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NEED FOR A REGIONAL SEISMOLOGICAL CENTRE IN ASIA

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ABSTRACT

The availability of seismological data from regional and local network of stations maintained by different geophysical institutions in India has been presented. Although the accuracy in the epicentral parameters of local earthquakes is far better than those for the regional earthquakes, the situation is far from being satisfactory for earthquakes near the Indian plate boundary. In spite of the improvements of network of seismological stations in the Himalayan region through the All India Coordinated Programme of the Department of Science and Technology on Himalayan Seismicity and Seismotectonics, the spareseness of data from the neighbouring countries and wide gap in Tibet is a major constraint. This could be overcome through regional cooperation for which some mechanism needs to be evolved. Such a mechanism will also help in quick data dissemination and exchange of information using high speed telecommunication circuits of W W W Programme of W.M.O. Since more and more seismological stations are being changed to digital type and a few wide band seismographs will be developed in the region, the enormous flow of data could be exchanged and transmitted through satellites and super computers.

1. INTRODUCTION

The seismic belt running through Turkey, Iran, Afghanistan, Pakistan, India, Bhutan, Burma and Indonesia is attributed to the collision of the Indian and Eurasian plates. It is postulated that a major portion of this collision is being taken over by the process of thrusting along the Himalayan Frontal Zone while components of remaining movements is distributed over wider tectonic regions including the Pamirs and the Tibatan Plateau. While the causes of the generation of the Main Central Thrust (MCT) and Main Boundary Thrust (MBT) could still be debated, there is evidence to suggest transmission of stresses from North to South extending upto the Main Frontal Thrust. These thrusting systems are of different geological ages and are associated with different tectonic characteristics. The MCT is linked with Miocence age metamorphism and is considered to be feature along which the higher Himalaya overthrust the lower Himalaya. The MBT is of mid Miocence-Pliocence age, along with the sub-Himalayas consisting of post-collisions and Siwaliks are overthrusted to the Northern side by the older age rocks of the lower Himalaya. Thus, the North North-easterly Indian Plate which is moving at about 5 cm per year is causing continued convergence process along the Himalaya which would continue to cause destructive earthquakes from time to time in the region. The object of the paper is to review the present system of reporting earthquakes in India and neighbourhood and suggest a system for rapid earthquake data exchange and dissemination so that disaster mitigation efforts can be taken at the earliest.

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2. EARTHQUAKES IN INDIA AND NEIGHBOURHOOD

Figure 1 shows the epicentral map of earthquakes in India and neighbourhood for the period 1800 to 1986. The data has been taken from the catalogue of earthquakes prepared by Tandon and Srivastava (1974) which has been updated using monthly bulletins of the International Seismological Centre, UK. It may be noted that the seismic activity is clustered along the borders of Iran, Afghanistan, Pakistan, the Himalaya, Northeast India and thence to the Andaman islands. Great earthquakes (magnitude ≥ 8.0) have occurred in Rann of Kutch (1819), Shillong (1897), Kangra (1905), Bihar Nepal (1934) and Assam Tibet (1950) during the last two hundered years. It may be pointed out that such earthquakes have caused damage in the neighbouring countries as well. For example, the recent earthquake of August 22, 1988 (Mag. 6.5) caused considerable damage to life and property in India as well as Nepal. The Isoseismal pattern associated with this earthquake show two meizo seismal areas; one near Kathmandu in Nepal and other in North Bihar and neighbouring parts of Nepal which was found to be similar to that of the great earthquake of January 1934 (Mag. 8.4). It was experienced during this earthquake that the epicentral parameters given by India Meteorological Department and Department of Mines, Nepal were different. Also, due to lack of azimuthal control for epicentral determination, warnings for migration of seismic activity could not be given even though India Meteorological Department issued after shock warnings. For disaster mitigation plan, therefore, accurate determination of epicentral parameters is necessary for which data from different azimuths needs to be received in the shortest possible time.

