in the Australia–Sunda plate boundary, within a short span of three months, producing the great earthquake of 28 March 2005. Such a triggering mechanism probably explains the frequent occurrence of large earthquakes around this plate junction, as indicated by records of historical earthquakes. Finite element modelling of stress field in three dimensions incorporating the plate geometries, geological ages and hence the mechanical properties of the slabs, their thicknesses, depths of penetration of the subducting slabs along different sections, and the differential velocities of plates involved, is likely to shed further light on the current understanding of the mechanism of multiple plate interactions and the resulting large earthquakes.

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ACKNOWLEDGEMENTS. We thank M. Ravi Kumar and D. S. Ramesh for useful suggestions and comments. We are grateful to Director, NGRI for permission to publish this work.

Received 6 April 2005; revised accepted 9 June 2005

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28 March 2005 Sumatra earthquake: expected, triggered or aftershock?

The recent great earthquake of 28 March 2005 (M_w 8.7) occurred about 150 km SE of the earlier giant earthquake (M_w 9.3)[1] of 26 December 2004. Here we attempt to answer (i) whether the recent great earthquake was an expected event whose possibility of occurrence was mooted by McCloskey *et al*.[2]; (ii) whether it was triggered by the giant earthquake of 26 December 2004; or (iii) whether it is an aftershock of the giant earthquake of 26 December 2004.

Before we discuss the first and second issues, which are in a way coupled, we provide a brief description of tectonics of the region. In this region of the two earthquakes, the Indian–Australian plate moves towards NNE at a rate of about 6 cm/year. This results in an oblique convergence at the Sunda and Andaman trench. The oblique motion is partitioned into thrust-faulting and strike-slip faulting[3]. The former occurs in the subduction zone, while the latter occurs on the Sumatra Fault System (SFS), which is located a few hundred kilometres to the east of the trench in the back-arc region. There are also evidences of spreading in the back-arc region, which is consistent with the normal focal mechanisms of the earthquakes. Further southeast, the subduction zone swings towards east and becomes perpendicular to the Indian–Australian plate motion and the entire deformation is accommodated through thrust motion in the subduction zone. Following the 26 December 2004 Sumatra earthquake, aftershocks occurred along the two belts (Figure 1). Thrust-type aftershocks occurred in the subduction zone, while strike-slip and normal-type aftershocks in the region of SFS. McCloskey *et al*.[2] calculated the change in stresses, referred as Coulomb stresses, due to the coseismic reverse slip on the rupture of 26 December 2004 earthquake in the subduction zone and resolved these stresses on the right lateral strike-slip planes corresponding to faults in the SFS, as well as on thrust planes in the subduction zone. They found increase in stress on strike-slip faults in the SFS, and also on the thrust planes in the subduction zone further southeast of the 26 December 2004 giant earthquake rupture. Increase in Coulomb stress in the back-arc region is consistent with the results of Taylor *et al*.[4], who studied the cycle-related stress changes induced by the main event which promotes or decreases the likelihood of strike-slip and/or normal events in the back-arc regions of Aleutians and Indonesia. Incidentally, we also performed such computations independently and arrived at similar conclusions (Figure 1). During February 2005, we circulated our results among many of our colleagues and presented them in some meetings and seminars. In addition, we explored the possibility of triggering of a strong earthquake in NE India and Myanmar and also investigated the swarm of aftershocks immediately east of the Nancowry group of islands, which started on 24 January 2005 and continued for about ten days. Focal mechanisms of these aftershocks indicated strike slip and normal slip motion, with their epicentres on SFS.

The above analyses suggested that the 26 December 2004 earthquake increased Coulomb stresses in three regions, namely near the northern and southern edges of the earthquake rupture, and on the SFS to the east of the rupture in the back-arc region. Increase on the northern edge of the rupture may not be significant as low slip on rupture is reported in this region. Thus the above two regions could be the locale of future earthquakes, as also indicated by McCloskey *et al*.[2]. The recent earthquake actually occurred in the increased stress zone that lies to the southeast of the rupture of 26 December 2004 earthquake.

