HIS MAJESTY'S GOVERNMENT OF NEPAL
MINISTRY OF INDUSTRY, COMMERCE AND SUPPLIES
DEPARTMENT OF MINES AND GEOLOGY

National Seismological Network

Lainchour Kathmandu, Nepal
March 2006,Chaitra 2062

Message from the Director General

Seismology has developed from a young science to a relatively mature science. Many advances in the understanding of the cause and effect of earthquakes and in the discovery of internal structure of the earth owe to seismology. Today it is not only the tool for the assessment of seismic hazard but also a tool to study the earth structure and image the subsurface for mineral and oil exploration.

The more we invest in basic research to upgrade ourl knowledge in geoscience, the the higher the chance that our development challenges will be met. Such investment cannot produce an instantaneous, directly tangible return. The benefit from research investments such as in the Department of Mines and Geology, National Seismological Network is essentially the disaster mitigation effects made possible by the scientific outputs such agencies produce. Such mitigation effect could and should be evaluated as the difference between the damage cost with and without the mitigation measures made possible by such scientific works.

The National Seismological Network in its present form is a culmination of the efforts of Nepali and French geoscientists over several years since the establishment of Nepal's first seismic station at Phulchoki, Kathmandu in November, 1978 by the Department of Mines and Geology in cooperation with the Laboratoire de Geophysique Appliquee, Paris University, France. Over these years, it has gained valuable experience in planning, construction, operation, and maintenance of seismological instrumentations in rough and remote regions of the country. It also has gathered experience in processing and interpretation including some limited research results.

The challenge now, is to operate the network at a high level of efficiency to secure an effective and almost instantaneous, post-earthquake rescue operation and to carry out meaningful seismological researches to resolve problems of earthquake hazard assessment and disaster mitigation and of regional mineral potentiality. The National Seismological Network of the Department of Mines and Geology is committed to meeting this challenge and calls for collaboration and requests support from concerned national, regional, and international agencies in this task.

N. R. Sthapit
Director General

cover photo: Laurent Bollinger

Bhaktapur's Durbur Square before (top) and after (below) the 1934 Bihar-Nepal Great Earthquake

INTRODUCTION

The Himalaya range from Assam in the east to Kumaon in the west has experienced four large, M~8 earthquakes in the last century, including the 1934 earthquake that occurred in Nepal. There is geological evidence that even larger events have occurred in the past, and geodetic and seismic monitoring show that stress is accumulating and that in the future, large earthquakes will rupture again along the Himalayan front. The area west of Kathmandu and east of Dehradun/India has not ruptured in the last three hundred years and stands out as a potential site for great Himalayan earthquakes.

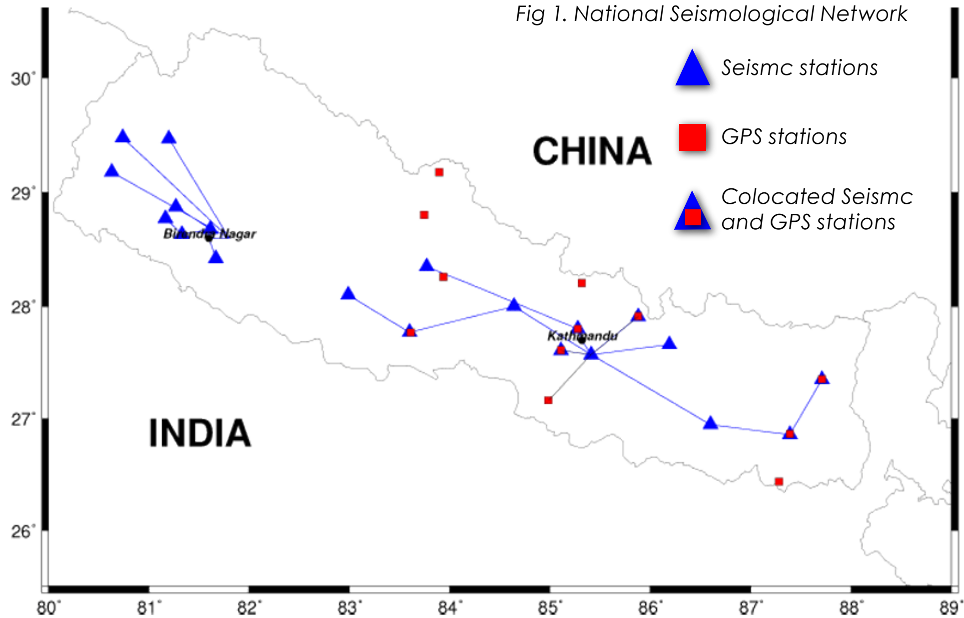
The Department of Mines and Geology (DMG) is collaborating with many scientists from all over the world to understand the cause and devastating effect of the earthquakes, and to help mitigate the ensuing destruction. The effort started in the eighties with Laboratoire de Geophysique Applique (LGA) Paris University, and the deployment of an array of short period vertical seismometers at Phulchoki around the Kathmandu Valley. After the 1988 Udayapur earthquake that claimed 1300 lives, a priority became the expansion of the national network of seismic stations to cover the whole territory of Nepal.

