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Planetary Configuration: Implications for Earthquake Prediction and Occurrence in Southern Peninsular India

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ABSTRACT

Though there have been several attempts at earthquake prediction from different perspectives, this attempt aims at establishing planetary configurations as a definitive means of earthquake prediction. When two or more planets, Sun and Moon are aligned more or less in line (0^o or 180^o) with the Earth, then the Earth would be caught in the middle of a huge gravity struggle between the Sun and the planets. The gravitational stresses would change the speed of the Earth in its orbit and when the speed of rotation of the earth changes the tectonic plate motion also gets affected. The total angular momentum of planets involved in earthquake triggering mechanism can be calculated and the total force acting at the epicenter in a direction opposite to that of the earth's rotation can also be determined. At the epicenter, the speed of rotation of the earth can be calculated with the help of available software. So the planetary forces in the opposite direction to the rotation of earth act as a triggering mechanism for the accumulated stress at faults and plate boundaries to be released abruptly. This does not, however, mean that earthquakes will occur at all edges of the plate boundaries. Two of the parameters contributing to the triggering of an earthquake at a place are a) distance of epicenter from the planet position and b) direction of force acting at the possible epicenter. From the analysis of "significant earthquakes" over the past 100 years from all over the world and from Southern Peninsular India, the relationship between (i) latitude, longitude, and magnitude of the tremor and (ii) distance from the planet and direction of forces acting at any point can be inferred. Such inferences already made for different localities in other parts of world have unfolded an accuracy of more than 75% with regard to earthquake prediction.

INTRODUCTION

No Indian can forget the 51st Republic Day morning of 26 January 2001 (8.45 am). Within two minutes, the furious ground shock completely wiped out Bhuj. More than physical devastation, natural calamities often leave scars on the collective psyche of an entire community or population.

In more seismic-prone areas, people know how to safeguard their lives since their awareness levels are relatively much higher. But in regions like Southern Peninsular India, which are traditionally considered to be more stable than the extra-Peninsular, the knowledge of people about earthquakes is very poor, one of the main reasons for the high causality count even for moderate earthquakes. Southern Peninsular India is known to have experienced several earthquakes with a magnitude of more than 5 in historical times (Bansal & Gupta 1998). In most cases, the causative factor for seismicity has been attributed to reactivation of ancient crustal faults. Slices of the crust at the continental edge of India are bounded by NE-SW to NNE-SSW faults. Vertical movement along the faults was imposed by stupendous sedimentation, giving rise to ridges and depressions. The faults continue to be active, accounting for earth tremors in the Southern Peninsular region (Subramanian & Goplalakrishnan 2002).

Due to earthquakes, there are some effects like ground shaking, ground displacement, liquefaction, flooding (tsunami), and fire which are hazardous to human beings (Walker 1982). The hazards mentioned above are avoidable if prediction can be made early, which would enable mitigation of the natural hazard, reduce damage to life and property drastically and facilitate precautionary measures by government and NGOs.

During the past several decades, there have been several attempts at earthquake prediction from different perspectives. Scientists have attempted to predict earthquakes using the “seismic gap” theory, by observing animal behaviour patterns or studying the changing colour of water in natural springs. Seismologists have used warning signs like a) foreshocks, b) strain in rocks, c) ground water levels, d) chemical changes in ground water, e) radon gas in ground water, f) thermal anomaly, g) ground tilting, and h) P–wave velocity (Ranjit 2001) for predicting earthquakes and issuing advance warnings to the people in the area likely to be affected.

The rupture zones of major South American earthquakes were investigated in detail by Kelleher (1972), who attempted to predict likely locations of future earthquakes using the “seismic gap” theory. According to this theory, gaps between rupture zones tend to be the focus of large-magnitude earthquakes. He predicted the occurrence of an earthquake in a segment along the Peru Trench located between the rupture zones of the 1940 and 1942 earthquakes (12° to 14° S). Kelleher’s prediction did come true but two years later when a large tsunamigenic earthquake (Mw ~8.0) occurred in the exact region. Scholz, Sykes & Aggarwal (1973) put forward the dilatancy-diffusion theory in an attempt to explain a great variety of phenomena that had been observed to shortly precede earthquakes. They opined that these phenomena were actually precursory, and therefore could be used to predict earthquakes. Although there have been controversial opinions regarding the physical background and efficiency of seismic gap predictions (e.g. Kagan & Jackson 1991; Nischenko & Sykes 1993; Rong, Jackson & Kagan 2003), Kelleher’s forecast was observed to be quite precise (Dewey & Spence 1979; Beck & Ruff 1989). Rabinovich, Kulikov & Thomson (2001) opined that there was high potential for a major earthquake of magnitude greater than 8.0 in the region between 15° and 24° S, straddling the Peru-Chile border, based on the existence of a seismic gap in the region and that the region had not experienced earthquake since 1877. This prediction came true when a catastrophic earthquake of Mw ~8.4 occurred about three months later on the coast of Southern Peru.

Hartmann & Levy (2005) investigated the relationships among the attributes of 229 earthquake related gas geochemical and hydrogeological precursory signals, and applied these results to improve future earthquake prediction strategies. They categorized the signals into four groups, reflecting differences in monitoring station densities, measurement methods and physical processes related to signal occurrence: (i) radon exhalation from the earth’s crust, (ii) exhalation of other gases (helium, argon and others), (iii) temporal variation in water level or discharge of springs and (iv) temporal variation in temperature and dissolved ions in the water of the monitoring sites.

Several workers have attempted to utilize hydrogeological anomalies as precursors to earthquakes and tried to forecast possible earthquake occurrences. Experimental investigations into conditions of ground waters in order to identify hydrodynamic earthquake forerunners were carried out by Kissin et al. (1983). Roeloffs (1988) gave a comprehensive review of hydrologic precursors to earthquakes. Asteriadis & Livieratos (1989) studied pre-seismic responses of underground water level and temperature related to a M4.8 earthquake that occurred in Greece on October 20, 1988. Igarashi & Wakita (1991) investigated tidal responses and earthquake-related changes in the water level of deep wells; later, they (1995) discussed the possibility of using geochemical and hydrological observations for earthquake prediction in Japan. Tsunogai & Wakita (1995, 1996) studied anomalous changes in ground water chemistry as possible precursors to the Kobe and Hyogo-ken Nanbu earthquakes in Japan. A possible explanation for hydrogeochemical earthquake precursors at Bad Brambach, Germany, was presented by Heinicke & Koch (2000).

Detection and monitoring of radon gas in ground water and soil have been systematically carried out by various researchers during the last decades. Radon concentrations in soil samples were analysed both preceding and succeeding four M 4.2–4.7 earthquakes on the San Jacinto fault in Southern California (Birchard & Libby 1980). Allegri et al. (1983) detected radon and tilt anomalies before the Irpinia (South Italy) earthquake of November 23, 1980; these anomalies were observed even at considerable distance from the epicenter of the quake. Segovia et al. (1989) opined that the radon anomaly observed in the soil at the Los Azufres Geothermal field, Michoacan, could have been a possible precursor of the 1985 Mexico earthquake of Ms ~8.1. Ground water radon anomalies were observed by Igarishi et al. (1995) before the Kobe earthquake in Japan. In the Himalayan region, similar radon monitoring and measurements have been carried out by Virk & Baljinder (1994) and Virk (1995) in the Uttarkashi, and Kangra and Chamba valleys, respectively. In addition to radon, anomalous emissions of other gases like helium (Reimer 1985; 1990), hydrogen (Satake et al. 1985; Sato et al. 1986), argon, helium/argon and nitrogen/argon ratios (Sugisaki, Ohasi & Hayashi 1978), methane/argon ratio (Kawabe 1985; 1987), and spring water chloride ion (Toutain et al., 1997).

