SUMATRA EARTHQUAKE OF DECEMBER 26, 2004 AND ITS AFTERSHOCKS AS RECORDED AT THE KOLAR GOLD FIELD OBSERVATORY, INDIA

A major earthquake was recorded on Sunday, December 26, 2004 at 01:15:17.15 (UTC). The earthquake has been located 2210 km southeast direction of Kolar Gold Fields (Northern Sumatra/Indonesia). The duration of the earthquake signal lasted for more than three hours at the Central Seismic Station (KGF Observatory) and followed by many earthquakes of lower magnitude on the following days. The earthquake has been recorded by broadband sensor at the Central Seismic Station operated and maintained by National Institute of Rock Mechanics under World Bank assisted project by the Department of Science and Technology, New Delhi.

The KGF Observatory was established in 1909 for the benefit of Kolar Gold Fields. A Wiechart Seismograph was installed at the Observatory in 1912 by Britishers and was maintained till recently. The vault has been prepared under hard bedrock at 10 feet depth and separated by one foot gap around the vault from the building to arrest cultural noise. The same vault has been used for the broadband seismometer installed during 1999 and functioning since then. The background noise around the site is within 1.56 nanometer and records seismic signals with good signal to noise ratio.

The Kolar Gold Fields is situated in a 100 km long north-south trending Precambrian greenstone belt, known in the earlier literature as the Kolar Schist Belt. This belt is in the eastern part of Karnataka craton. The belt is about 4 to 6 km wide and the rocks have a general westerly dip. The rock formations occur within the regional Peninsular Gneissic Complex and are metamorphosed. Faulting, especially diagonal faults (NW-SE) have dislocated the rock formations. The major faults are the Mysore north fault in the Champion Reef-Mysore mine area, Balaghat north fault and the Gifford's system of faults.