3. SEISMOLOGICAL NETWORK IN INDIA AND NEIGHBOURHOOD

Figure 2 shows the network of seismological stations maintained by IMD. The local network of stations in the Northwest Himalayas around Pong and Pondoh dams is also shown in the same figure. It may be noted that although there are some gaps in the National network of seismological stations in India, there is an excellent coverage from the southern side for the earthquakes originating in the Himalayas. This network is being further expanded to instal 102 stations in the country. However, non-receipt of seismological data from the stations in the neighbouring countries namely, Pakistan, Afghanistan, Bangladesh and Burma does not enable us to determine the epicentral parameters of Himalayan earthquakes which is needed for seismological studies near the Indian plate boundary. The data from the neighbouring countries like Pakistan, Afghanistan and Nepal is however, included in the Bulletins of the International Seismological Centre which are published after a time lag of about $1\frac{1}{2}$ years, thereby causing limitations in earthquake risk assessment. The stations in these countries are located at Kabul, Karachi, Quetta, Nellore and Warsak Dam besides a four element radio telemetered network with the central receiving stations at Kathmandu.

4. RECEPTION AND DISSEMINATION OF SEISMOLOGICAL INFORMATION

At present, the epicentral parameters of earthquakes of magnitude 6 and more are transmitted through World Meteorological Organisation, GTS channel by US Geological Survey within two hours of occurrence of earthquake. However, from earthquake mitigation point of view, these information needs to be supplied in a shorter time. Figure 2 also shows the telecommunication links in India for seismic data reception. It may be mentioned that the permanent seismological stations send their data by Teleprinter lines (T/P), land line telegrams, telephone and telex to New Delhi which is the seismological headquarters of IMD. Round the clock watch is maintained at New Delhi, Bombay, Pune, Madras, Calcutta and

Shillong. However, there is no mechanism for exchange of data with the neighbouring countries which would be useful not only for improving the epicentral parameters but also the focal depth of earthquakes particularly if they occur near the boundary of neighbouring countries.

5. EPICENTRAL DETERMINATION IN INDIA

Figure 3 shows the system followed for determination of epicentral parameters of earthquakes in the Indian region. For regional events the computer programme by Shaikh et al., (1988) is used. For local events, however, the programme by Lee and Lahr,(1982) called Hypo-71 is used on the IMD computer. Of late, the P and S wave onset times from the strong motion arrays in Western Himalayas and Northwest India have also been used to locate earthquakes in this region. (Srivastava, 1989). The data from the Indian Seismological Stations is published in the form of monthly seismological bulletin which is also sent to the International Seismological Centre (ISC), UK according to their schedule and utilized for epicentral parameters based on global data.

6. REGIONAL PLATE TECTONICS AND EARTHQUAKE SOURCE MECHANISM

Studies of the structure of the Himalayas and other areas of ongoing collision in relation to active tectonics enable us to understand how collision process took place. The study of the focal mechanism of earthquakes in the region (Tandon and Srivastava,(1976) ,Srivastava and Chaudhury,(1979) and others), has brought to light that earthquakes of normal as well as tear fault mechanism take place near the foot hills of Himalayas apart from the thrust faulting which is expected from the geological considerations of underthrusting of the Indian plate below Eurasian plate. The overall shape of the basement surface in the Himalayan foreland appears analogous to that of oceanic crust in modern subduction settings. (Molnar et al.(1976); Karner and Watts,(1983)). The studies based upon the seismic profiles upon foreland of India (Acharya and Ray, (1982)) and Pakistan show a low angle detachment zone extending northward to just south of the MBT where the seismic coverage ends. The extent of the low angle detachment zone beneath the Himalaya and its relationship to more interior thrust faults (MBT, MCT) would be tested through the acquisition of deep crustal reflection data. However, improvement in the epicentral parameters of earthquakes would also enable us to obtain a more coherent mechanism, requiring better observational network in the region. Redetermination of focal mechanism of earthquakes based upon the local crustal velocity models have shown that tear faults in Himachal Pradesh could be associated with the earthquakes of 1968 and 1978 in the region. However, the recent earthquake of April, 1986 occurred near the main boundary fault where the focal mechanism was found to be that of normal type instead of thrust type as would be expected from the observations reported by the geologists. This result was found to be similar to a normal fault observed North of Salt Range in Pakistan which would be attributed to the extension of the upper part of the elastic plate in that region. Normal fault solutions for two large earthquakes beneath the Ganga Basin have also been interpreted as a result of fluxures of the Indian continental lithosphere (Molnar et al.,(1976); Ni and Barazangi, (1984)). However, Srivastava and Chaudhury (1979) re-examined the focal mechanism solution of 1966 earthquake. Their solution was based upon data from large number of Indian Seismological Stations and reported strike slip faulting for the same earthquake. In Northeast India Burma Border region, where the Indian plate boundary could be discernible based upon the depth distance cross section, thrust as well as normal faulting of earthquake has been reported (Srivastava and Chaudhury, 1979). It may be mentioned that many of these focal mechanism solutions of earthquakes could be improved if the network of seismological stations in the region could be increased.