As a result, the National Seismological Network project was launched in 1991, in collaboration with Laboratoire de Geophysique (Department Analyse Surveillance Environment, France) with, as an objective, the deployment and operation of a nationwide seismic network designed for early warning. Deployment was completed in 1994, and the NSC is now operating twenty short-period 1-component stations that are telemetered in real-time. (Fig 1)

Data from eight seismic stations west of Pyuthan are telemetered to the Regional Seismological Centre at Birendranagar, Surkhet and the data from remaining twelve stations east of Pyuthan are telemetered to the National Seismological Centre in Lainchaur, Kathmandu. More recently, the seismic network was complemented with continuously recording GPS stations as part of a collaborative project with the Laboratoire de Geophysique (France) and the Caltech Tectonics Observatory (Californian Institute of Technology, USA). The first three stations were deployed in 1997 and the geodetic network now consists of thirteen stations.

The data from these networks have revealed key information on Himalayan seismicity and crustal deformation, providing firm basis for seismic hazard assessment in the Nepal Himalaya. The network provides routine information on global seismicity, contributing to world-wide monitoring and early warning in case of damaging earthquakes.

Fig 1. National Seismological Network

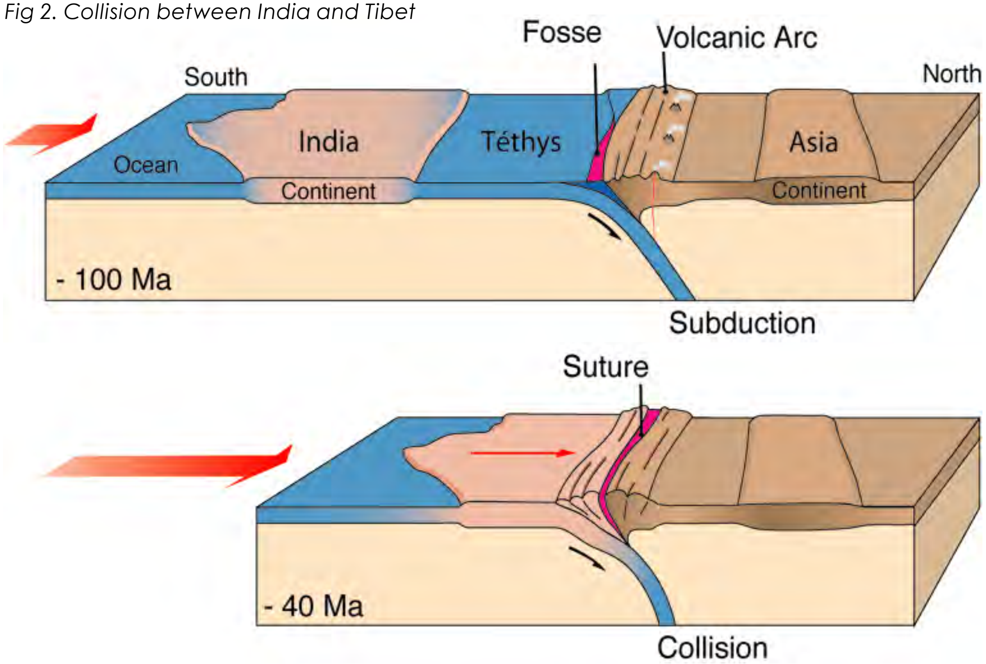


TECTONIC SETTING

About 200 million years ago, an ocean, the Tethys sea, separated India from the rest of Eurasia. This sea was gradually consumed through the subduction of the oceanic floor beneath Tibet. Sometime between fifty-five and forty million years ago, the Indian plate collided with Eurasia along the Indus and Tsangpo rivers valley suture zone that now lies within Tibet.