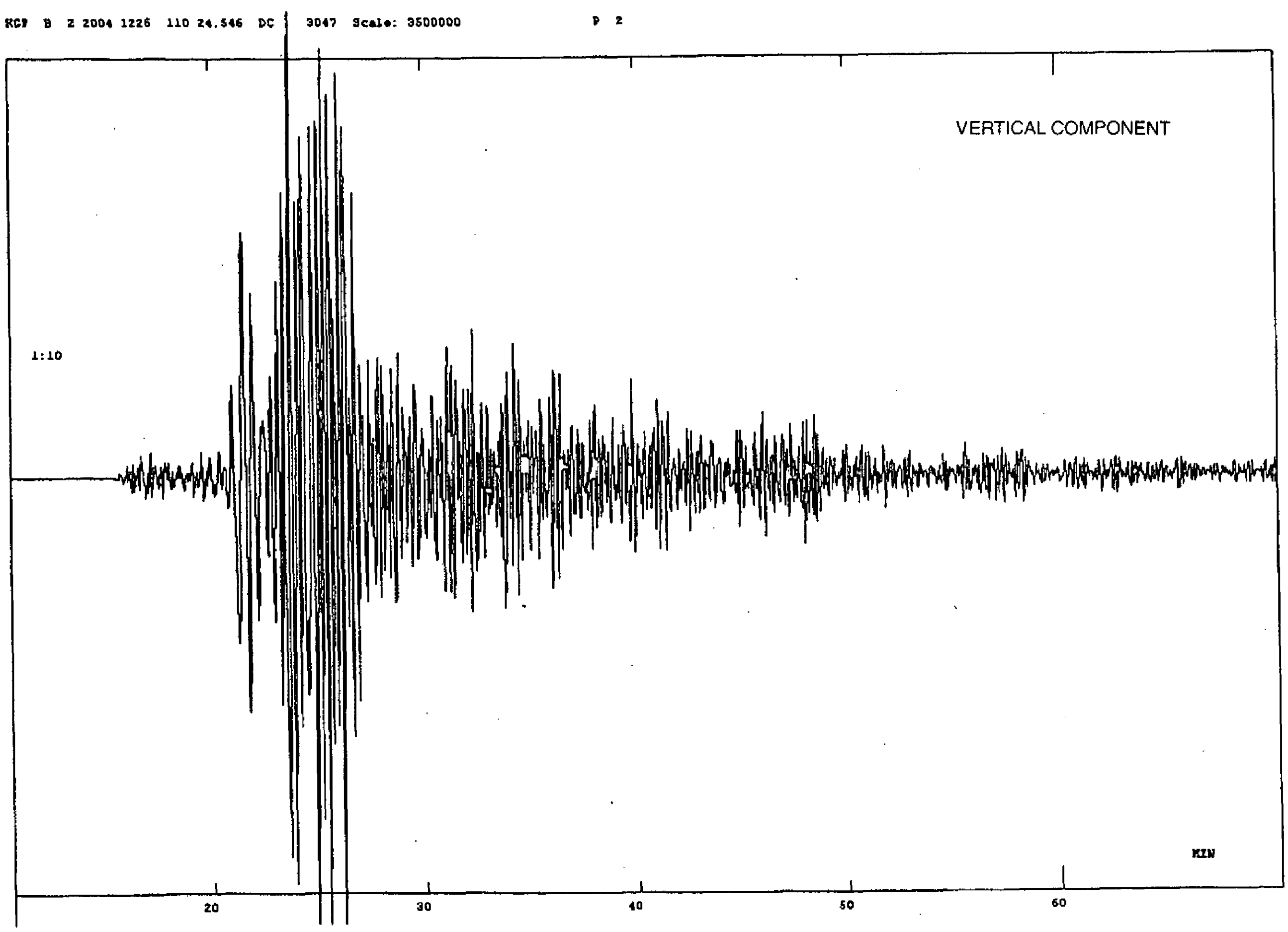

Fig.1. Sumatra earthquake on 26 December 2004, at 01:15:17.50 hrs (UTC).

Table 1. List of Sumatra earthquake and its aftershocks from 26-12-2004 to 06-01-2005

Sl. No.	Date	Onset time	Latitude (° N)	Longitude (° E)	Depth (km)	Magnitude (Mb)	Location
1	12/26/04	01:15:17.15	4°52.35'	96°46.84'	10	8.9	Northern Sumatera
2	12/26/04	4:37:01.08	12°29.13'	96°8.13'	33	5.6	Nicobar Islands region
3	12/26/04	7:53:40.47	13°51.18'	93°2.26'	15	5.7	Andaman Islands region
4	12/26/04	9:35:20.55	9°11.62'	93°56.19'	15	6	Nicobar Islands, region
5	12/26/04	18:14:43.62	18°58.40'	99°56.19'	33	5.2	Northern Sumatera
6	12/26/04	18:57:6.20	44°17.90'	92°39.18'	15	5.9	Bay of Bengal
7	12/26/04	19:45:46.47	5°14.92'	95°31.10'	15	5.6	Northern Sumatera
8	12/27/04	1:14:9.70	19°14.10'	65°48.96'	8	6	Andaman Islands, region
9	12/27/04	8:13:24.94	5°33.94'	95°30.86'	15.1	5.8	Northern Sumatera
10	12/27/04	9:02:49.49	20°17.79'	96°37.44'	33	5.3	Nicobar Islands, region
11	12/27/04	10:04:42.43	9°8.23'	94°22.05	15	6.2	Nicobar Islands, region
12	12/27/04	10:22:52.32	27°49.16'	81°20.90'	33	5.7	Nicobar Islands, region
13	12/27/04	15:11:29.85	13°41.986	102°1.49'	10	5.9	Andaman Islands, region
14	12/27/04	18:05:24.89	8°53.30'	93°2.68'	15	6.0	Northern Sumatera
15	12/27/04	18:35:23.55	6°56.40'	96°42:38	15	5.3	Northern Sumatera
16	12/27/04	19:38:00.13	1°58.94'	96°0.04'	33	5.9	Andaman Islands, region
17	12/27/04	20:36:48.74	7°0.17'	97°22.32'	15	5.8	Northern Sumatera
18	12/27/04	22:28:11.17	7°4.11'	91°56.48'	15	5.8	Nicobar Islands, region
19	12/28/04	00:22:50.98	25°31.12'	83°36.02'	33	5.2	Nicobar Islands, region
20	12/28/04	03:45:24.35	7°23'	12°15.4'	33	5.6	Nicobar Islands, region
21	12/28/04	6:01:16.92	9°49.61	92°43.82'	15	5.8	Nicobar Islands, region
22	12/28/04	17:36:18.08	10°17.23'	92°44.96'	15	5.9	Andaman Islands, region
23	12/28/04	20:20:15.78	5°14.53'	90°16.96'	33	5.7	Andaman Islands, region
24	12/28/04	22:12:38.76	11°33.00'	92°57.54'	15	5.9	Nicobar Islands, region
25	12/29/04	2:04:43.19	6°36.33'	90°54.34'	15	6.2	Nicobar Islands, region