7. SPATIO TEMPORAL SEISMICITY PATTERNS

Spatio temporal seismicity patterns preceding earthquakes of 1968, 1978 in Himachal Pradesh, 1966 and 1980 in India-Nepal border and August 1988 near India-Burma and India-Nepal borders have been analysed by Srivastava et al. (1988), Srivastava and Gautam (1987) and Srivastava and Rao (1989). Out of six earthquakes four showed almost similar pattern of seismicity namely, increase of seismic activity followed by quiescence preceding the earthquakes. The logarithm of area of seismic quiescence was found to be proportional to the magnitude of the impending earthquake in three cases except for Manipur- Burma earthquake which had intermediate focal depth (100 km). Greater confidence in seismicity patterns has been found for the areas having close network of seismological stations like Himachal Pradesh in Western India. However, such studies based on ISC data often loose operational value since the anomalous patterns can be detected only when the data is available after about $1\frac{1}{2}$ years while the event may occur earlier depending upon its magnitude.

8. REGIONAL SEISMOLOGICAL CENTER - A PROPOSAL

Keeping in view that the Himalaya represents the most extensive active collision zone in the world, extending westward from Burma through northern India, Nepal and southern Tibet, into northern Pakistan and active foreland thrusting is occurring on a continental scale due to Indian shield being overriden by its own northern margin in a series of thrusts, recurrence of great earthquakes is not expected near the boundary of India and its neighbourhood due to accumulation of strain since 1950. It is, therefore, necessary that a mechanism is worked out for rapid transmission and exchange of seismological data in this region which can provide more accurate information on the epicentral parameters of earthquakes in the shortest possible time on operational basis besides providing data for warnings of aftershocks and migration of seismic activity. Such methodology could also be valuable to study space time variations of seismicity preceding earthquakes on semi real time basis than what is possible from the ISC data at present.

Figure 4 shows how the World Meteorological Organisation/GTS channels are connected from the neighbouring countries via New Delhi. Through the acquisition of VAX Computer at the Regional Telecommunication Hub at New Delhi, data upto 9,600 bauds could now be transmitted through this channel. The IASPEI has already worked out a telegraphic code for the transmission of seismological data which is slightly more exchaustive than the one present used by IMD on day-to-day basis within India. Robotran and VAX Computers are also functioning at the National Data Centre, Pune, at IMD which are being upgraded keeping in view the future requirements for data archiving and its dissemination. Arrangements to record data on optical discs (600 mb) and reading facilities are being made. A super computer, CRAY XMP 14 has been installed at the National Centre for Medium Range Weather Forecasting (IMD Campus, New Delhi) under the Department of Science and Technology, which could enable us to utilise for synthetic seismogram simulation and source dynamics studies for regional plate tectonic studies. It would thus be useful if a Regional Seismological Centre could be established at New Delhi utilising the present WMO channels for the rapid exchange of the data and existing observational and data computing facilities in IMD.

9. CONCLUSIONS

The above study has shown that, there is a need for a Regional Seismological Centre in Asia for rapid exchange of data, epicentral determination, earthquake risk assessment, refinements of regional plate tectonic model and identification of precursary seismicity patterns and issue of warnings for aftershocks and migration of seismic activity. In view of a close network of seismological stations and the availability of WMO/GTS telecommunication channels between India and neighbouring countries and computational back up (super computer), such a network could be established at IMD, New Delhi.