Electrical and magnetic field measurements are also supposed to indicate impending earthquakes. A heavily debated method of earthquake prediction based on the identification of transient variations in the earth's electric field, or seismic electric signals (SES), is the VAN method, named after the researchers who developed the method (Varotsos, Alexopoulos & Nagao). The VAN method, as described by Varotsos & Alexopoulos (1984a, b) is based on observed empirical relationships between the occurrence and magnitude (ΔV) of a SES and the corresponding seismic activity. Magnetic field measurements in the ultra-low frequency (ULF) band prior to the October 17, 1989 Loma Prieta earthquake (M_s 7.1) showed distinct anomalous patterns which could be interpreted as precursors (Fraser-Smith et al. 1990). The anomalous signals began over a month before the earthquake, around September 12, when a narrow band (.05-.2 Hz) signal appeared. Approximately 13 days before the earthquake there was a substantial increase in the background noise across nearly the whole ULF frequency band (.01-10 Hz). Starting one day before the earthquake there was a pronounced dip in background noise, then three hours prior to the earthquake, the signal strength started to increase dramatically. The anomalous signals seem to be directly correlatable with the occurrence of the Loma Prieta earthquake; however, they were not observed during two earlier magnitude 5 earthquakes, suggesting that there is a threshold below which the anomalies are not produced. The anomalous signals represent an isolated measurement, so it is difficult, if not impossible, to estimate the applicability of the precursory patterns to future earthquakes. In any case, although the VAN method has been highly debated over the years, some researchers continue to use it.

Abnormal animal or bird behaviour has been widely used by Japanese and Chinese researchers for earthquake prediction. Some of the earliest reports include those of Terada (1932) wherein a positive correlation was observed between abundant catches by fisheries and earthquake activity; Hatai & Abe (1932), who studied behaviour of a species of catfish, Parasilurus asotus, in tanks; and Suyehiro (1934) who observed abnormally high consumption of diatoms by sardines the evening before a large earthquake. Although most of these reports seem to be anecdotal, a recent explanation by Kirschvink (2000) is that animals have developed a higher sensitivity to earthquake precursory signals through evolutionary processes. Animals living within seismically active regions are more susceptible to burrow collapse resulting in death. Therefore, animals which have the ability to detect earthquake precursors (a seismic escape response gene) would be naturally selected over those animals which do not.

One well-known successful prediction was for the Haicheng earthquake (China) of 1975 (M 7.3). Evacuation warning was issued a day before the event occurred. In the preceding months, changes in land elevation and ground water levels, widespread reports of peculiar animal behaviour, and many foreshocks had led to a lower level warning. An increase in foreshock activity triggered the evacuation warning (Ludwin 1990). In spite of innumerable warning signs at our disposal, most earthquakes unfortunately do not have such obvious precursors. For example, there was no warning of the 1976 Tang Shan earthquake (magnitude 7.6), which caused an estimated 250,000 fatalities. Sometimes, these early warning signs may also be misleading. For example, from August 12–19, 2003, in and around Jamnagar Taluk in Gujarat, some minor tremors of magnitude 3.0 were recorded. The Gujarat Government geared itself to face another major disaster, but fortunately nothing happened.

If a fault segment is known to have broken in a past major earthquake, recurrence time and probable magnitude can be estimated based on fault segment size, rupture history, and strain accumulation. This forecasting technique can only be used for well-understood faults, such as the San Andreas. No such forecasts can be made for poorly-understood faults, such as those that caused the 1994 Northridge, California and 1995 Kobe, Japan quakes. Along the San Andreas Fault, the segment considered most likely to rupture is near Parkfield, California. Using a set of assumptions about fault mechanics and the rate of stress accumulation, the United States Geological Survey (USGS) made a more precise Parkfield prediction – of a M 6.0 earthquake between 1988 and 1992. Though that prediction failed to materialise during the aforesaid period (Ludwin, 1990), an M6.0 earthquake did occur on September 28, 2004, but its rupture was opposite to what had been predicted.

Based on catalogues of historical seismicity, Keilis-Borok et al. (1988) developed prediction algorithms designed to identify times of increased probability (TIPs) for a given region using statistical methods. They devised the CN and M8 algorithms and used them to predict the October 17, 1989 Loma Prieta earthquake of M_s 7.1. Their prediction of a =M 6.4 for the Northern California and Northern Nevada region using the CN algorithm, however, encompassed a spatial window of 600 x 450 km and a time window of 4-year TIP starting in mid-summer 1986. On the other hand, their M8 algorithm predicted that an earthquake with =M 7.0 would occur within 5-7 years after 1985 in a spatial window of 800 x 560 km along the coast of California.

The three vital parameters – time, location and magnitude of an earthquake – assume significance especially in view of the fact that they all need to be rendered more accurate. The time windows of few years (2 years: Kelleher 1972; 4 and 5-7 years: Keilis-Borok et al. 1988) or for that matter 3 months (Rabinovich, Kulikov & Thomson 2001) need to be certainly reduced to a few days if the prediction were to be of higher value. Similarly, it is also imperative that the spatial windows of 15° to 24° S (Rabinovich, Kulikov & Thomson 2001) as per the seismic gap theory, or 800 x 560 km and 600 x 450 km (Keilis-Borok et al. 1988) be minimized as much as possible. The present study demonstrates how planetary configurations, their gravitational force and direction of force act as the triggering mechanism for the release of accumulated stresses at plate boundaries/intraplate faults, resulting in earthquakes. This has made prediction of plate boundary as well as intraplate earthquakes relatively much more successful with reasonable accuracy with regard to time, location and magnitude.

SOME IMPORTANT FAULTS IN THE SOUTHERN PENINSULAR REGION

(Source: www.asc.org)

1. Andhra Pradesh: NW-SE trending Kaddam fault, NW-SE trending Gundlakamma fault and faults associated with Godavari graben.
2. Karnataka: ESE-WNW trending active faults near Bhatkal and Udipi towns and faults in the offshore region of the Arabian Sea.
3. Kerala: Palghat-Cauvery fault and Periyar fault.
4. Tamil Nadu: The E-W trending Cauvery fault, Tirukkavilur – Pondicherry fault, Vaigai river fault, and the N-S trending Comorin – Point Calimere fault and Rajapalayam – Devipattinam fault.
5. Maharashtra: The N-S trending west coast and Chiplin faults, the SE-NW trending Upper Godavari fault, the Ghod river fault, and the E-W trending Narmada fault zone.
6. Orissa: The Brahmani fault, and several deep-seated faults in the Mahanadi Delta.

