

## RECENT SIGNIFICANT EARTHQUAKES IN QUICK SUCCESSION IN KOTTAYAM - IDUKKI REGION, KERALA – A MACROSEISMIC STUDY

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The Kottayam-Idukki region of Kerala was jolted by two significant earthquakes that struck in quick succession on 12<sup>th</sup>

December, 2000 and 7<sup>th</sup> January, 2001. The vital parameters of the two events are as follows:

| Date         | Time          | Latitude | Long.  | Magnitude | Focal Depth | Source |
|--------------|---------------|----------|--------|-----------|-------------|--------|
| 12.12.2000 - | 0655(IST)     | 9.70°    | 77.00° | 5.0       | -           | IMD    |
| -            | 012358"(GMT)  | 9.71°    | 76.72° | -         | 10 km       | USGS   |
| 07.01.2001 - | 082559" (IST) | 9.70°    | 76.80° | 4.8       | -           | IMD    |

Both these earthquakes were felt across almost the entire length and breadth of Kerala and the neighbouring parts of Tamil Nadu, although the area of damage and strong felt intensities were confined to only parts of Kottayam and Idukki districts. They were both followed by a distinct sequence of mild aftershocks that were strong enough to be felt in the epicentral areas of their respective main shocks. The two main shocks were investigated separately and the reports that emanated from ground revealed that the aftershocks of felt intensities continued well into February, 2001 after the 7<sup>th</sup> January event while the 12<sup>th</sup> December shock did not yield after shocks of felt intensity beyond the first week of its occurrence.

The 7<sup>th</sup> January main shock left a trail of slight but consistent damage over a relatively larger area as compared to the 12<sup>th</sup> December event. Both events were preceded or associated with acoustic emissions akin to rumbling or thunderous sound. They caused panic and most people in the epicentral tracts were frightened and rushed out of their houses. Loose objects rattled severely and in some

cases toppled and fell. The 12<sup>th</sup> December shock caused up to Grade 2 damage to a few well constructed buildings type (B), as at a new Polio Home in Melkavu and a 50 year old church constructed on overburden of a hill slope at Mel Adukkam where distinct shear cracks in NW-SE walls and peeling off of large chunks of plaster were observed due to local accentuation attributed to thick overburden. In a wider area stretching in approx. NW-SE direction between Thodupuzha and Peermedu, however, the shock caused only Grade-I damage to a few type (A) houses and an occasional type (B) building. The 7<sup>th</sup> January main shock was more damaging around Pala. The 5 year old and N-S oriented Keezhaparayar Church about 4 km East of Pala suffered Grade-3 damage with gaping tensional cracks in N-S long walls and partial collapse in its northern half that is founded close to a marked break in slope of the order of about 20°. The E-W walls in this church and its neighbouring buildings have come under shear.

While no distinct terrain manifestations, excepting a few reports of

some open wells going dry in Kanjirapalli, were reported with respect to the 12<sup>th</sup> Dec. are at a slight variance with respect to their meizoseists and the areas enclosed. The isoseists of both the events are ellipsoidal and trend in a NNW-SSE direction. While the meizoseist of 12<sup>th</sup> December event is only a local high around Melkavu and Adukkam within isoseist -V, the meizoseist of 7<sup>th</sup> January event is well constrained and encompasses an area of nearly 150 sq km

around Pala and further to its southeast. Although the attenuation pattern of both the events is similar, the 7<sup>th</sup> January event attenuated relatively faster towards east and southeast and slower towards west and southwest. The meizoseismal area of the latter event is separated from that of the former by about 15 km towards west and southwest (Fig.1). The following table indicates the decay pattern of the intensities.