Nepal is situated within this seismically active Himalayan mountain belt, which formed as a result of the indentation of peninsular India into central Asia. According to the prevailing concept of plate tectonics, the outer shell of the earth is divided in a limited number of rigid plates that float over the viscous earth mantle, slipping and sliding laterally along each other's edges and generating earthquakes. These tectonic plates move as the result of deep earth dynamic processes, which govern the plate formation by magmatism at oceanic ridges, and their sinking into the mantle along oceanic trenches. (Fig 2)

Fig 2. Collision between India and Tibet



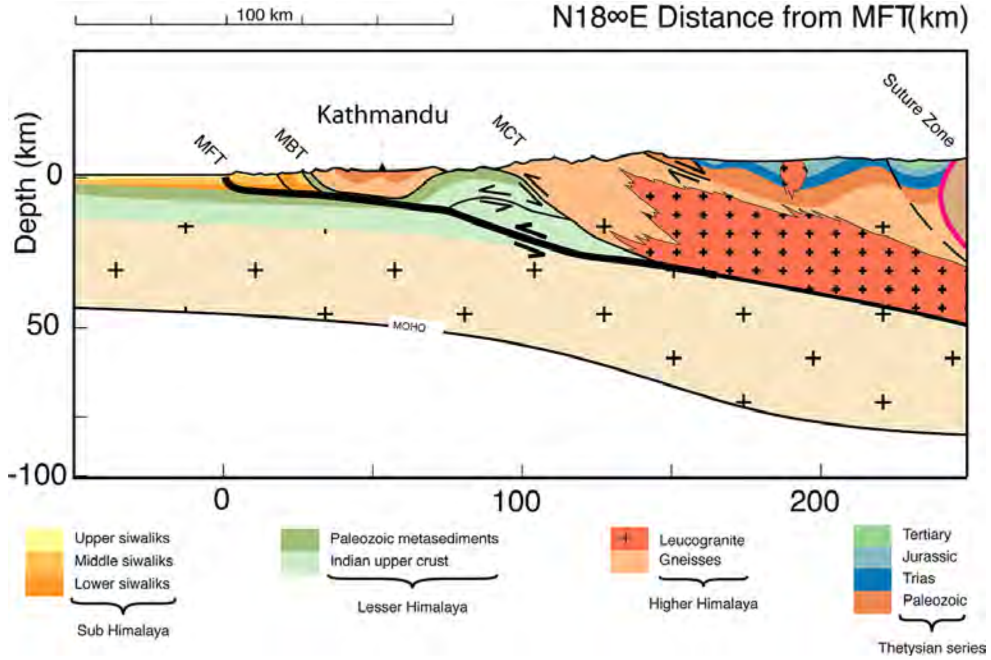


Fig 3. Geological section across the Himalaya through Kathmandu basin

The continuing northward motion of India at the rate of about 4cm per year has created widespread deformation, giving rise to the world's highest mountains. Large scale thrusting developed from north to south in the last twenty-five million years producing the Main Central Thrust (MCT) separating the Lesser Himalayas from the Higher Himalayas, Main Boundary Thrust (MBT) separating the Lesser Himalayas from the Sub Himalayas of the Churia range and Main Frontal Thrust (MFT) separating the Churia range from the Indo-Gangetic plane. Seismicity in the Himalaya is the direct consequence of this ongoing process of faulting and thrusting. (Fig 3)

Earthquakes occur when a fault slips suddenly as a result of excessive stresses generated by tectonic processes, thus contributing to crustal deformation. Earthquakes cause permanent ground displacements and elastic waves that can be measured from seismological stations and from geodetic measurements, using the GPS system.