PAST NOTABLE EARTHQUAKES IN SOUTHERN PENINSULAR REGION

1. 08 February 1900 – Coimbatore area, Tamil Nadu: M? 6.0; 10.800 N, 76.800 E; known as the Coimbatore earthquake, it was felt over a large section of south India and is the largest event during the historical period (Chandra 1977).
2. 14 March 1938 – Bhusawal-Sawda area, Maharashtra: Mw 6.3; 21.130 N, 75.830 E; D = 040.0 km; OT = 00:48:38 UTC; maximum observed intensity VII; this earthquake was felt over a wide region, including at Agra in the north and Mumbai in the west. It was a deep-seated event, with a focal depth of 40 kilometres (USGS, NEIC, Golden, CO, USA).
3. 10 December 1967 – Koyna area, Maharashtra; Mw 6.6; 17.450 N, 73.850 E; D = 027.0 km; OT = 06:48:25 UTC; 200 people were killed and many villages in the Koyna Nagar area were severely affected. The Koyna Dam suffered some structural damage and leaks were observed in the face of the dam. Tremors were felt strongly in many towns and cities in western Maharashtra, including Mumbai and Pune. It was also felt in Goa and other parts of western and southern India (www.isc.ac.uk).
4. 13 April 1969 – Kichanapalle-Gollagudem area, Andhra Pradesh: Mw 5.7; 17.810 N, 80.670 E; D = 025.0 km; OT = 15:24:55 UTC; this event is often referred to as the Bhadrachalam earthquake of 1969. It is among the strongest earthquakes in the Southern Peninsula. The shock caused considerable damage in and around Bhadrachalam. The maximum observed intensity was VII. The quake interrupted the functioning of the Kinnerasani reservoir for a while. It was felt all over South India, including Hyderabad, where people ran out into the streets in panic (USGS, NEIC, Golden, CO, USA).
5. 30 September 1993 – Killari, Maharashtra: Mw 6.2; 18.066 N, 76.451 E; OT = 22:25:48 UTC; among the deadliest intraplate earthquakes on record. Close to 9,000 people were killed and thousands injured in the pre-dawn earthquake. Many villages in the epicentral area around Khilari were razed to the ground. 55 people were killed in the neighbouring state of Karnataka, in Gulbarga District. Strong tremors were experienced at Hyderabad, Pune and Mumbai, and across much of Maharashtra, Karnataka, Andhra Pradesh and Goa. Tremors were felt as far as Chennai (USGS, NEIC, Golden, CO, USA; Dasgupta et al. 2000).
6. 08 December 1993 – Chandoli area, Maharashtra; Mw 5.1; 17.000 N, 73.650 E; D = 032.0 km; OT = 01:42:17 UTC; one elderly woman died of a heart attack and 6 were injured in this early morning quake. It was felt very strongly all over western Maharashtra and Goa for close to 20 seconds. Moderate damage was reported in several villages in the epicentral region (Dasgupta et al. 2000).
7. 12 March 2000 – Koyna area, Maharashtra: Mw 5.0; 17.099 N, 73.673 E, D = 033.0 km; OT = 18:03:56.27 UTC; felt widely in western Maharashtra and Goa for close to 30 seconds. Structural damage

was reported in the epicentral region (Johnston 1993).

8. 05 September 2000 – Koyna area, Maharashtra: Mw 5.3; 17.290 N, 73.760 E; D = 010.0 km; OT = 00:32:45 UTC; largest earthquake (based on seismic moment release) since December 1967. It was felt strongly in many parts of western Maharashtra as well as in Goa and Karnataka. More than 400 buildings were damaged in this quake in Satara, Sangli and Kolhapur Districts. A temple at Jejuri in Pune District was also damaged. No injuries or fatalities were reported (IMD).

9. 26 September 2001 – Off the coast of Pondicherry: Mw 5.4; 11.945 N, 80.227 E; D = 019.0 km; OT = 14:56:44 UTC; three earthquake-related deaths reported in the Chennai area. It was felt widely in Tamil Nadu and Pondicherry and, to a lesser extent, in adjoining parts of Andhra Pradesh and Karnataka. Slight damage was reported at Chennai and Chetpet in Tamil Nadu (USGS, NEI C, Golden, CO, USA).

MATERIALS AND METHODS

If two or more than two planets, Sun and Moon are aligned more or less in line (0^o or 180^o) with the Earth, then the Earth would be caught in the middle of a huge gravity struggle between the Sun and the planets. The gravitational stresses would change the speed of the Earth in its orbit, and shift the centre of the solar system (Karl 1990). When the speed of rotation of the earth changes, the tectonic plate motion is also affected, just as people collide with each other when the bus driver applies the brake suddenly. Thus, the planetary forces act as a triggering mechanism for the accumulated stress to be released abruptly.

FORCE OF ATTRACTION BY PLANETS, SUN AND MOON

$F_{p1} = GMm/r^2$ (1)

$F_{p2} = GMm/r^2$ (2)

Adding equations (1) & (2),

Total force $= F_{p1} + F_{p2}$ N (3)

$L = GMm/v$ kgm^2s^{-1} (4)

where L is angular momentum of planets, Moon and Sun.

With this total angular momentum, the total force acts at the epicenter in the opposite direction to the rotation of the earth. At the epicenter, the speed of rotation of earth can be calculated with help of software available. This does not, however, mean that earthquakes would occur at all edges of the plate boundaries. For an earthquake to be triggered at a particular place, two conditions should be satisfied: a) triggering distance (T.D.) and b) direction of force acting at the possible epicenter.

TRIGGERING DISTANCES

When the planets (up to Saturn), Sun and Moon exert their force on the Earth, two bulges are created along the circumference of the earth. If these bulges are imagined as crests of the sine wave (Fig. 1), there would then be two waves along the circumference of the earth (~40,072 km), whose wave length (λ) = 20,036 km, which is approximately equal to half the circumference of the earth. The planetary positions with regard to the Earth are decided by their shortest distance to a particular point on its surface, which is normally measured as Right Ascension (Longitude) and

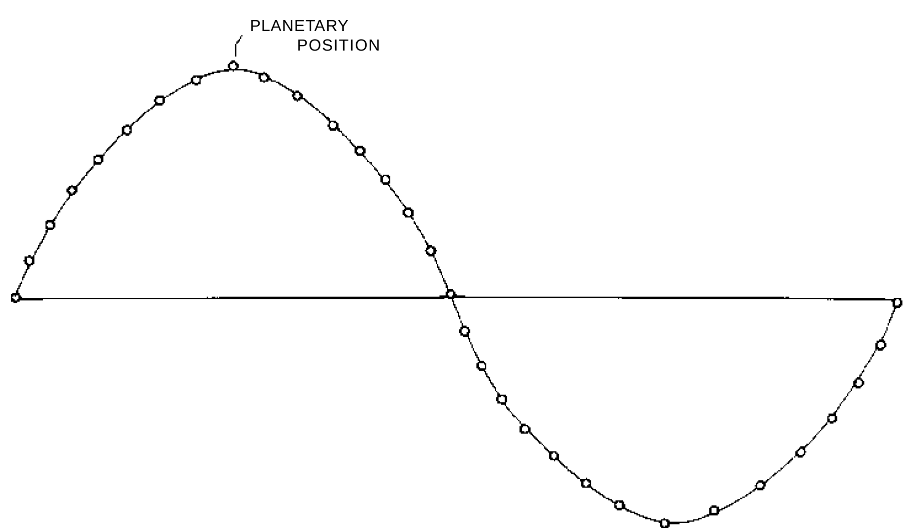


Figure 1. Bulge created by planets represented in sine wave form Legend: o - Triggering Distances

Declination (Latitude). The peak of the sine wave represents the position of the planets (Fig. 1). The possible epicenters would then be at 0.125λ/4, 0.25λ/4, 0.375λ/4, 0.5λ/4, 0.625λ/4, 0.75λ/4, 0.875λ/4, λ/4, and so on from the projected planet position on the earth. These distances have been termed the "Triggering Distance (T.D.)".

