THE KINNAUR EARTHQUAKE OF JANUARY 19,1975 AND ITS AFTERSHOCKS

by

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SYNOPSIS

Among the recent destructive earthquakes in India, the Kinnaur earthquake of January 19, 1975 is of special significance. In this paper, this earthquake and its aftershocks recorded till the end of March,1975 have been discussed. Based on well determined epicentral parameters of the aftershocks of magnitude more than 4.5, a two layered model has been derived to determine the crustal structure of the region.

The frequency magnitude relationship of the aftershocks has been discussed.

The focal mechanism of the main earthquake has been studied and discussed in relation to the spatial distribution of the aftershocks and the trend of the isoseismals.

INTRODUCTION

At 08h. 02m. 03s. GMT on January 19,1975 an earthquake of damaging magnitude struck the Kinnaur and adjoining districts of Himachal Pradesh. The earthquake was felt over an area of 0.55 million sq. km. in the Indian territory. It caused the death of 42 persons with injuries to 40 more. 278 houses were destroyed and another 2000 were damaged. Field investigations reveal that the maximum intensity reached MM X nearest the source. In the Himachal region this is the second damaging earthquake, in the present century; the earlier one was the Kangra earthquake of 1905. The aftershocks of this earthquake were numerous and are still contiming to occur, although in decreasing numbers. A seismological study of some aspects of this earthquake has thus been possible and are presented in this paper.

EPICENTRAL PARAMETERS AND BROAD STRUCTURE OF THE CRUST

The main earthquake was strong enough to be recorded by seismographs at long distances outside the country. Based on data from world-wide recordings, the United States Geological Survey have located its parameters as below :

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Origin Time - 08h 02m 2.5s (GMT)
Epicentre - Lat. 32.45°N, Long. 78.43°E
Depth of focus - Normal
Magnitude - $m_b = 6.2$ $M_s = 6.8$

Although a close network of seismic stations are operating in India - and particularly in Himachal Pradesh, - a foreshock occurring a few minutes earlier did not enable the times of onset of waves from the main event to be read with any reliability. No determination of its location from near station data was therefore attempted. Instead, since the USCG determination was based on data enjoying a better azimuthal control, we have used the USGS determination of the parameters of the main earthquake and a few of the stronger aftershocks to work out the structure in this region. The inset map in figure 1 shows the location of the seismic stations whose data have thus been used. The analysis gave the following broad structure, on the adoption of a two layer model crust.

Layer	P.Vel. km/sec	S.Vel. km/sec.	Thickness (kms).
(Granitic) Top layer	5.6	3.3	33
(Basaltic) Second layer	6.67	3.65	16
M-Discontinuity at Ultrabasic	8.2	4.4	49

It may be pointed that in working out the above structure no rigorous error analysis/estimate has been made, as our objective was to arrive at a tentative structure which could be used for locating the aftershocks. Any small differences in this structure will affect the accuracy of these locations but while dealing with a number of events close to one another, their relative positions will not be so affected. This has been taken advantage of in the study of the aftershocks in the next section.

It may, however, be mentioned that the above structure is in fairly good agreement with results obtained in other studies. The depth of the M-discontinuity (i.e. 49 kms) also appears reasonable in view of the general elevation of the region and the established roots of the Himalayan Mountains. It is significant to note that in the thickening of the crust, the granitic layer mostly has contributed. In the oceanic areas where the crust is thinner, the granitic layer is absent. It thus appears that the granitic layer plays an important role in the evolution of the mountain roots.

AFTERSHOCKS OF THE EARTHQUAKE

As mentioned earlier, the main earthquake was followed by a large number of aftershocks. For studying these, the data from the close-in observatories were used. The Pg Pn interval was used. as a control on the depth determination.

All recorded aftershocks with magnitude 3.5 or more on the Richter Local Magnitude Scale (M_L) /during the period Jan 19 to March 31, 1975 have been shown in figure 1. The depths have been fixed in multiples of 5 kms as we felt that the data available did not warrant a higher order of reliance. It may be seen that most of the earthquakes had their focus close to the base of the granitic layer and that the overall aftershock zone is elongated in a NNW-SSE direction with most of the events forming two clusters one in the north and the other south. While the main event (USGS location) is in the north, more of the aftershocks are clustered south, near Kaurik. This may explain the large damage noticed in this region. Such type of aftershock distributions, with most of the aftershocks a little removed from the main event is not an uncommon observation. Dumbbell shaped aftershock zones have been noticed in many large earthquakes and the disposition of these zones have been related to the connected faulting. In this event, such an inference would lead to a NNW-SSE faulting. The shape of the isoseismals also shows a similar disposition, which is nearly subparallel to the regional structural trend of the rock formations in the area.