NATIONAL SEISMOLOGICAL NETWORK

The National Seismological Network consists currently of 20 stations that are telemetered to two independent recording centers:

THE NATIONAL SEISMOLOGICAL CENTER, (NSC), KATHMANDU

NSC administrates and controls twelve stations: Lukagoan (Pyuthan), Koldanda (Palpa), Dansing (Kaski), Gorkha (Gorkha), Daman (Makawanpur), Kakani (Nuwakot), Phulchoki (Lalitpur), Gumba (Sindhupalchok), Jiri (Dolakha), Ramite (Udayapur), Odare (Dhankuta) and Taplejung (Taplejung). NSC is equipped with an electronic maintenance and control laboratory, and an automatic alarm system, (Seismic Alert System), in case of a large earthquake or technical failure, (Technical Alert System), of the network. This center is also equipped with facilities for routine processing of the seismic data, in particular the Jade/Onyx software package and a Geographic Information System. NSC compiles a weekly seismological bulletin reporting arrival time and data of seismic events recorded by the network with the processing of seismic signals being done in near real time.

Seismic station antenna and solar panel

GPS device at ------

Short period seismometer in its vault

View of recording and processing center at NSC

REGIONAL SEISMOLOGICAL CENTER, (RSC), BIRENDRANAGAR

RSC is an autonomous center responsible for the operation and maintenance of the eight stations at: Ghanteshwar (Dandeldhura), Ganjri (Baitadi), Badegauja (Kaii), Pushma (Surkhet), Bayana (Bajhing), Gainekanda (Surkhet), Gaibana (Surkhet) and Harre (Surkhet). It is equipped with data processing and earthquake location facility along with the Technical Alert System and the Seismic Alert System. The center also has facilities for electronic maintenance. The bulletin produced by RSC is regularly sent to NSC where all the data are combined to produce a mixed earthquake catalogue.

An effective and timely mobilization of post-earthquake rescue operations can save life and property loss considerably. Therefore, one major mission of the NSC is to issue a warning to authorities and media as soon as possible after any earthquake with local magnitude greater than 4.0 occurring inside the Kingdom of Nepal.

The weekly bulletins are distributed to National Earthquake Information Service (NEIS), USGS, Colorado and through NEIS to the International Seismological Centre (ISC), UK and to the Laboratoire de Gephysique(LDG), Bruyeres-le-Chatel, France.

CRUSTAL DEFORMATION MONITORING

Geodetic monitoring from permanent GPS stations has emerged as a very useful complement to seismic monitoring. This technique makes it possible to measure crustal deformation that may be too slow to generate seismic waves, in particular those revealing the gradual stress accumulation preceding large earthquake or the release of stress by transient, eventually aseismic, events. Such transient deformation events have been detected along some subduction zones, and might also occur in an intra-continental setting such as along the Himalaya. If transient aseismic deformation occurs at seismogenic depths in the Himalaya, it would have direct implication for seismic hazard assessment, because major recurring earthquakes might not absorb all the deformation. There is also a possibility that the rates of deformation might vary during the seismic cycle and could provide some indications on the timing of future earthquakes. In 2003, the DMG, the Tectonics Observatory, (Californian Institute of Technology, USA), and DASE, (CEA, France) agreed to install twenty three permanent continuous GPS stations. The first phase led to the deployment of ten continuous GPS stations between January and May 2004. A second phase of deployment is planned at the end of 2006.