DIRECTION OF FORCE

Fault lines (or) plate boundaries should be at a particular angle, so that the net force can effectively trigger the earthquake. For convergent plates, the force should act in order to give more convergence for one plate, so as to create enough stress to trigger the

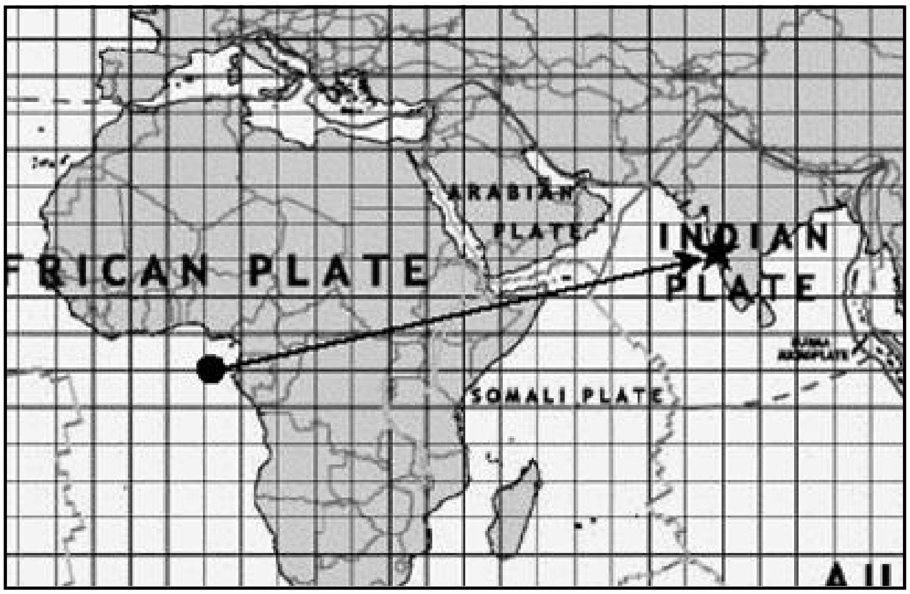


Figure 2. Koyna 1967 Earthquake: The Direction of Planetary force acting at the Epicenter.

Table 1. Planetary Configuration and their Forces for Maharastra Earthquakes

Place, Date & (Magnitude)	Planets aligned	Right Ascension	Declina-tion	T.D.	Planetary Force acting as Kinetic Energy (N)	Angular Momentum of planets (kgm^2s^{-1})	Rotational Speed of Earth at Epicenter (km/hr)
Bhusawal – Sawda Area, Maharashtra, (6.3); 14.03.1938	Sun, Mercury & Venus	358.1366°	-1.6358°	13774.75	2.7002×10^{28}	2.6725×10^{40}	1557.8419
Koyna, Maharashtra (6.6); 10.12.1967	Moon & Saturn	5.55674°	0.0427°	11270.25	4.5714×10^{25}	2.3801×10^{37}	1592.9501
Khilari, Maharashtra (6.2); 01.10.1993	Mars & Mercury	48.7731°	12.6109°	5009	6.0628×10^{21}	1.3390×10^{34}	1587.6192
Chandoli, Maharashtra (5.1); 08.12.1993	Venus & Mercury	62.0581°	20.1984°	1878.375	1.3004×10^{22}	5.8811×10^{34}	1596.8336
Koyna, Maharashtra (5.0); 12.03.2000	Venus & Mercury	332.9515°	-10.7511°	17531.5	2.5350×10^{22}	5.8811×10^{34}	1596.1219
Koyna, Maharashtra (5.3); 05.09.2000	Venus & Mercury	66.4487°	19.2562°	1252.25	1.0171×10^{22}	5.8811×10^{34}	1594.3999

earthquake. In the case of divergent plates, the force should act so that they interfere with the divergence of one plate that would increase the divergence of one of the plates. For normal and reverse faults, the direction of force should act perpendicular to the fault line; for strike and slip faults, it should act more or less parallel to the fault line.

DISCUSSION

Maharashtra Earthquakes

Among the several earthquakes that have occurred in Maharashtra, sixteen earthquakes in the Koyna region (from 1967 to 2000) were analysed for planetary configurations, net force and direction of force. In all of these, it is apparent that planetary configuration has acted as the triggering mechanism for release of accumulated stress. This comprehensive analysis has revealed that there is an inverse relationship between the magnitude of the earthquake and rotational speed of the Earth at the epicentre (Table 1). For example, in the case of the earthquake that occurred on 10 December 1967 with M6.6 (Fig. 2), the rotational speed of the earth was 1592.9501 km/hr, but for the 12 March 2000 earthquake with M5.0 (Fig. 3), the rotational speed was 3.1718 km/hr higher.

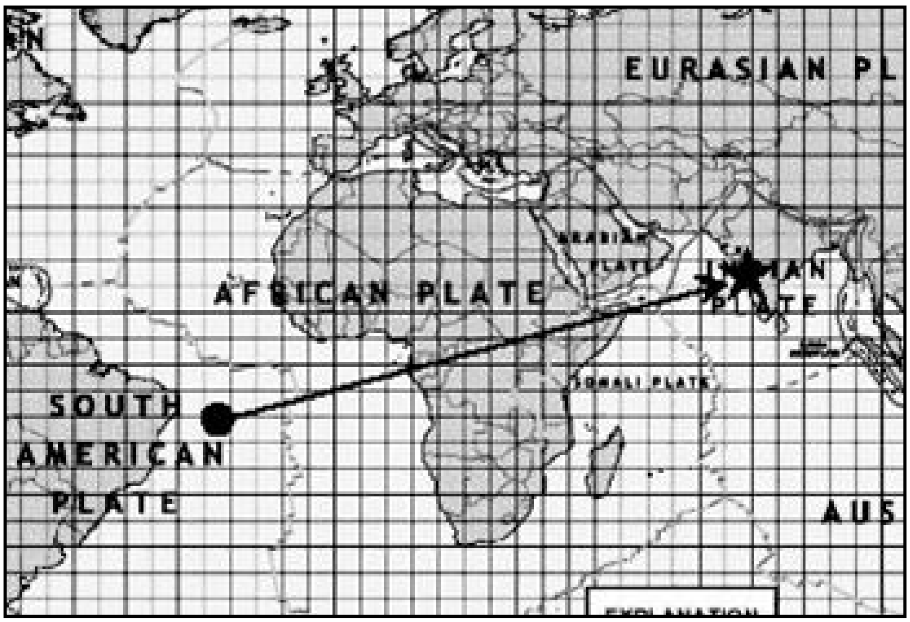


Figure 3. Koyna 2000 Earthquake: The Direction of Planetary force acting at the Epicenter.