26	12/29/04	6:21:48.27	4°42.06'	99°7.10'	30	5.4	Nicobar Islands, region
27	12/29/04	10:34:38.4	0°36.88'	79°3.57'	33	5.8	Nicobar Islands, region
28	12/29/04	10:39:19.83	12°30.7'	79°15.21'	33	5.3	Nicobar Islands, region
29	12/29/04	10:51:18.03	12°1.89'	78°25.76'	0	5.5	Northern Sumatera
30	12/29/04	11:18:58.91	3°24.81'	68°21.58'	15	5.4	Northern Sumatera
31	12/29/04	19:15:49.16	0°49.89'	70°48.90'	33	5.4	Northern Sumatera, Indonesia
32	12/29/04	21:38:36.21	7°57.30'	94°5.04'	15	6.5	Northern Sumatera, Indonesia
33	12/29/04	23:38:56.70	0°35.43'	79°23.69'	20	5.4	Nicobar Islands region
34	12/30/04	18:22:51.15	12°33.55'	91°58.51'	10	5.9	Andaman Islands region
35	12/31/04	2:49:00.79	7°11.86'	93°21.28'	10	5.3	Nicobar Islands region
36	12/31/04	10:22:16.41	9°56.66'	94°38.17'	15	5.3	Nicobar Islands region
37	12/31/04	12:30:8.71	9°46.38'	94°53.64'	15	5.5	Nicobar Islands region
38	01/01/05	1:17:44.82	18°31.18'	65°28.36'	33	4.7	Nicobar Islands region
39	01/01/05	2:21:26.92	8°5.96'	97°34.51'	10	5.6	Northern Sumatera
40	01/01/05	6:50:52.71	7°46.68'	92°1.35'	15	5.9	Nicobar Islands region
41	01/01/05	14:54:16.56	9°52.24'	92°7.88'	15	6.3	Nicobar Islands region
42	01/01/05	19:33:25.10	8°24.65'	94°55.56'	15	5.6	Nicobar Islands region
43	01/01/05	22:51:06.45	1°22.58	85°23.29'	33	6.3	Nicobar Islands region
44	01/02/05	8:53:39.48	5°55.17'	97°12.96'	10	5.9	Northern Sumatera
45	01/02/05	16:01:02.14	7°.53'	92°46.85'	15	5.8	Nicobar Islands region
46	01/04/05	9:37:53.92	11°23.47'	91°19.54'	22	6.0	Andaman Islands region
47	01/04/05	19:39:25.10	11°8.11'	91°38.63'	33	5.7	Andaman Islands region
48	01/05/05	15:00:07.41	8°29.69'	93°52.41'	35	5.4	Nicobar Islands region
49	01/05/05	15:19:34.40	8°26.50'	93°29.66	15	5.7	Nicobar Islands region
50	01/06/05	00:36:37.43	6°22.89'	93°11.21'	15	5.7	Nicobar Islands region
51	01/06/05	01:22:04.46	5°57.69'	94°44.51'	10	6.2	Northern Sumatera
52	01/06/05	05:17:38.38	5°48.94'	93°46.87'	15	6.1	Northern Sumatera
53	01/06/05	12:20:22.38	11°07.55'	91°21.82'	33	5.4	Andaman Islands region