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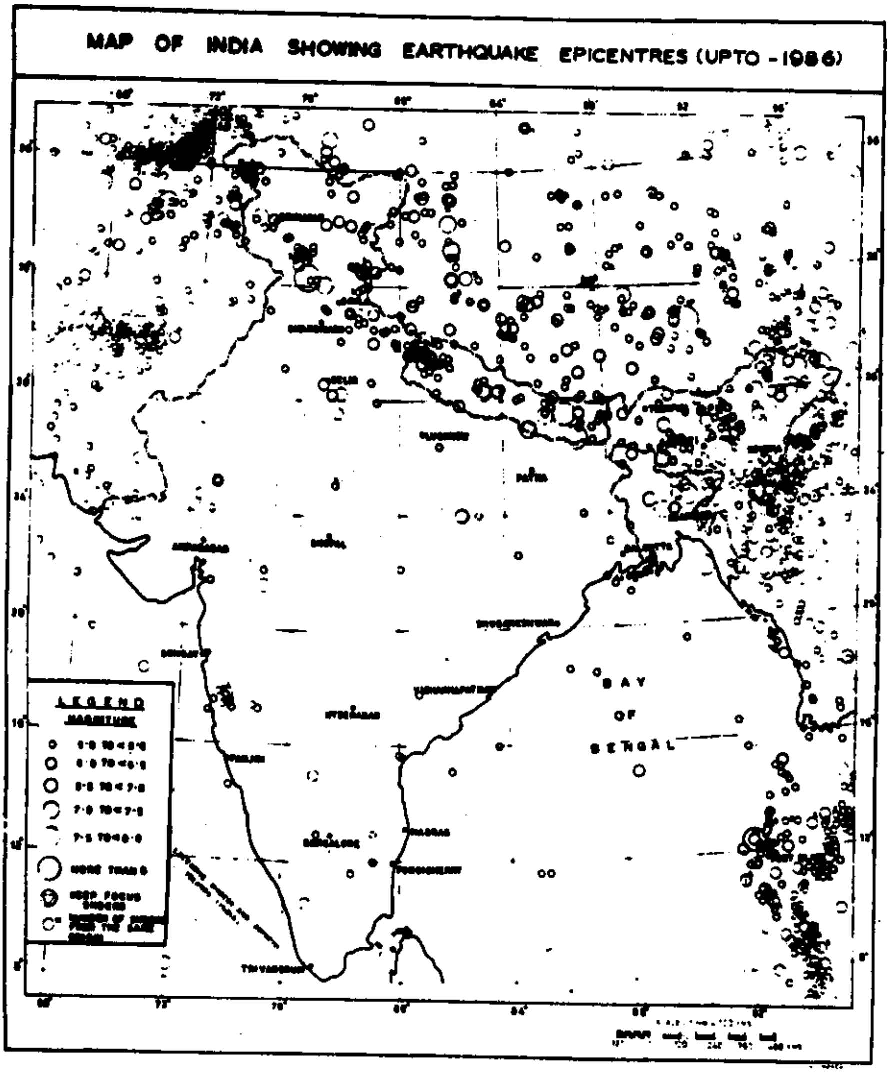

Fig. 1 : Epicentres of earthquakes in and near India (Upto 1986)