Table 2. Planetary Configuration and their Forces for Tamil Nadu & Andhra Pradesh Earthquakes

Place, Date & (Magnitude)	Planets aligned	Right Ascension	Declination	T.D. (in km)	Planetary Force acting as Kinetic Energy (N)	Angular Momentum of planets (Kgm^2s^{-1})	Rotational Speed of Earth at Epicenter (km/hr)
Coimbatore, Tamil Nadu (6.0); 08.02.1900	Moon & Jupiter	64.3750°	21.5325°	3756.75	1.4916×10^{26}	5.8098×10^{37}	1640.2191
Bhadrachalam, A.P. (5.7); 13.04.1969	Sun, Mercury & Saturn	25.0783°	9.5809°	8139.625	1.3264×10^{28}	2.6748×10^{40}	1591.0452
Off Coast of Pondicherry, (5.4); 26.09.2001	Mars & Jupiter	102.8715°	24.3130°	10644.125	1.5833×10^{23}	5.8098×10^{37}	1633.7096

Tamil Nadu & Andhra Pradesh Earthquakes

In Tamil Nadu, two major earthquakes occurred, one at Coimbatore (8 February, 1900) and the other off the Pondicherry coast (26 September, 2001). In both cases, Jupiter aligned with another planet and was involved in the triggering of stresses related to these two quakes that involved strike–slip movement. The planetary forces acted more or less parallel to the fault line in order to trigger the earthquake. This can be inferred from the declination of the planets (Table 2).

In the case of Coimbatore earthquake (Fig.5), the activated fault was an E-W trending strike-slip fault; the Pondicherry earthquake also occurred due to the activation of another strike–slip fault but with a N-S trend. So the planetary forces which can act either in parallel or in oblique parallel directions can trigger the earthquakes. This type of planetary configuration is a rare phenomenon and most probably the reason for the rare occurrence of earthquakes in Tamil Nadu region.

The Bhadrachalam earthquake of April 13, 1969 occurred along the NW-SE trending fault transverse to the Godavari rift (Chandra 1977) triggered by the Sun-Mercury-Saturn combination. The planetary force acting as kinetic energy at the epicenter at the time of event was 1.326446 x 10^{28} N, in a more or less NE direction perpendicular to the fault at that place.

From the analysis of past 100 years of earthquakes and notable earthquakes of the Southern Peninsular region, the preliminary investigations of planetary configurations showed that there was a high probability of occurrence of an earthquake in the Koyna region between 17 February, 2005 and 30 March, 2005 with M5.0-6.0. Later, based on detailed analysis for the same region, it was predicted that an earthquake of M5.0-5.5 would occur in the Koyna

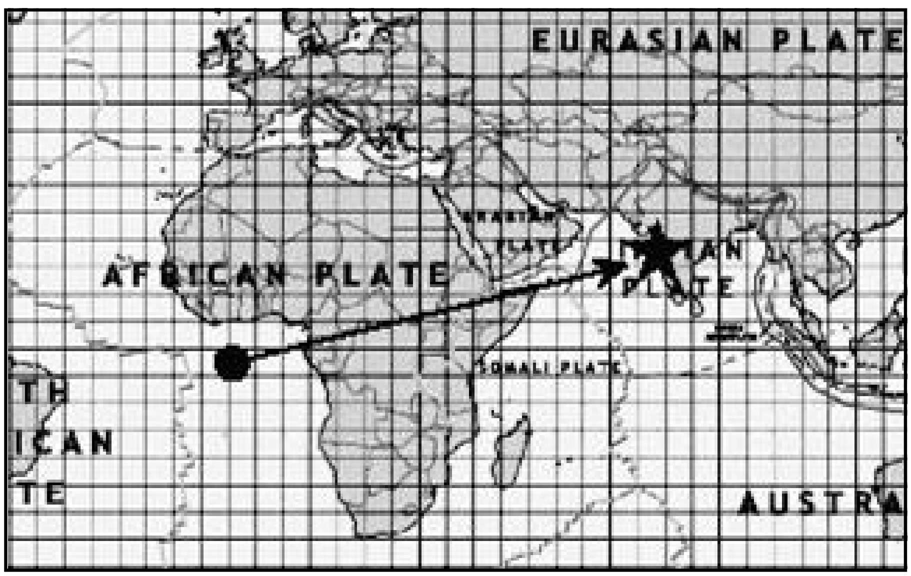
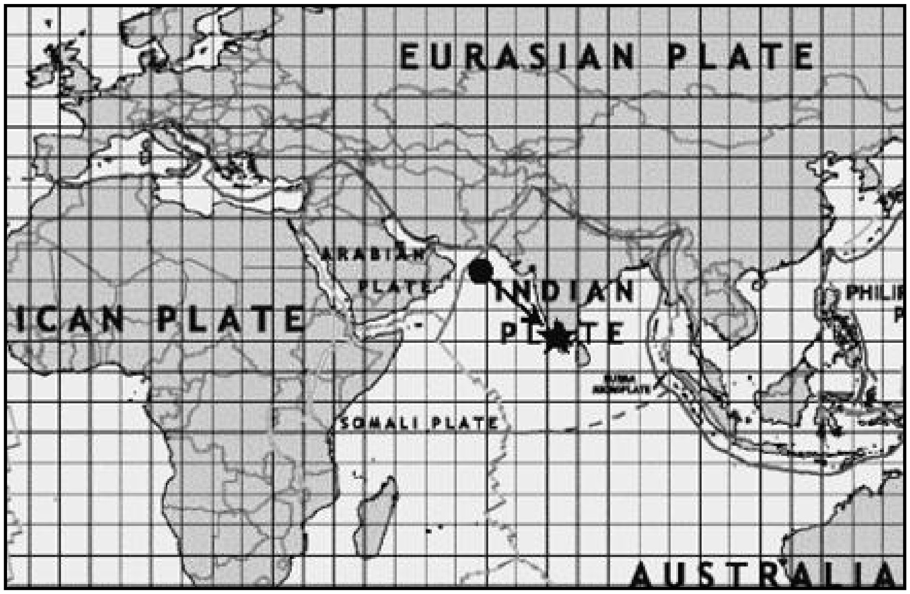


Figure 4. Koyna 2005 Predicted Earthquake: The Direction of Planetary force acting at the Epicenter.

Table: 3 - Planetary Configuration for the predicted earthquakes of Koyna region and Coimbatore.