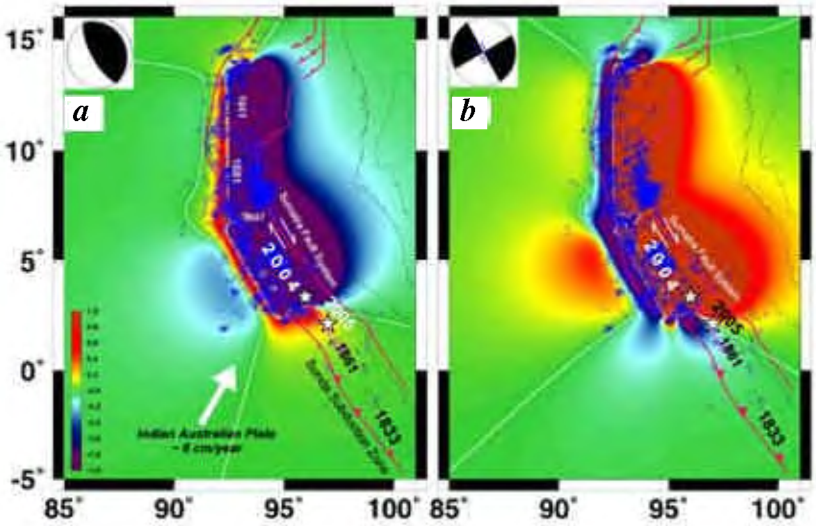

Figure 1. Coulomb stresses (in bar) on thrust planes simulating subduction zone (***a***) and on right lateral strike-slip fault planes simulating Sumatra Fault System (SFS) (***b***). In (***a***), note the increase in stress near the southeastern edge of the 26 December 2004 earthquake rupture, where recent earthquake of 28 March 2005 occurred. In (***b***), note increase in stress on right lateral strike slip faults of the SFS. Stars indicate epicentres of the two main shocks. Blue and magenta coloured circles represent aftershocks of the two earthquakes till 31 March 2005. Coulomb stresses have been calculated at 10 km depth. The slip on the 1200 km long and 150 km wide rupture of 26 December 2004 earthquake has been assumed to be 20 m near the southern edge, which decreases linearly up to 5 m under the Andaman islands. Hot colours show increase in stress and vice versa.

Hence it can be stated that this earthquake was expected. Based on the above analyses, the region of SFS that lies to the east of the two earthquake ruptures may experience a strong earthquake in near future.

Further, on the basis of the above analysis, it can be stated that this earthquake was triggered by the earlier earthquake of 26 December 2004, as the latter increased Coulomb stress in the source region of this earthquake by about 1 bar.

The other issue pertaining to this earthquake is whether it is an aftershock of the earlier earthquake of 26 December 2004. Aftershocks are defined as 'earthquakes that follow the largest earthquake of an earthquake sequence. They are smaller than the main shock and within 1–2 fault lengths distance from the main shock fault. Aftershocks can continue over a period of weeks, months, or years. In general, the larger the mainshock, the larger and more numerous the aftershocks, and the longer they will continue'. Thus from the definition, it appears that the recent earthquake was an aftershock of the earlier earthquake. However, we differ on this view and suggest the following. Analyses of GPS and palaeogeodetic data[5–8] from Sumatra island suggests the presence of a locked zone with full coupling along the subduction zone in southern Sumatra. However, the coupling was not found to be prominent in northern Sumatra, leading to slower rate of strain accumulation. The recent earthquake occurred in the northern part of the southern Sumatra locked zone and released the accumulated strain. Thus the evidence of strain accumulation suggests that in any case this earthquake was imminent[8]. The earlier earthquake only advanced the occurrence of this earthquake by increasing the stress on it. So it is an earthquake occurring because of fault interaction and we prefer to call it a main shock or an independent earthquake. Further, it may be noted that after 26 December 2004 mainshock, only a few earthquakes occurred in the source region of the recent earthquake, which could be a part of background seismicity. Thus it appears that almost no aftershocks of the 26 December 2004 main shock occurred in the source region of the recent earthquake.

The previous earthquake in this region occurred in 1861. If that earthquake had released all the accumulated strain, then using the trench normal convergence rate of 40.4 mm/yr, and assuming full locking on the fault[7], one arrives at a slip accumulation of about 5.8 m in the intervening period of 144 years. This accumulated slip is approximately consistent with the average coseismic slip of about 6 m on the rupture, moment (1.5×10^{21} Nm) and moment magnitude (M_w 8.7) of the recent earthquake.