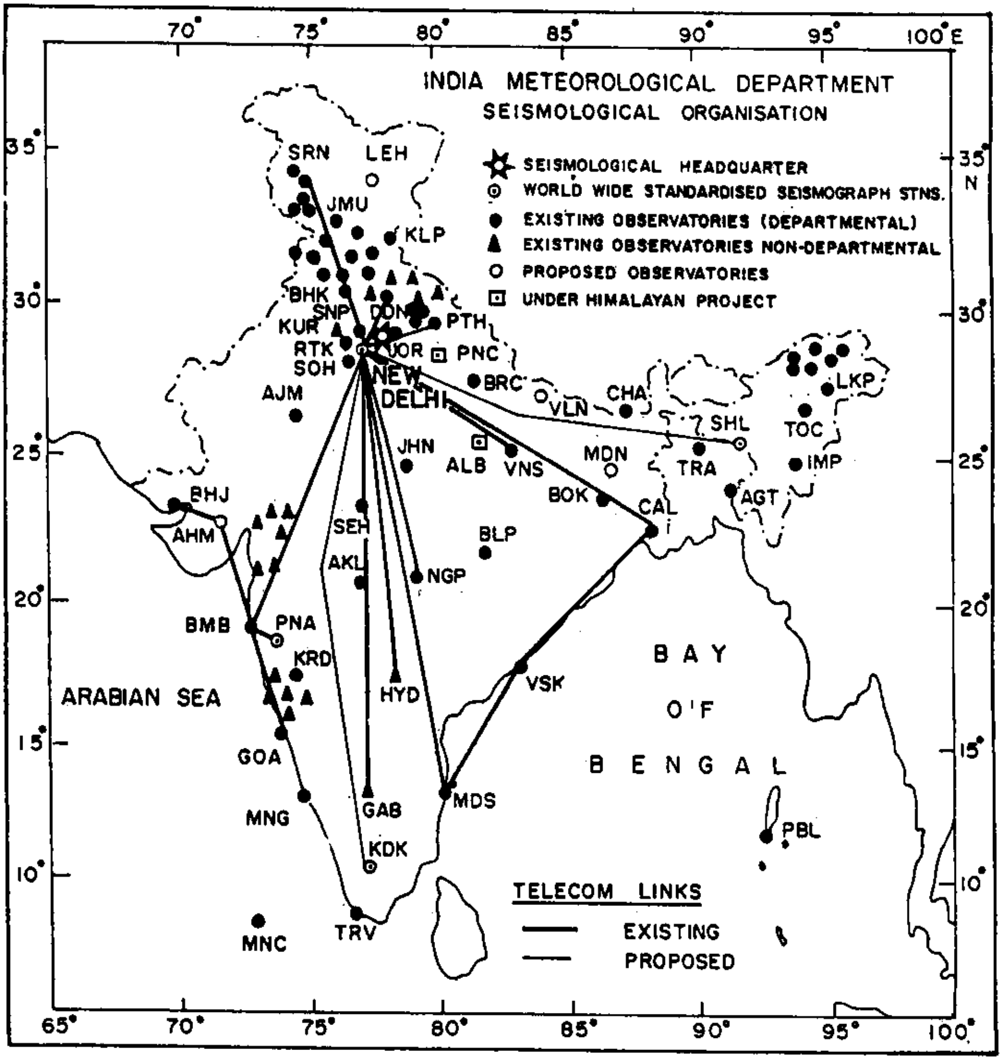

Fig. 2 : Network of Seismological Stations in India and their connections through teleprinter channels.