/located

The depths of foci of the aftershocks also show that the shallower events are towards the west with the comparatively deeper events towards the east. An attempt to demarcate the aftershocks with respect to their depths leads again to a NNW-SSE line with dip towards the NE (Figure 1).

AFTERSHOCK 'b' VALUE

The aftershock magnitudes were measured from the records of standard Wood-Anderson Type Torsion Seismographs. In order to get the maximum data we have chosen the records of NURPUR which has an excellent site and gives very clean records. However, as this observatory is located at a distance of about 200 kms from the epicentral zone, only events of magnitude 3.5 and over could be utilised. From these data for the period Jan 19,1975 to Dec 31, 1975 including about 500 events the 'b' value was found to be 0.76 ± 0.12. This value is of the same order as that for other along the Himalayan foothills namely 0.80 for Kashmir-Tibet border and 0.58 for Anantnag area (Srivastava and Kamble,1972)[1].

MECHANISM OF THE EARTHQUAKE

The mechanism of the main shock has been worked out from the first P wave motions recorded at seismic stations throughout the world. In order to maximise the data, both Short Period and Long Period data have been used. A double couple mechanism has been assumed. The solution is given in figure 2. It may be seen that both of the nodal planes are oriented in a northwest to Northnorthwest direction. While one of them (A) is dipping Southwest the other (B) dips to the Northeast. In order to choose the fault plane out of these two, we have taken the indication of the (i) aftershock zone (ii) their disposition with respect to focal depth and (iii) the shape of the isoseismals. All these seem to favour the plane (B) oriented Northnorthwest and dipping towards Northeast as the fault plane. It further gives that the faulting is normal dip-slip. The solutions indicate that the pressure is from west and is rather steep.

DISCUSSION

In discussing the results, the following aspects appear significant. The earthquake mechanism in the Himalayan zone is broadly expected to be of thrst faulting, as indeed has been found in the case of the Kangra (1905), Anantnag (1967) and many more earthquakes. The normal faulting obtained for this earthquake does not apparently fit in with the above broad picture, which is also called for as per the conept of the Indian Plate undercutting the Eurasian Plate. However similar normal dip-slip faulting has also been reported for a few more earthquakes in the Himalayan region by Ichikawa (1972)[2], Tandon (1955)[3], Molnar (1973)[4], A suitable explanation for these is yet to be given.

Genetically this earthquake is associated with the observed Kaurik fault. This is oriented in a roughly northsouth direction but dips towards the west. The aftershocks however show a dip towards the north-east. A similar result of a dip not in confirming to the geological observations has been obtained in the case of the Anantnag earthquake (Tandon,1972)[5] and a few earthquakes in the Assam-Burma border region (Ichikawa et al, 1972). These observations remain to be explained.

From the aftershocks which have been located, it is found that the aftershock zone has a length of 120 kms and an area of about 4000 sq. kms. Taking the length of faulting, as equal to the length of the aftershock zone, the rupture velocity, V_F calculated from the relation (Bath 1974)[6]

$$\log \frac{L}{V_F} = 0.5\,M - 1.9$$

were M is the surface wave magnitude. For this earthquake of M_S the rupture velocity comes to 3.8 kms/sec.