Place, Date & (Magnitude)	Planets aligned	Right Ascension	Declina-tion	T.D. (in km).	Planetary Force acting as Kinetic Energy (N)	Angular Momentum of planets (Kgm^2s^{-1})	Rotational Speed of Earth at Epicenter (km/hr)
Koyna, Maharashtra (5.0 - 5.5); 17.03.2005	Venus & Sun	355.5786°	-2.6958°	13148.625	3.59 x 10^{22}	5.60532 x 10^{34}	1596.1219
Coimbatore, Tamil Nadu (6.0); 08.02.2011	Mars & Sun	321.1158°	-15.7918°	19409.875	3.66 x 10^{26}	1.06325 x 10^{37}	1640.2191



Legend: ● Planets' position
★ Epicentre of the particular earthquake
⟶ Direction of the planetary force

Figure 5. Coimbatore 1900 Earthquake: The Direction of Planetary force acting at the Epicenter.

region on 17 March, 2005, with a time window of ± 3 days. As predicted, the Koyna region did experience a M5.1 earthquake on 14 March, 2005. Another prediction for a possible M5.0 earthquake on 23 March, 2005, was given for the Bamnala area in Madhya Pradesh; on 25 March, there was an earthquake of M3.7 in this region. Similarly, the probability of the occurrence of an earthquake in the Coimbatore region (especially along the Noyyal River) is predicted on 8 February, 2011 with a magnitude of ~6.0 (Table 3). Some of our earlier predictions include the 9 December, 2004 Assam earthquake, the devastating 26 December, 2004 Sumatra earthquake, and several others in various regions including the Andaman and Nicobar (India), El Salvador and Guatemala (Central America), Honshu (Japan), Nias region (Indonesia), Xizang (Tibet) and Solomon Islands (Appendix 1).

CONCLUSIONS

The Earth is often caught in a huge gravitational web due to the alignment of major planets and other celestial bodies such as Sun and Moon. These planetary configurations exert gravitational stresses that lead to variations in the earth's rotational speed, affecting tectonic plate motion and triggering the release of accumulated stresses at plate boundaries/intraplate faults. Comprehensive analysis of the past 100 years of earthquakes reveals that earthquakes can be predicted using planetary configurations with fair accuracy with regard to time, location and magnitude. There are, however, specific conditions that control the release of these stresses such as the net planetary force, its direction with respect to the nature of the fault, and the triggering distances. Using these parameters, prediction of several earthquakes has been achieved with a time window of just ± 3 days and a spatial window of a minimum of 2.2 km (difference in distance between predicted epicenter and actual epicenter). It is inferred that the magnitude of the tremor is related to the direction of planetary forces acting at any particular point.

REFERENCES

Allegri, L., Bella, F., Della, M., Ermini, A., Improta, S. & Sgringa, V., 1983. Radon and tilt anomalies detected before the Irpinia (South Italy) earthquake of November 23, 1980 at great distance from the epicenter. Geophys. Res. Lett., 10, 269–272.

ASC., Amateur Seismological Commission. www.asc-india.org.

Asteriadis, G. & Livieratos, E., 1989. Pre-seismic responses of underground water level and temperature concerning a 4.8 magnitude earthquake in Greece on October 20, 1988. Tectonophysics, 170, 165–169.

Bansal, B.K. & Gupta, S., 1998. A glance through the seismicity of Peninsular India. J. Geol. Soc. India, 52, 67 – 80.

Beck, S.L. & Ruff, L.J., 1989. Great earthquakes and subduction along the Peru Trench. Phys. Earth Planet Interiors, 57, 199-224.

Birchard, G.F. & Libby, W.F., 1980. Soil Radon concentration changes proceeding and following four magnitude 4.2–4.7 earthquakes on the San Jacinto fault in Southern California. J. Geophys. Res., 83 B6, 3100–3106.

Chandra, U., 1977, Earthquakes of Peninsular India – A seismotectonic study. Bull. Seismol. Soc. Amer., 67(5), 1387-1413.

Dasgupta, S., Sural, B., Harendranath, L., Mazumdar, K., Sanyal, S., Roy, K., Das, L.K., Misra, P.S. & Gupta, H., 2000. Seismotectonic Atlas of India and its Environs. Geological Survey of India (GSI).

Dewey, J.W. & Spence, W., 1979. Seismic gaps and source zones of recent large earthquakes in coastal Peru. Pure Appl. Geophys., 117, 1148-1171.

Fraser-Smith, A.C., Bernardi, A., McGill, P.R., Ladd, M.E., Helliwell, R.A. & Villard, O.G., Jr., 1990. Low-frequency magnetic field measurements near the epicenter of the Ms 7.1 Loma Prieta earthquake. Geophys. Res. Letts., 17(9), 1465-1468.

Hartmann, J. & Levy, J.K., 2005. Hydrogeological and Gasgeochemical Earthquake Precursors – A Review for Application. Nat. Haz., 34, 279–304.

Hatai, S. & Abe, N., 1932. The response of catfish, Parasilurus asotus, to earthquakes. Proc. Imp. Acad. Japan, 8, 375-378.

Heinicke,J. & Koch,U., 2000. Slug flow – A possible explanation for hydrogeochemical earthquake precursors at Bad Brambach, Germany. Pure Appl. Geophys., 157, 1621–1641.

Igarashi, G. & Wakita, H., 1991. Tidal responses and earthquake-related changes in the water level of deep wells. J. Geophys. Res., 96 B3, 4269–4278.

Igarashi, G. & Wakita, H., 1995. Geochemical and hydrological observations for earthquake prediction in Japan. J. Phys. Earth, 43, 585–598.

Igarashi, G., Saeki, S., Takahata, N., Sumikawa, K., Tasaka, S., Sasaki, Y., Takahashi, M. & Sano, Y., 1995. Groundwater radon anomaly before the Kobe earthquake in Japan. Science, 269, 60–61.

ISC, 2001. International Seismological Centre. On-line Bulletin, Thatcham, U.K., http://www.isc.ac.uk.

Johnston, A.C., 1993. Report TR-102261. Electric Power Research Institute, Chap. 3.

Kagan, Y.Y. & Jackson, D.D., 1991. Seismic gap hypothesis: Ten years after. J. Geophys. Res., 96, 21419-21431.

Karl S., 1990. Planetary Alignment – Part 2, Great Moments in Science, Kruszelnicki Pty Ltd.

Kawabe, I., 1985. Anomalous changes of CH_4/Ar ratio in subsurface gas bubbles as seismogeochemical precursors at Matsuyama, Japan. Pure Appl. Geophys., 122, 194–214.

Kawabe, I., 1987. Identification of seismo-geochemical anomalies in subsurface gas CH_4/Ar ratio, geochemical filtering of earthquakes. Geochemical J., 21, 105–117.

Kelleher, J.A., 1972. Rupture zones of large South American earthquakes and some predictions. J. Geophys. Res., 77(11), 2087-2103.

Kellis-Borok, V.I., Knopoff, L., Kossobokov, V. & Rotvain, I., 1990. Intermediate-term prediction in advance of the Loma Prieta earthquake. Geophys. Res. Letts., 17(9), 1461-1464.

Kirschvink, J.L., 2000. Earthquake prediction by animals: Evolution and sensory perception. Bull. Seis. Soc. Amer., 90(2), 312-323.

Kissin, I.G., Barabanov, V.L., Grinevsky, A.O., Markov, V.M. & Khudzinskiy, L.L., 1983. Experimental investigations into conditions of groundwaters in order to identify hydrodynamic earthquake forerunners. Izvestiya, Earth Phys., 19/6, 482–491.