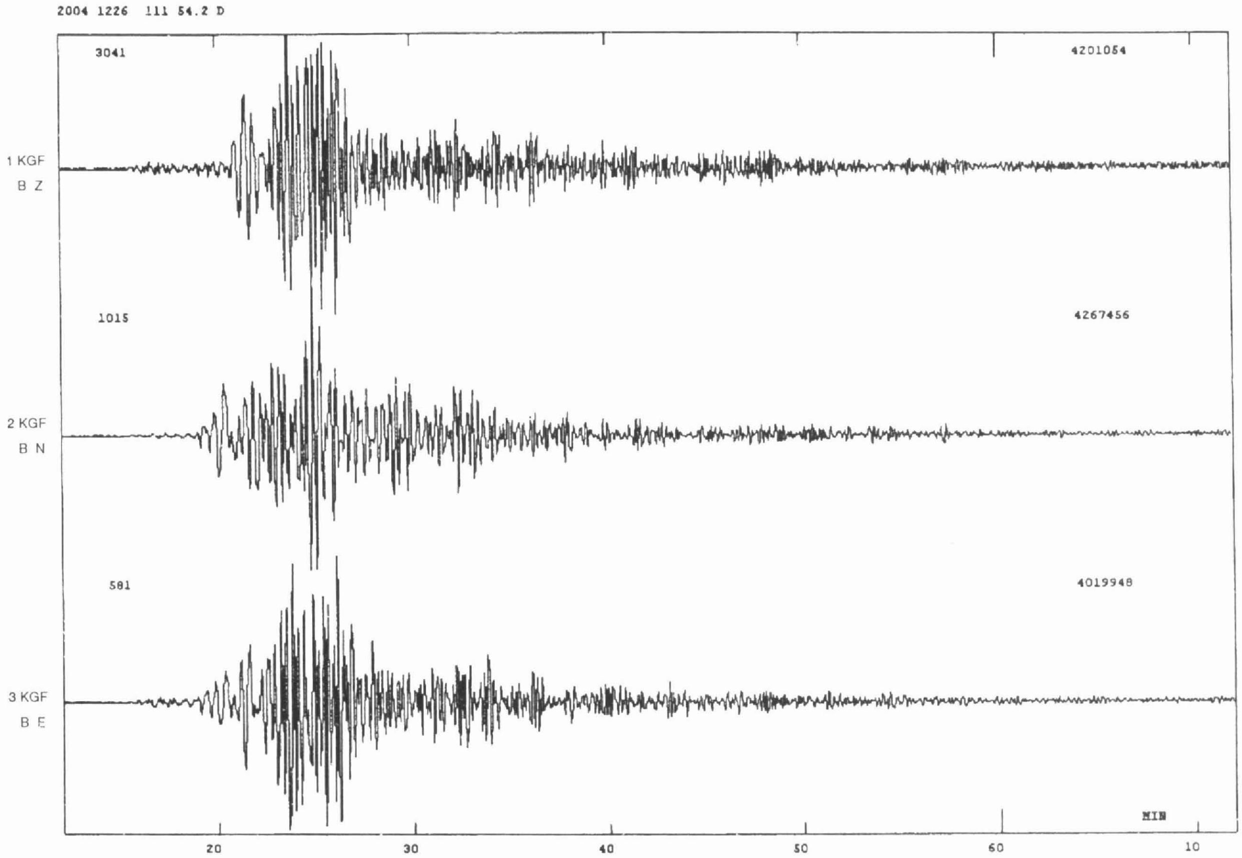

Fig.2. Sumatra earthquake on 26 December 2004, at 01:15:17.50 hrs (UTC).

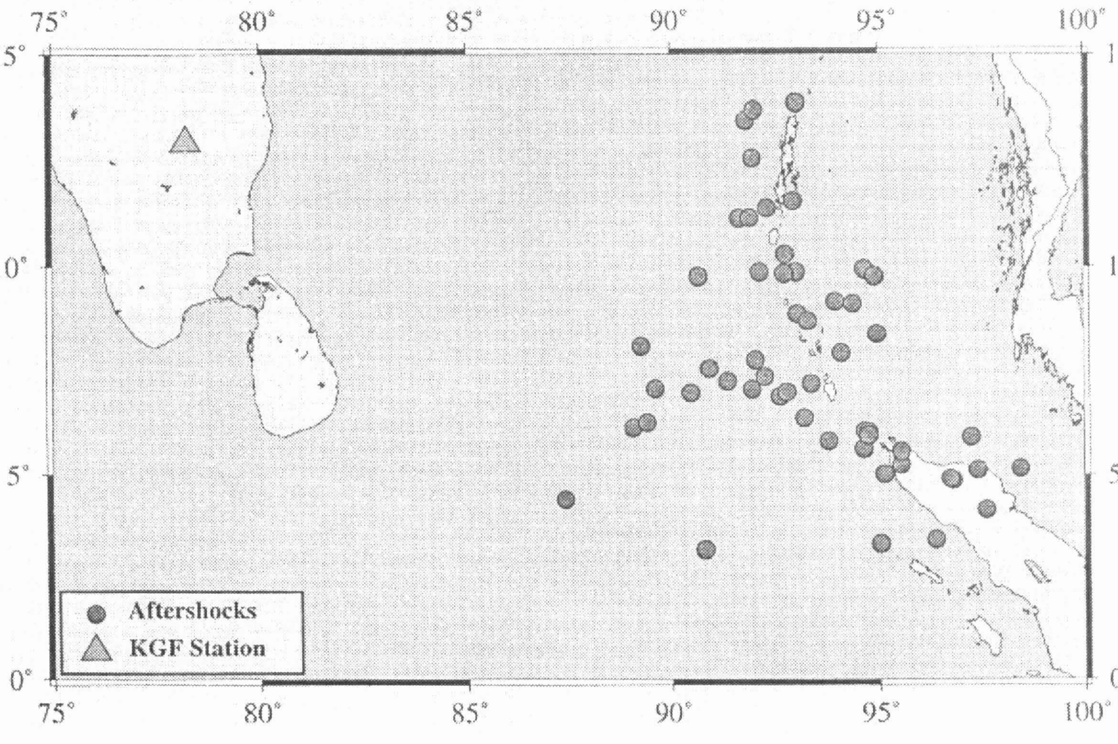

Fig.3. Sumatra earthquake on 26-12-04 and its aftershocks from 26-12-04 to 06-1-05.