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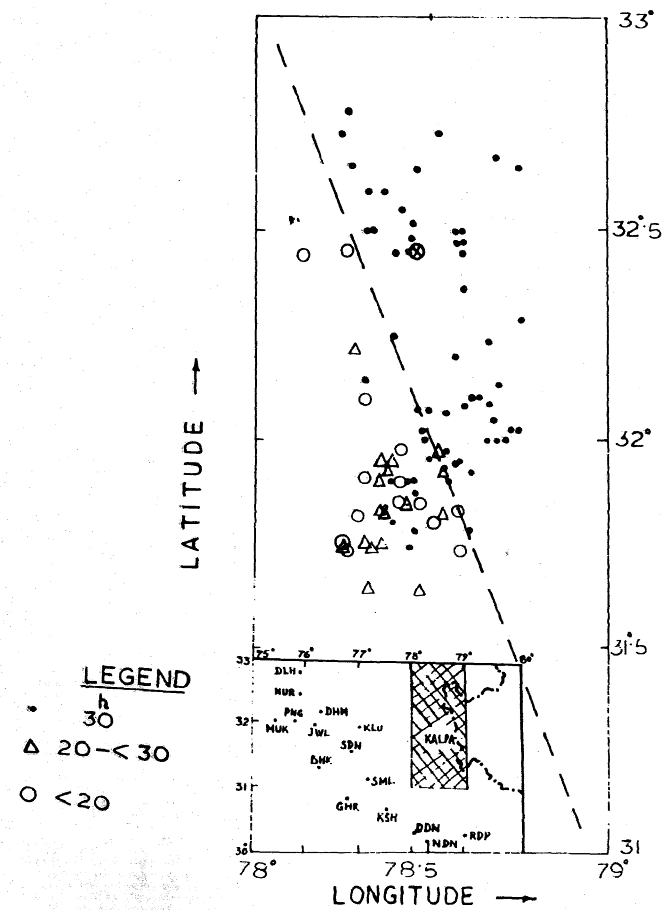
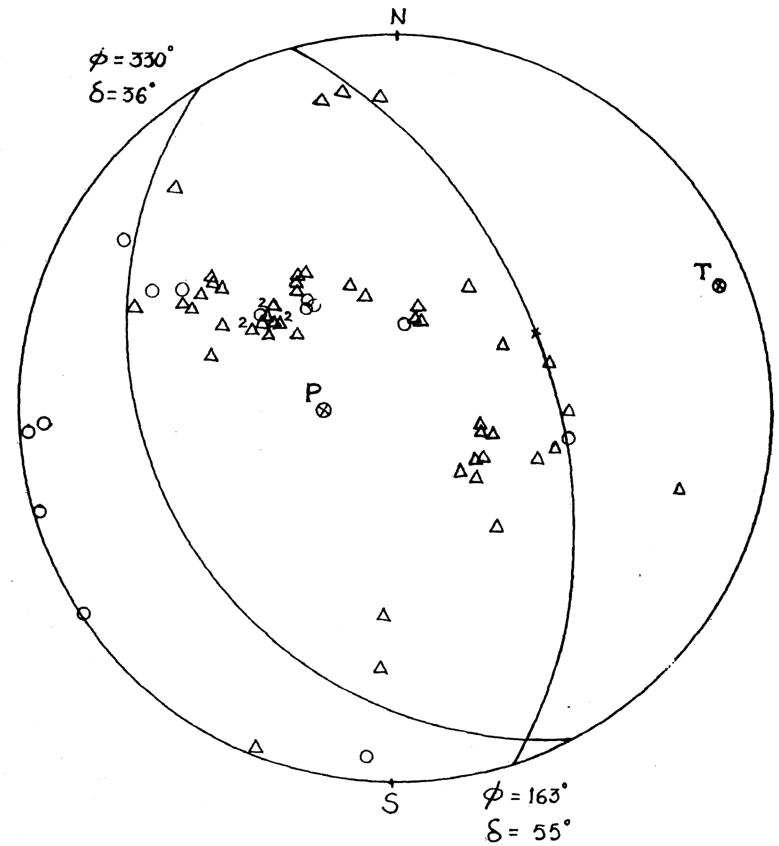
CAPTIONS

Fig. 1 Spatial distribution of aftershocks.

Fig. 2 Focal mechanism of Kinnaur Earthquake.





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DISCUSSION

S. Singh (India)

Have the authors computed the fault plane solution of the fore shock ?

B.K. Rastogi (India)

Is the nature and orientation of fault deduced from focal mechanism study compatible with the surface fault traced in the area ?

Author's Closure

With regard to the question of Mr. Singh, we wish to state that fault plane solution of the fore-shock has not been computed by us.

Regarding the querry of Mr. Rastogi, our reply is as follows:

The geological fault in the region called Karnik fault is oriented in North South direction. Our analysis based on fault plane solution and orientation of aftershocks accepts north-north westerly fault in the region dipping towards easterly direction.