Ludwin, R., 1990. Earthquake Research at Parkfield, California, for 1993 and Beyond. U.S.G.S. Circular, 1116, 14.

Nischenko, S.P. & Sykes, L.R., 1993. Comment on "Seismic gap hypothesis: Ten years after" by Y.Y. Kagan and D.D. Jackson. J. Geophys. Res., 98, 9909-9916.

Rabinovich, A.B., Kulikov, E.A. & Thomson, R.E., 2001. Tsunami risk estimation for the coasts of Peru and Northern Chile. International Tsunami Symposium 2001, Seattle, WA, Proceedings, CD, 281-291.

Ranjit, B., 2001. The Quake Manual. Outlook, 5, 26-27.

Reimer, G.M., 1985. Prediction of Central California earthquakes from soil gas helium fluctuation. Pure Appl. Geophys., 122, 369–375.

Reimer, G.M. 1990. Helium increase. Nature, 347, 342.

Roeloffs, E.A., 1988. Hydrologic precursors to earthquakes, A review. Pure Appl. Geophys., 126, 177–209.

Rong, Y., Jackson, D.D. & Kagan, Y.Y., 2003. Sesimic gaps and earthquakes. J. Geophys. Res., 108 (BIO) (ESE 6.1-6.1, 2471, doi: 10.1029/2002JB002334).

Satake, H., Ohashi, M. & Hayashi, Y., 1985. Discharge of H_2 from the Atotsugawa and Ushikubi faults, Japan, and its relation to earthquakes. Pure Appl. Geophys., 122, 185–193.

Sato, M., Sutton, A.J., McGee, K.A. & Robinson, R., 1986. Monitoring of hydrogen along the San Andreas and Calveras faults in Central California, 1980–1984. J. Geophys. Res., 91, 12315–12326.

Scholz, C.H, Sykes, L.R. & Aggarwal, Y.P., 1973. Earthquake prediction - Physical basis, Science, 181(4102), 803–810.

Segovia, N., De la Cruz Reyna, S., Mena, M., Ramos, E., Monin, M. & Seidel, J.L., 1989. Radon in soil anomaly observed at Los Azufres Geothermal field, Michoacan: a possible precursor of the 1985 Mexico earthquake (Ms~8.1). Nat. Haz., 1, 319–329.

Subramanian, K.S. & Gopalakrishnan, K., 2002. Earth Tremors in the Coastal Belt of Tamil Nadu and Pondicherry in September, 2001 – A Geological Analysis. J. Geol. Soc. India, 60, 691-694.

Sugisaki, R., 1978. Changing He/Ar and N_2/Ar ratios of fault air may be earthquake precursors. Nature, 275, 209–211.

Suyehiro, Y., 1934. Some observations on the unusual behaviour of fishes prior to an earthquake. Bull. Earthquake Res. Inst., Univ. Tokyo, Suppl., 1, 228-231.

Terada, T., 1932. On some probable influence of earthquakes upon fisheries. Bull. Earthquake Res. Inst., Univ. Tokyo, 10, 393-401.

Toutain, J.P., Munoz, M., Poitrasson, F. & Lienard, A.C., 1997. Springwater chloride ion anomaly prior to a M'L¼5.2 Pyrenean earthquake. Earth Planet. Sc. Letts., 149, 113–119.

Tsunogai, U. & Wakita, H., 1995. Precursory chemical changes in groundwater: Kobe earthquake, Japan. Science, 269, 61–63.

Tsunogai, U. & Wakita, H., 1996. Anomalous changes in groundwater chemistry possible precursors of the 1995 Hyogo-ken Nanbu earthquake, Japan. J. Phys. Earth, 44, 381–390.

USGS, NEIC, United States Geological Survey, National Earthquake Information Centre, Golden, Colorado, USA. www.neic.usgs.gov.

Varotsos, P. & Alexopoulos, K., 1984a. Physical properties of the variations of the electric field of the earth preceding earthquakes, I.. Tectonophysics, 110, 73-98.

Varotsos, P. & Alexopoulos, K., 1984b. Physical properties of the variations of the electric field of the earth preceding earthquakes, II., Determination of epicenter and magnitude. Tectonophysics, 110, 99-125.

Virk, H.S. & Baljinder, S., 1994. Radon recording of Uttarkashi earthquake. Geophys. Res. Letts., 21, 737–740.

Virk, H.S., 1995. Radon monitoring of microseismicity in the Kangra and Chamba Valleys of Himachal Pradesh, India. Nucl. Geophys. 9, 141–146.

Walker, B., 1982. Earthquake. Alexandria, VA. Time-Life Books Inc, USA.

Wilson, D.C., Earthquake Prediction: Methodology and Feasibility, www.ees.nmt.edu/~davew/rweb/eqpaper2.htm.

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APPENDIX 1

Expected places vulnerable to earthquakes on 26 September 2004

- ✓ Planets Aligned: Sun, Mercury, Mars and Jupiter
- ✓ Planetary forces: $3.54103566 \times 10^{28}$ N
- ✓ Places: S.Coast of Honshu (~ 33 N, ~ 137 E), Sulawesi (~ 2 N, ~ 120 E), S.Coast of Taiwan (~ 23 N, ~ 121 E), Papua New Guinea (~ 2 S, ~ 142 E), Solomon Is (~ 6 S, ~ 154 E), Gorda Plate (~ 41 N, ~ 124 W), Los Angeles (~ 35 N, ~ 120 W), Mexico (~ 15 N, ~ 97 W), Nicaragua (~ 12 N, ~ 87 W), Dominican Republic (~ 20 N, ~ 72 W), Gulf of Alaska (~ 60 N, ~ 136 W), & Aleutian Is (~ 50 N, ~ 179 W).

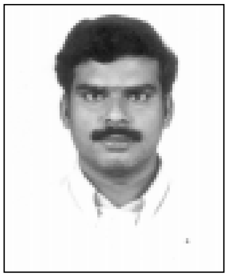
Expected places vulnerable to earthquakes on 28 September 2004

- ✓ Planets Aligned: Sun, Moon, Mercury, Mars and Jupiter
- ✓ Planetary forces: $3.56736492 \times 10^{28}$ N
- ✓ Places: Taiwan (~ 22 N, ~ 121 E), Honshu (~ 33 N, ~ 137 E), Hokkaido (~ 42 N, ~ 143 E), Kamachatka (~ 49 N, ~ 158 E), Gulf of Alaska (~ 58 N , ~ 141 W), Papua New Guinea (~ 7 S, ~ 148 E), Solomon Is. (~ 12 S, ~ 162 E), Molucca Sea (~ 1S, ~ 125 E), Gulf of California (~ 27 N, ~ 112 W), Mexico (~ 17 N, ~ 102 W), Costa Rica (~ 10 N, ~ 83 W), Hindu Kush (~ 34 N, ~ 72.50 E) & Ecuador (~ 1 S, ~ 82 W)