More than seventy earthquakes of different magnitude (main and aftershocks) have been recorded from 26 December, 2004 to 6 January, 2005. Out of total number of earthquakes recorded, only 53 earthquakes can be located as listed in Table 1. Fifteen earthquakes in the magnitude range between 5.4 and 8.9 were recorded from Sumatra region and 38 earthquakes from Andaman/Nicobar Islands in the magnitude range between 5.2 and 6.3. Majority of aftershocks occurred in the Andaman/Nicobar Islands. The seismogram of the main Sumatra earthquake vertical component and three components are shown in Figs.1 and 2. The epicenter plot of aftershocks are plotted as shown in Fig.3.

This major megathrust earthquake occurred on the interface of India and Burma plates and was caused by the release of stresses that develop as the Indian plate subducts beneath the overriding Burma plate. As with the recent event, megathrust earthquakes often generate large seismic sea waves called tsunamis that can cause damage over a much wider area than is directly affected by ground shaking near the earthquake rupture. When the earthquake occurs, seismic sea waves of small magnitude are caused on the surface. These seismic sea waves travel very fast up to 800 km per hour, which means that in the present case the sea waves hit Tamil Nadu after three hours.

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GENERAL PATH OF THE TSUNAMI OF 26 DECEMBER 2004

The Tsunami generated off Sumatra on 26 Dec 2004 traveled over some 4500 km from Sumatra across to Somalia in the east coast of South Africa. It hit India along its eastern coast mainly south of Visakhapatnam but did not viist Orissa or Bengal coast, the northern part of the Bay of Bengal. It visited Kanyakumari and turning northwards thereafter hit several low lying areas on the western coastal tip up to Cochin some 350 km from Kanyakumari Incidentally the west coast of Kerala was hit from strong waves striking eastwards. However the tsunami waves did not proceed to the northern part of the Arabian sea. I have been addressing the question as to why the Tsunami that could travel another 2500 km from the southern tip of India to the Maldives and African Coast could not proceed to the Bengal basin or well into the Arabian sea.

We have a working picture of the bathmetry of the Bay of Bengal and the sediments flow from the Ganges down to very much south of Sri Lanka. The 90 degrees east and the 85 degree east ridges may have influenced the course of the Tsunami but well before they reached Sri Lanka and their influence has not been very effective.

There are two hydrodynamic aspects of a tsunami, as I infer, (i) the wave power largely modulated by the initial thrust and sea floor topography; they become more ferocious as they are obstructed by a shallowing coast line and (ii) the rise in the water level. I suppose the manifestation of a tsunami along the lowlying coasts are due to both these aspects, so that while some parts of the coast are forcefully hit and damaged, large areas get flooded depending on the height contours above sea level.

So one possible explanation why the tsunami did not move northwards of the Bay of Bengal is the resistance offered by the Bengal Fan. The Ganges brings a lot of sediments down the Himalaya and empties the same into the Bay of Bengal. Satellite pictures reveal that the Ganga sediments are carried all the way from the Bengal Delta (swath of no ground) to several thousands of kilometers down to south of the Sri Lanka. Similarly The Indus sediments are carried down to Somalia coast. (I have less information on the Indus now but am collecting more data). The Tsunami would have met this southward flowing load of sediments. The waters that carry these sediments may be denser than the average sea water by virtue of the charged sediments and the southward flowing sea water may have a great deal of energy in itself. They therefore can offer a hydrodynamic force restricting the flow of the Tsunami northwards. Water level considerations may have also stopped a hydrostatic flow of the Tsunami water system northwards. In fact south flowing sediments, though very much slower in their motion may, however, have even added part of their velocity to the Tsunami waves, thereby rendering their flow a little more rapid.

The model of a the Bengal sedimentary fan and perhaps the Indus fan too providing a hydrodynamic barrier for tsunamis arising from the Sunda-Andaman thrust zone if sustainable scientifically, has very deep implications.

1. The 26 Dec 2004 Tsunami being the largest in the Indian Ocean, we can expect most of tsunamis generated at the great Andaman-Sumatra thrust zone