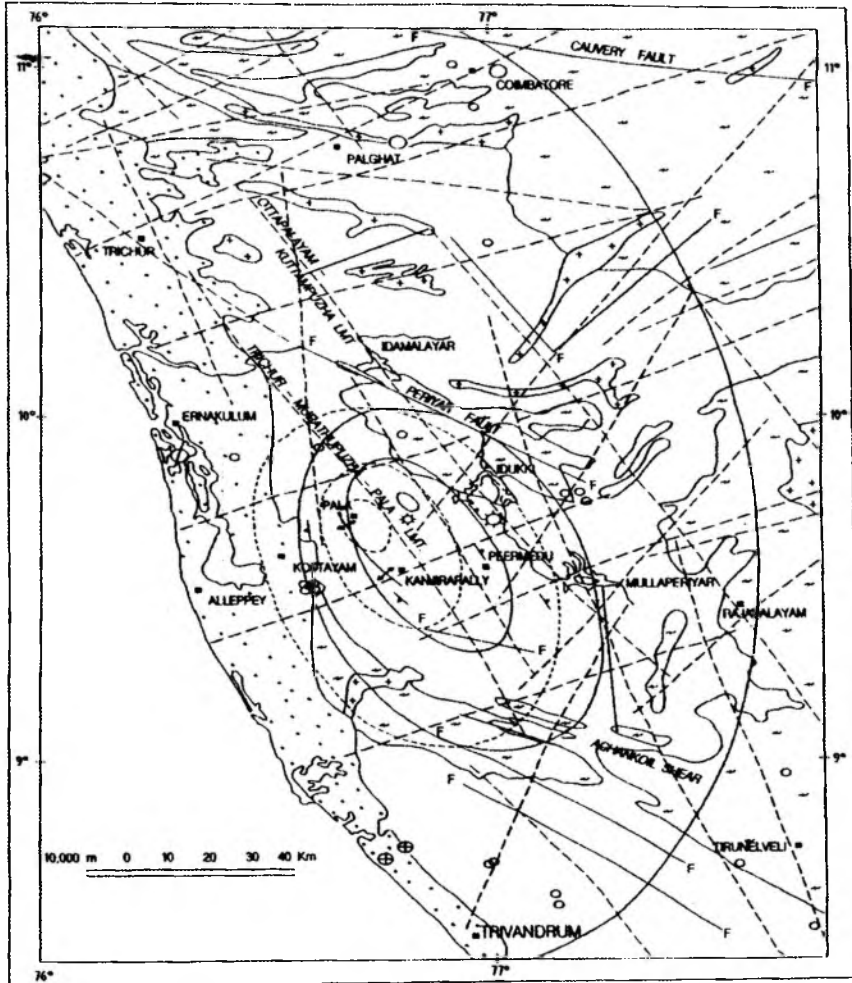
### Isoseismal Parameters

| Event Date            | Isoseist | Area in sq.km.       | Length of long axis in km. | Length of short axis in km. | Trend of the long axis |
|-----------------------|----------|----------------------|----------------------------|-----------------------------|------------------------|
| 12 <sup>th</sup> Dec. | VI       | ~ 20                 | 6                          | 3.5                         | N 35° W-S 35°E         |
|                       | V        | 1,700                | 67                         | 32.0                        | N 30° W-S 30°E         |
|                       | IV       | 6,300                | 115                        | 68.0                        | N 28° W-S 28°E         |
|                       | III      | >30,000<br>(on land) | ~350                       | -                           | N 15° W-S 15°E         |
| 7 <sup>th</sup> Jan.  | VI       | 150                  | 17                         | 11.0                        | N 30° W-S 30°E         |
|                       | V        | 1300                 | 55                         | 32.0                        | N 22° W-S 22°E         |
|                       | IV       | 6100                 | 112                        | 70.0                        | N 25° W-S 25°E         |
|                       | III      | >30,000              | ~350                       | -                           | N 15° W-S 15°E         |

The total felt area of the two main shocks comprises three major tectonic domains of the southwestern part of Dharwar craton with high grade gneiss granulite, gneisses and migmatites of Peninsular Gneissic Complex and granitoid massifs of the Pandyan Mobile Belt with younger chornockites and the NW-SE trending khondalite belt of Southern Kerala. The Western coastal tract comprises Tertiary coastal sedimentaries and Quaternaries. The eastern parts of the area investigated in Kottayam and Idukki districts comprise the Anamalai and Cardomom hill ranges that are deeply dissected along the axes of antiform-synforms trending in NNW-SSE to NW-SE. Several major river valley projects, namely

the Mullaperiyar dam, the Idukki project, Lower Periyar project, Idamalayar project – all in Periyar basin are located within a stretch of about 100 km. enclosed by the isoseist-IV of the 12<sup>th</sup> December event (Fig.1). Some of the valleys close to the eastern boundary of isoseist -V present seemingly unstable westerly steep slopes occupied by scree overburden as revealed by the study of imageries. The terrain is traversed by a fairly dense network of lineaments trending predominantly in NW-SE to ENE-WSW. Of these the Trichur-Muvathupuzha-Pala-Kanjirapalli lineament/fault occupied by a major basic dyke, the Ottapalam-Kuttampuzha lineament (Idamalayar fault, (Rajagopalan, 1996) an intermediate parallel lineament in between

ISOSEISMAL MAP OF 12th DEC., 2000 & 7th JAN., 2001 EARTHQUAKES OF KOTTAYAM-IDUKKI REGION, KERALA



LEGEND

- |  |   |  |   |
|--|---|--|---|
|  | Coastal Sediments & Quaternary Alluvium |  | Isoseismal of 12th December, 2000 event                             |
|  | Composite Batholithic Complex           |  | Isoseismal of 7th January, 2001 event                               |
|  | Unclassified Gneissic Complex           |  | Epicentre of 12th December, 2000 event                              |
|  | High Grade Gneiss /Granulite            |  | Epicentre of 7th January, 2001 event                                |
|  | Faults                                  |  | Epicentres of past seismic events of magnitude >5 & <5 respectively |
|  | Foliation & Antiformal Axis             |  | Hotsprings  |

the these two – all trending in NNW-SSE direction and the Periyar fault / lineament trending in WNW-ESE direction are relevant to the present study.