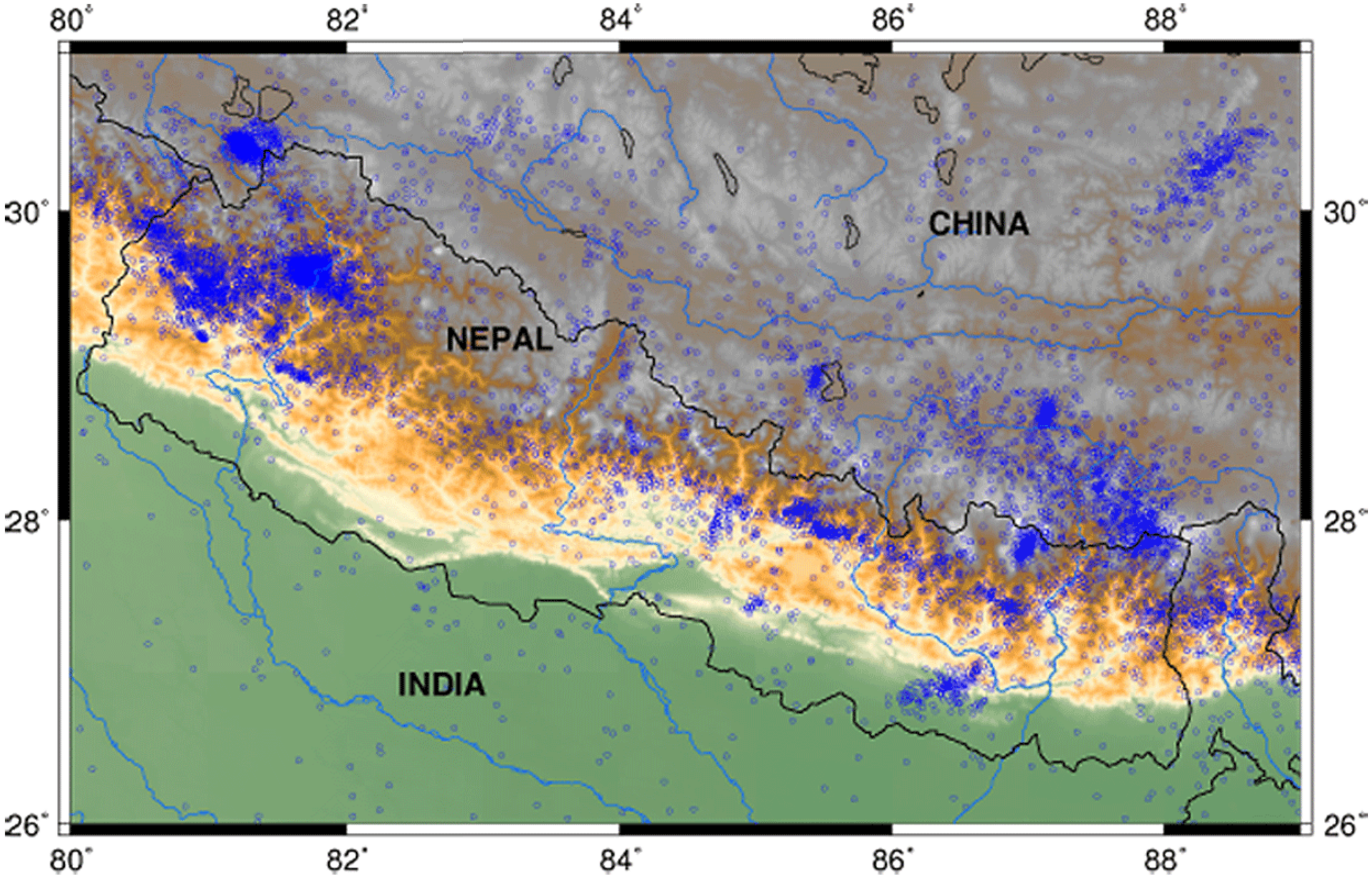


Fig 4. Seismicity map of Nepal shows earthquakes greater than 3 Magnitude (1995 - 2002)

Research Activities

SEISMOTECTONICS

Our understanding of the seismic cycle in the Himalaya has greatly improved over the last decade thanks to various research projects combining seismological monitoring, geodetic measurements, and geological investigations. These studies have shown that the most active fault is the Main Frontal Thrust fault, which absorbs about 2cm/yr of north-south convergence. Seimological, geodetic, geomorphologic, and paleoseismological investigations show that this fault is locked from the surface to beneath the High Himalayan peaks, over a distance of about 100km, and probably mainly slips during very large earthquakes with magnitude possibly exceeding Mw 8. The 1934 Bihar-Nepal earthquake is one of these recurrent damaging events, but even larger events appear to have happened in the past, according to paleoseismological investigations, and might occur again in the future.

