding of this study has been that there was far more damage due to the earthquake in caves that were above ground than in caves that were below ground. This can be attributed to the structure of the caves, size, rock type and the location of the cave, and the presence of buffers against the earthquake waves. Most of the caves above ground had irregular walls and ceilings with projecting rocks, whereas the caves below ground had more regular standing walls and dome-shaped ceilings with almost no boulders or rocks projecting out of the wall or ceiling except the stalactites hanging from the roof or running down the walls.

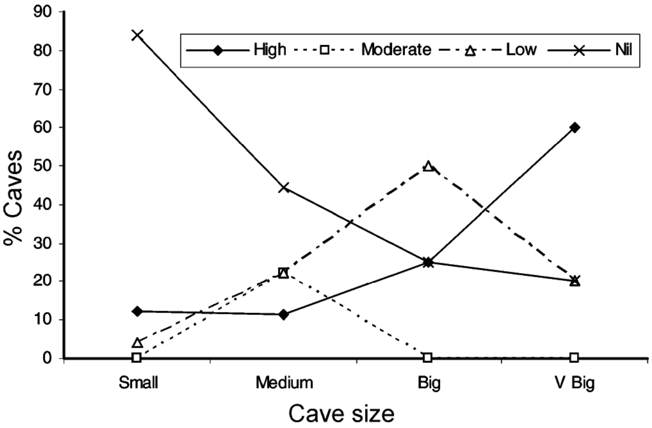

Figure 3. Damage inside the caves with respect to size of the caves.

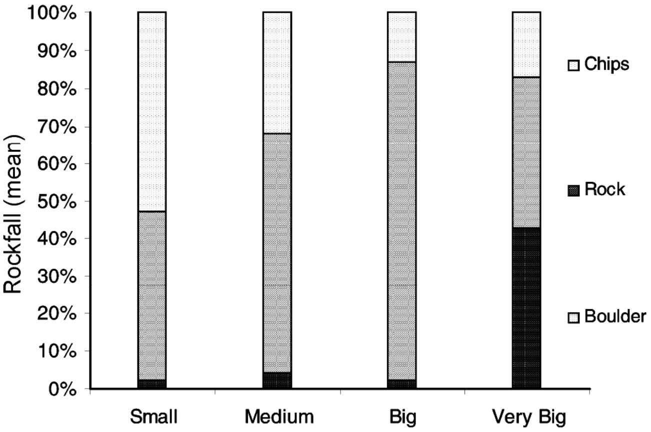

Figure 4. Proportion of the different rock sizes fallen inside caves in North and Middle Andaman Islands.

Implications of the damage caused to the cave fauna due to the earthquake were dependent on the type of fauna and nature of its association with caves. In none of the caves we could see troglobites (obligate cave dwelling fauna). We located stygobites (obligate cave dwelling aquatic fauna) in two of the 43 caves. However, these caves were not damaged due to earthquake. We observed that the damage to caves affected trogloxenes (cave fauna which require caves complete part of their life cycle), with the most significant changes that impact them being increased light penetration and light availability within caves due to widening of the existing openings. In two out of five caves, this resulted in the bats and edible-nest swiftlets abandoning or shifting their roosting and nesting sites to darker areas of the caves. In none of the caves under study was there a complete blockage of the entries to the caves. The main entry of one of the caves with two entry points was completely blocked. Although bats continued to access the caves through the second opening, the edible-nest swiftlet stopped using the cave in 2005, because this species uses the same path and cave openings for entry and exit[12–14]. However, in subsequent years, the swiftlets started using the second opening.

As the rockfall must have killed some organisms present in the cave, we were unable to locate remains of larger troglodytes, primarily bats and swiftlets. While swiftlets leave the cave before dawn, the bats would have been present in the cave at the time of the earthquake (06 : 30 h). Perhaps they sensed the quake and left the cave in time. However, we did not observe any such behaviour, either by bats or swiftlets, during mild aftershocks. Loosening of the rocks of the walls and ceilings inside the caves increased water seepage during the rainy season, adversely affecting the nests of swiftlets at those sites. The increase in seepage in some caves may also have affected the invertebrate fauna of the cave floor that depend largely on guano. There is a possibility of several micro-level effects on the ecosystem which is beyond the scope of our present study as very less or no information is available about the biospeleology of Andaman and Nicobar Islands.

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U–Pb zircon age for a granite intrusion within the Shyok suture zone, Saltoro Hills, northern Ladakh

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In the Saltoro Hills of northern Ladakh, Shyok volcanics of the Shyok suture zone are dissected by a ~5 m wide granite intrusion. Such granitic intrusions, in the Shyok volcanics are more pronounced to the west of Udmaru village and could be observed for several hundred metres. The Cretaceous Shyok volcanics consist of basalts and andesites. U–Pb age data from separated zircon suggests that the crystallization age of this calc-alkaline granitic body is 24.52 ± 0.40 Ma. Younger granitic intrusion or body has not been reported earlier from the Shyok suture zone of northern Ladakh, however, the younger intrusive bodies ranging between 25 and 17 Ma have been recorded from the Baltoro and Tangtse–Mugalib plutonic unit of the Karakoram block. Therefore, it is most likely that the young post-collisional intrusive phase of the Shyok suture zone and the Karakoram block are similar and may be part of a common major late-to-post-tectonic plutonic phase of the Karakoram batholith or they are related to the incipient synkinematic activity along the Karakoram fault.

Keywords: Granite, northern Ladakh, Shyok suture zone, Shyok volcanics, U–Pb zircon.

IN northern India, the Ladakh block lies between the Indian plate in the south and the Eurasian plate in the north[1]. To the west, this block is separated from the Kohistan complex[2] by the Nanga Parbat–Haramosh syntaxis and to the east it is separated from the Lhasa block by the Karakoram fault (Figure 1). Most workers interpreted the Ladakh block and the Kohistan complex, as one single accreted island arc terrane[3–7]. The Ladakh block is bounded by two suture zones – the Indus suture in the south and the Shyok suture to the north. These sutures mark the closing of different branches of the Tethys Ocean. The Indus suture records the final collision of India with Asia at 60–50 Ma (refs 3 and 8–10). The complex sequence of rocks that occur along the Indus suture is characterized by obducted remnants of the Neo–Tethyan oceanic crust[10]. The more northerly Shyok suture (Figure 1) separated Ladakh from the Asian continental rocks of the Karakoram mountains to the north and contains ophiolitic mélanges and thrust units derived from the southern Asian margin, which were juxtaposed when Kohistan/Ladakh collided with Asia during 102–85 Ma (refs 3 and 5). The Shyok suture zone is interpreted as a suture embodying the rocks of a marginal basin[11,12]. Recently, it has also been interpreted that the Kohistan arc is a fully oceanic arc[13,14], possibly formed near the equator in early Cretaceous time[15]. This interpretation implies that the Shyok suture zone records the destruction of a large oceanic basin.

In Saltoro Hills (Figure 1) the rocks of the Shyok suture zone trending northwest–southeast across the Nubra–Shyok valleys occur within intensely deformed tectonic slices between the Ladakh batholith to the southwest, and the Karakoram batholith to the northeast (Figure 1). Across a traverse through the Shyok–Nubra river valleys and the adjoining part of the Karakoram block, these tectonic slices comprise a variety of sedimentary, metamorphic and igneous rocks interpreted as an ancient accretionary complex[4,5,11,12,16]. From south to north, i.e. from the structural bottom to top, these tectonic units are: Saltoro/Hundri formation, Shyok volcanics, Saltoro

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