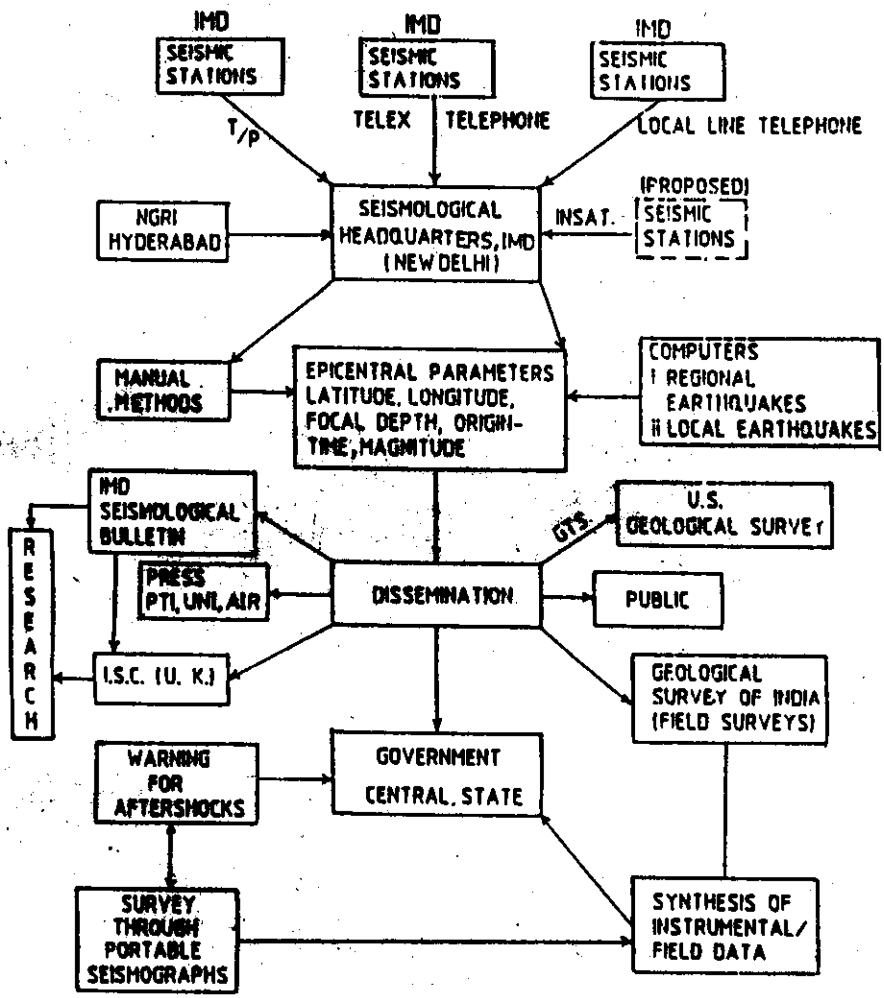

Fig. 3 : Epicentral determination and dissemination in India.

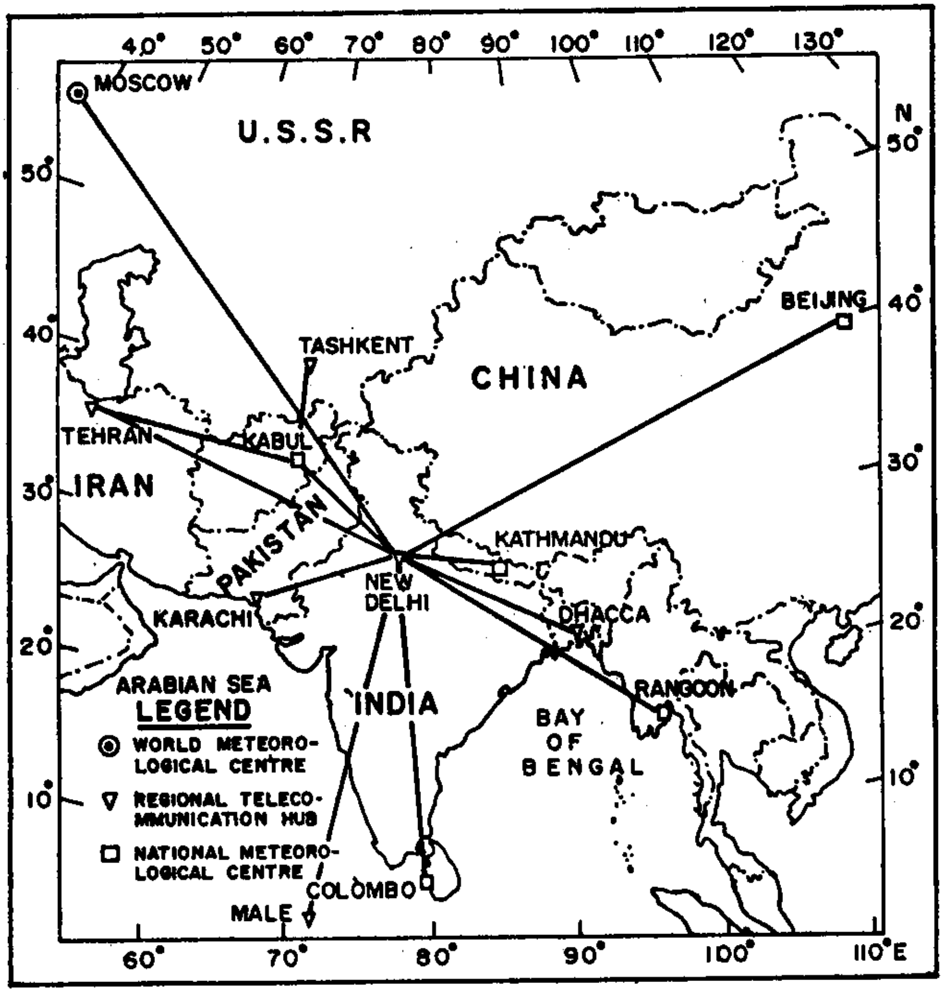

Fig. 4 : WMO/GTS channels to India and neighbouring regions.