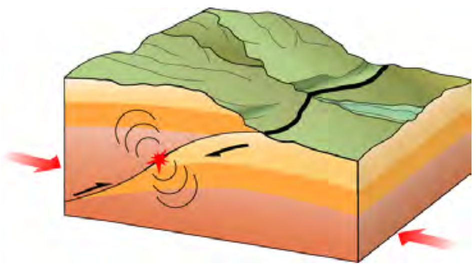


Fig 5.

MICROTREMOR SURVEY

Damages due to the 1934 earthquake were particularly high in the Kathmandu basin. The basin is filled with up to 600m of poorly consolidated lacustrine and fluviatile deposits which may have contributed to amplifying ground shaking. The NSC has carried on microtremor surveys which confirmed that the ground motion is indeed generally much higher on the sediments than on the bedrock surrounding the basin. This kind of measurements are key to estimate the characteristics of the ground motion that should be expected in future large earthquakes.

IMAGING THE STRUCTURE OF THE HIMALAYAN RANGE

A number of geophysical experiments using a variety of techniques, were carried out by the DMG in collaboration with various institutions from France, (CEA and CNRS), the USA, (Colorado University, Oregon State University, University of Illinois), and China, (Chinese Academy of geological Sciences), to obtain images of the structure of the Himalayan range and fault geometry. Gravity and MT sounding experiments were carried on as part of the IDYL-HIM project, (Imagerie et Dynamique de la Lithosphere) in collaboration with DASE and CNRS.

Fifteen broadband seismometers were deployed between September 2001 and September 2002 in eastern Nepal as part of the collaborative research project "Himalayan Nepal Tibet Broadband Seismic Experiment" ,(HIMNT), between Department of Mines and Geology and Colorado University, Boulder, USA. Similarly, seventy five Broadband seismometers were deployed between September 2002 and April 2004 in Central and Western Nepal under collaborative research Project "Himalayan-Tibet Continental Lithosphere during Mountain Building" (Hi-CLIMB), in collaboration with Oregon State University, and the University of Illinois (USA).

photo: Laurent Bollinger

The National Seismological Centre, under Department of Mines and Geology, is emerging as a leading research institute focusing on Himalayan seismotectonics and related seismic hazard. More than twenty-five research papers have been published in national and international scientific journals, www.seismonepal.gov.np. The NSC is committed to operating the network at the highest level of efficiency, to contribute to a better understanding of seismic hazard in Nepal, and warrant an effective and rapid post-earthquake rescue operation. The National Seismological Network of the Department of Mines and Geology is welcomes meeting this challenge and is open to international collaboration.

Acknowledgements

The National Seismological Centre of the Ministry of Industry, Commerce and Supplies, and the Department of Mines and Geology acknowledges with thanks and gratitude the support of all authorities and agencies in the successful making and operation of the National Seismological Network. We are greateful and thankful in particular to:

-the Government of France for the financial and technical assitance

-the National Seismological Centre of Department of Mines and Geology acknowledges the National Planning Commission and Ministry of Industry, Commerce and Supplies, HMG/Nepal for the support

-the Laboratoire de Geophysique, Bruyeres-le-Chatel at cea/DASE, France, for effective services as executing agency in the concerned field for the government of France

-Tectonics Observatory at the California Insititute of Technology

-Sofreavia, Issey-les-Moulineaux, France for successfully performing the construction of the project

-the Ministry of Water Resources, HMG/Nepal for providing the premises or the RSCB, Surkhet

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