The historical records reveal that the region under investigation has experienced several low-order to moderate seismic events, although their frequency had been

very low. The epicentre clusters near Kottayam and Idukki are of particular interest to the present study. The Seismic Zonation Map (BIS-1893-1984) shows the region under study in Zone-III implying moderate seismicity for the region. Following table lists most of the seismic events recorded in the region.

### List of past seismic events between 8°-11°N/76° -77.7°E

| Sl. | Date       | Latitude in °. | Long. | I max. | Mag. | Depth | Source |
|-----|------------|----------------|-------|--------|------|-------|--------|
| 01  | 10.01.1821 | 9.50           | 76.60 | III    | -    | -     | OLD    |
| 02  | 15.09.1841 | 9.50           | 76.60 | IV     | -    | -     | "      |
| 03  | 23.11.1849 | 9.50           | 76.60 | IV     | -    | -     | "      |
| 04  | 11.08.1856 | 8.70           | 77.00 | IV     | -    | -     | "      |
| 05  | 25.08.1856 | 8.70           | 77.00 | II     | -    | -     | "      |
| 06  | 01.09.1856 | 8.70           | 77.00 | V      | -    | -     | "      |
| 07  | 24.06.1865 | 11.00          | 76.95 | IV     | -    | -     | UGS    |
| 08  | 16.03.1881 | 08.48          | 77.70 | III    | -    | -     | "      |
| 09  | 08.02.1900 | 10.80          | 76.80 | VII    | -    | -     | UC     |
| 10  | 26.07.1953 | 09.90          | 76.30 | -      | 5.0  | -     | GUB    |
| 11  | 25.09.1968 | 08.29          | 76.57 | -      | 3.0  | -     | IMD    |
| 12  | 29.07.1972 | 11.00          | 77.00 | -      | 5.0  | -     | IMD    |
| 13  | 10.02.1979 | 10.50          | 77.00 | -      | 3.7  | -     | CVR    |
| 14  | 11.01.1981 | 09.92          | 76.61 | -      | 3.0  | -     | GBA    |
| 15  | 17.02.1981 | 09.95          | 76.80 | -      | 3.3  | -     | GBA    |
| 16  | 23.01.1986 | 09.94          | 76.36 | -      | 3.0  | -     | GBA    |
| 17  | 07.06.1988 | 09.80          | 77.20 | -      | 4.5  | 5 km  | NGRI   |
| 18  | 07.06.1988 | 09.80          | 77.20 | -      | 4.2  | 5 km  | NGRI   |
| 19  | 07.06.1988 | 08.58          | 77.13 | -      | 4.5  | -     | GBA    |
| 20  | 07.06.1988 | 09.80          | 77.13 | -      | 4.3  | -     | GBA    |
| 21  | 08.06.1988 | 08.75          | 77.13 | -      | 3.5  | 5 km  | GBA    |
| 22  | 26.08.1988 | 08.94          | 77.68 | -      | 3.2  | -     | GBA    |

The closest past seismic event, both in space and time, to the present events is the Idukki earthquake of magnitude 4.5 that occurred on 7<sup>th</sup> June, 1988 with its epicentre near Nedunkandam about 25 km ESE of Idukki dam. The isoseismal pattern of this event showed a binary trend with a predominant WNW-ESE and a minor NE - SW arm, (Balachandran & Harendranath, 1988). The fault plane solution worked out for the event revealed two nodal planes in N50° W-S50°E and N40°E-S40°W direction with vertical dips and a strike slip focal mechanism (Rastogi, 1992). It was attributed to tectonic reactivation along the Periyar fault and the RIS as a causative factor was ruled out even though the epicenter was just 25 km from the Idukki dam which provides a 100 m + water column – two of the important factors of reservoir induced seismicity (Gupta, 1992).

In the present case, though the epicentre of the 12<sup>th</sup> December event is located fairly close to the Idukki dam, the epicentre of the 7<sup>th</sup> January event and the meizoseismal centres of both events are far away towards west from the Idukki reservoir with an intervening high mountain range. A cursory glance at the seismic records of Kerala State Electricity Board which runs a network of stations around Idukki does not indicate any spurt of seismic activity either related to the reservoir level changes in the last five seasons or to the weeks immediately preceding the present main shocks. Hence, the RIS factor in the case of present events too is quite unlikely.

Based on the isoseismal pattern and the areas enclosed by them, the trends of longer axes and well separated nature of the meizoseismal areas, the two events are assessed to be independent of each other, caused by reactivation along two different fault planes under the compressive stress regime. While the intermediate lineament

trending in NNW-SSE direction is attributable, based on spatial association of the meizoseismal longer axis, for the 12<sup>th</sup> Dec., 2000 main shock, the Trichur-Muvathupuzha-Pala-Kanjirapalli lineament /fault is inferred to be the causative fault of the 7<sup>th</sup> January, 2001 main shock.

Facts such as occurrence of events in proximity to several reservoirs – a number of them being located on major lineaments, population density of events, their shallow focal depth and vulnerability of slopes and slope forming material capable of generating co-seismic landslides, particularly during monsoon, warrant a close constant monitoring of the seismicity of the terrain at micro level.

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