APPENDIX 1A

	Date	Latitude	Longitude	Mag	Region
Predicted data	26 & 28 Sep 2004	~33 N	~137E	-	NEAR S. COAST OF HONSHU, JAPAN
Actual event	28 Sep 2004	33.27N	137.81E	4.9	NEAR S. COAST OF HONSHU, JAPAN
Actual event	02 Oct 2004	33.41N	136.73E	4.7	NEAR S. COAST OF HONSHU, JAPAN
Predicted data	26 Sep 2004	~35 N	~120 W	-	California Region
Actual event	28 Sep 2004	35.85N	120.41W	5.0	California Region
Actual event	28 Sep 2004	35.81N	120.37W	6.0	California Region
Actual event	29 Sep 2004	35.38N	118.62W	5.0	California Region
Actual event	29 Sep 2004	35.95N	120.49W	4.5	California Region
Actual event	29 Sep 2004	35.95N	120.50W	5.1	California Region
Predicted data	26 Sep 2004	~2 N	~120 E	-	Sulawesi, Indonesia
Actual event	26 Sep 2004	1.05N	120.32E	5.2	Sulawesi, Indonesia
Predicted data	26 Sep 2004	~50 N	~179 W	-	Aleutian Islands
Actual event	26 Sep 2004	51.33N	179.97W	3.4	ANDREANOF IS., ALEUTIAN IS., AK
Predicted data	28 Sep 2004	~27 N	~112 W		Gulf of California
Actual event	24 Sep 2004	29.21N	112.55W	3.8	Gulf of California
Actual event	24 Sep 2004	28.56N	112.72W	5.9	Gulf of California
Predicted data	28 Sep 2004	~34 N	~72.50 E		Hindu Kush Region
Actual event	26 Sep 2004	36.26N	71.02E	4.0	Hindu Kush Region
Actual event	26 Sep 2004	36.40N	71.04E	4.1	Hindu Kush Region

Note: The Negative sign indicates South latitudes and West longitudes.
Sources for actual events data: http://earthquake.usgs.gov/recenteqsww/Quakes/quakes_big.html



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SUMMARY OF QUALIFICATIONS

DCAS (Comp.Sci)	Alagappa, Alagappa University
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M.Sc (Physics)	Bharathidasan, Jamal Mohamed College, Trichy
B.Ed	Annamalai, Annamalai University
M.Ed	Annamalai, , Annamalai University
MBA (Marketing)	IGNOU, IGNOU

RESEARCH AREA

PH.D.: PURSUING PH.D. PROGRAMME IN "PREDICTING EARTHQUAKE & ASEISMIC CONSTRUCTION DESIGNING" UNDER THE GUIDANCE OF DR.N.RAJESHWARA RAO, SENIOR LECTURER, DEPARTMENT OF APPLIED GEOLOGY, UNIVERSITY OF MADRAS.

CONFERENCES ATTENTED

1. Presented a paper titled "Planetary Configuration: Implications for earthquake prediction" in the International Conference on "Managing Seismic Risk in Developing Countries (MSRDC – 2004)" Organized by Disaster Management Institute, Bhopal dated 17^{th} – 19^{th} March 2004.
2. Presented a paper titled "Planetary Configuration: Implications for Earthquake Prediction – A Case study on Bhuj Earthquakes" in SC-E Earthquake Prediction Research Session, at the International Conference of the "European Seismological Commission – XXIX General Assembly", jointly organized by the University of Potsdam, Germany, and Geo Forschungs Zentrum, Potsdam, Germany from September 12-17, 2004.
3. Venkatanathan. N, Rajeshwara Rao. N, Sharma K.K, Periakali. P, presented a paper titled "Planetary Configuration: Implications for Earthquake prediction – A case study on Hokkaido Earthquakes" was published in the official web site of Asian Seismological Commission. The Conference was organized by ASC on October 18 – 21, 2004 at Yerevan, Armenia.
4. Presented a paper titled "Planetary Configuration: Implications for foreshocks and failed events, Parkfield, California" in Session: Earthquakes, at the International Conference "Hazards 2004" on "Natural and Human-induced hazards" organized by NGRI, Hyderabad, India, from December 2-4, 2004.
5. A paper titled "Planetary Configuration: Implications for Earthquake Prediction and Occurrence in Southern Peninsular India" presented in Main theme Session: "Inter and Intraplate Seismicity in India and future Strategies", at the 41^{st} Annual Convention of Indian Geophysical Union (IGU) organized by IGU, Hyderabad, India, from December 29-31, 2004.

AWARDS RECEIVED

Received "Best Teacher Award" from Lions Club for the academic year 1997 – 98.

How I entered this Field of Research
Bhuj earthquake and its repercussions:
Within two minutes, the furious ground shock completely wiped out Bhuj and the life style of Bhuj people was turned upside down. Those who survived the quake took their dead on vegetable carts to cremation and burial grounds. This catastrophic event catapulted me into this field of research.

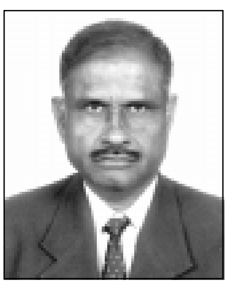
Dr. N.RAJESHWARA RAO

Has 20 years of teaching and research experience in the field of Micropaleontology and Paleoseismology.

- Has published over 11 research papers in various International and National journals.
- Visiting Faculty at Anna University for teaching Engineering Geology for B.E. Civil Engineering students.
- Life Member of Geological Society of India.
- Life Member of Paleontological Society of India.
- Field of Interest: Earthquake prediction using planetary configurations, Paleoseismicity studies using foraminiferal analysis, Ecology and distribution of benthic foraminifera from sewage outfalls and mangrove swamps, Ecology and distribution of benthic foraminifera from inner shelf and saline lakes, and Pathological morphogenesis in benthic foraminifera.

Dr. K.K. SHARMA

- Has 25 years of teaching and research experience in the field of Exploration Geophysics. Since 1998 working professor in the University of Madras.
- Has published over 35 research papers in various International and National journals.
- Carried out research as a visiting Research Associate at NGRI, Hyderabad and also as visiting scientist of DST to work in NGRI, Hyderabad.
- Having collaborative research work with NGRI, Hyderabad and CWRDM, Calicut.
- Field of Interest: Ground water geophysics and geophysical data processing especially potential field data.



Dr. P.PERIAKALI

- Basically a Environmental Geochemist working in the University of Madras since 1975 and holding the position of professor and Head, Department of Applied Geology.
- Has made significant pioneering research in Tamil Nadu during the last three decades to understand the impact of toxic and heavy metal pollution in the ground water around mining areas and coastal ecosystems.
- Has produced 8 Ph.D. thesis in the field of Environmental geochemistry, Micropaleontology and Applied Geochemistry during the last 13 years and 7 students are currently working for their Ph.D. degree in the field of Environmental geochemistry and Applied Hydro geochemistry.
- Has published a text book for the benefit postgraduate students in geology.
- Has initiated research collaborations jointly with the various organisations in India and abroad and guiding a team of professionals in his department working in the applied aspects of geosciences such as integrated coastal zone management, mitigation and management of natural hazard, global climate change, remote sensing and GIS applications, etc.
- Has published over 40 research papers in various National and International journals.