Occurrence of the recent earthquake in the locked zone is understandable, but occurrence of the earlier earthquake in the northern Sumatra and Andaman – Nicobar region of low rate of strain accumulation, partial coupling and in the region where at least three major earthquakes of $7.5 > M > 8$ occurred in 1881 and 1941 and 1947, is intriguing. Probably strain accumulation in the region of the 26 December 2004 earthquake was underway for more time than in the neighbouring region of recent earthquake and the previous major earthquakes did not release the entire strain[9]. Hence, though the rate of strain accumulation was slow in northern Sumatra, the available accumulated strain was more. Evidence of strain accumulation and full coupling under southern Sumatra[7,9] in the region of the 1833 earthquake suggests that sufficient strain, corresponding to a slip deficit of about 7 m in 172 years, must have accumulated in this region, which can be released in the next great earthquake. Stress loading from the recent earthquake will only advance the occurrence of an earthquake in this region, analogous to the case of the recent earthquake. One may argue that owing to low slip near the southeastern edge of the recent earthquake rupture, sufficient stress may not have been transferred in the region of 1833 earthquake, as argued above in case of the northern Andaman region. There is already sufficient strain available for an earthquake to occur in this region, which has accumulated in past 172 years since 1833.

We hope that analyses of GPS measurements of pre-, co- and post-seismic deformation in the Sumatra and Andaman–Nicobar region will help in validating some of the above ideas and also in inferring the regions of strain accumulation and increased stress due to post-seismic relaxation of the coseismic stresses, which could be the possible locale of future major earthquake(s).

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ACKNOWLEDGEMENTS. We thank an anonymous reviewer for thoughtful comments, Roland Burgmann for discussions, Director, NGRI, R. K. Chadha and M. Ravikumar for support and DST for financial support.

Received 4 April 2005; revised accepted 23 June 2005

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Borneo's proboscis monkey – a study of its diet of mineral and phytochemical concentrations

Proboscis monkey, *Nasalis larvatus* (van Wurmb, 1787) is a large and sexually dimorphic non-human primate that belongs to the family Cercopithecidae, and more specifically to the subfamily Colobinae, which also includes the langur (leaf) monkeys[1]. The monkeys are endemic to the island of Borneo. Adults have reddish orange crown and back, and the legs, belly, rump patch and tail are white to whitish grey; the rest of the body is pale orange (Figure 1 *a*). Mature males have an elongated and pendulous nose that evolved through natural selection, from which the common name is derived (Figure 1 *b*). The nose, mostly in males, looks like an outsized appendage that is used in sexual display, and also as a voice amplifier[1]. The natural habitat of proboscis monkeys comprises lowland coastal rainforests that include mangroves and peat swamps[2,3]. According to the World Conservation Union, this endangered monkey faces a significant reduction of population in the wild (50% projected or suspected) within the next 10 years[4]. The on-going habitat destruction, agriculture activities, palm-plantation expansions, and hunting may pressure the actual numbers of these rare leaf-eating monkeys to decline at an alarming rate, if long-term conservation measures are not met to safeguard their natural habitats[1–3].

Although leaves are the most easily available food source for arboreal colobines, they are difficult to digest. Other constraints for leaf-eating monkeys include the availability or abundance of specific nutrients in diet and the production of toxic compounds by plants that may act as feeding deterrents[5]. Therefore, colobines can be expected to select an optimal diet containing readily available source of energy such as carbohydrates and lipids, as well as high levels of essential nutrients such as protein and minerals.

India is known for its diversity of 15 species of non-human primates, including five species of colobines such as Hanuman langurs, *Semnopithecus entellus*, Nilgiri langur, *Trachypithecus johnii*, Phayre's langur, *T. phayrei*, capped langur, *T. pileatus*, and golden langur, *T. geei*[6]. These specialized leaf eaters use their sharp molars to cut off leaves and their enlarged salivary glands produce chemicals to facilitate digestion. Furthermore, their stomach is set with fermentation chambers similar to cows, where symbiotic microbes break down leaf fibres to help in digestion[7]. These special features that support leaf-eating are adaptations that define the characters of the subfamily Colobinae[7].

Little is known about the phytochemical influences on foliage selection by wild proboscis monkeys and so far only one field study investigated this aspect[8]. Here we present preliminary data on the mineral and phytochemical concentrations in the diet of a semi-provisioned population of proboscis monkeys that live in an isolated mangrove habitat in northern Borneo.

A small population of wild proboscis monkeys exists in the 162-ha Labuk Bay Sanctuary, located near Samawang village in Sabah (Malaysia), northern Borneo. A local palm-plantation owner manages the private sanctuary. Between 1 May 2002 and 20 June 2003, population surveys were conducted to determine the status of proboscis monkeys in northern Borneo and the selected groups were observed to record data on social interactions using an all-occurrences sampling method[9,10]. During the surveys, plants that were eaten by monkeys were collected for nutritional analysis and results pertaining to the nutritional contents of plant analysis are presented here.

Samples were dried to a constant weight in an oven (60°C) to determine total dry matter. They were then ashed in a muffle