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550.341.5 : 551.24 (235.21)

Seismotectonics of the Hindukush and adjoining area

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ABSTRACT. The spatial distribution of epicentres of earthquakes occurring in the region for the past ten years, shows that the region under study has special characteristics. The Hindukush region, in particular, shows a cluster of epicentres having intermediate depths, particularly events having foci at depths between 200 & 250 km and thereby forming more or less a V-shaped region making an angle with the vertical. Bringing a homogeneity in magnitude data from different sources, recurrence curves for the regions have been drawn and interpreted.

. Introduction

The Hindukush and Baluchistan regions, lying in the active part of the Alpide belt, are considered to be seismically active regions of the world. Detailed studies of the tectonic history of this part of the globe suggest that considerable number of earthquakes of varying magnitude and depth occurs every year (Gutenberg and Richter 1954, Niazi and Basford 1968, Nowroozi 1971). Moreover the seismic activity of the Hindukush region has special characteristics — the concentrated pocket of intermediate depth foci, running along the great circular latitude 36.3°N and bounded by longitudes 70°-71·5°E forming thereby a V-shaped region. In the vicinity of 71·5°E, the general N45°E-S45°W trend of the Pamir appears. The seismic zone is broader than its counterpart—the east-west trend of Hindukush and extends approximately from 36°N, 70°E to 38°N, 73°E. The focal depths are shallower (less than 250 km) and generally fall between 100 and 200 km. At the intersection of the two zones the seismicity scatters and is more complex (Santo 1969, Nowroozi 1971).

This region being one of the most active regions of the globe, attention has been paid by different seismologists time and again to study the seismicity from the interpretation of tectonic characteristics, interpretation of a and b values in relation to tectonics, fault plane solutions, anomaly of the subduction zone of the Hindukush region and the possible explanation from the concept of the plate tectonics (Santo 1969, Chauhan 1970, Nowroozi 1971, Fitch 1970, Molnar *et al.* 1973, Drakopulos and Srivastava 1972, Gutenberg and Richter 1954, Richter 1965).

Regarding interpretation of b values, there are two schools of thought. A section of geophysicists believes that the b value remains constan for all regions and is close to unity (Riznochenko 1959, Bune 1965, Tandon and Chatterjee 1968) while others believe b value relates to the tectonic character of the region (Miyamura 1962, Mogi 1967).

In the present study each of the geographical regions under the seismic regions 47 and 48 (Baluchistan and Hindukush) has been studied from the interpretation of a and b values.

2. Data

Since the formation of International Seismological Centre (ISC) in 1964, data from all international reporting agencies besides ISC's own determination of epicentral parameters, have been collected and printed in regional catalogues. Prior to 1964, ISS was not even reporting the magnitude of events. Even though USCGS data is available since 1957, these seldom cover events for lower magnitude ranges due to non-availability of data from high sensitive seismographs from Indian sub-continent and as such, such data does not give a full coverage of events which took place in the region under study.

The regional catalogue, published by International Seismological Centre, is arranged under the geographical region numbers and of seismic region number within each geographical region (Gutenberg and Richter 1954, Flinn and Engdhal 1965). Epicentral estimates of ISC are calculated by the method of uniform reduction (Jeffreys 1961), a variant of the method of least squares. Calculations of unified magnitude m follow the procedure outlined in Gutenberg and Richter (1956). If Q is the depth distance factor and q is log (ampli-

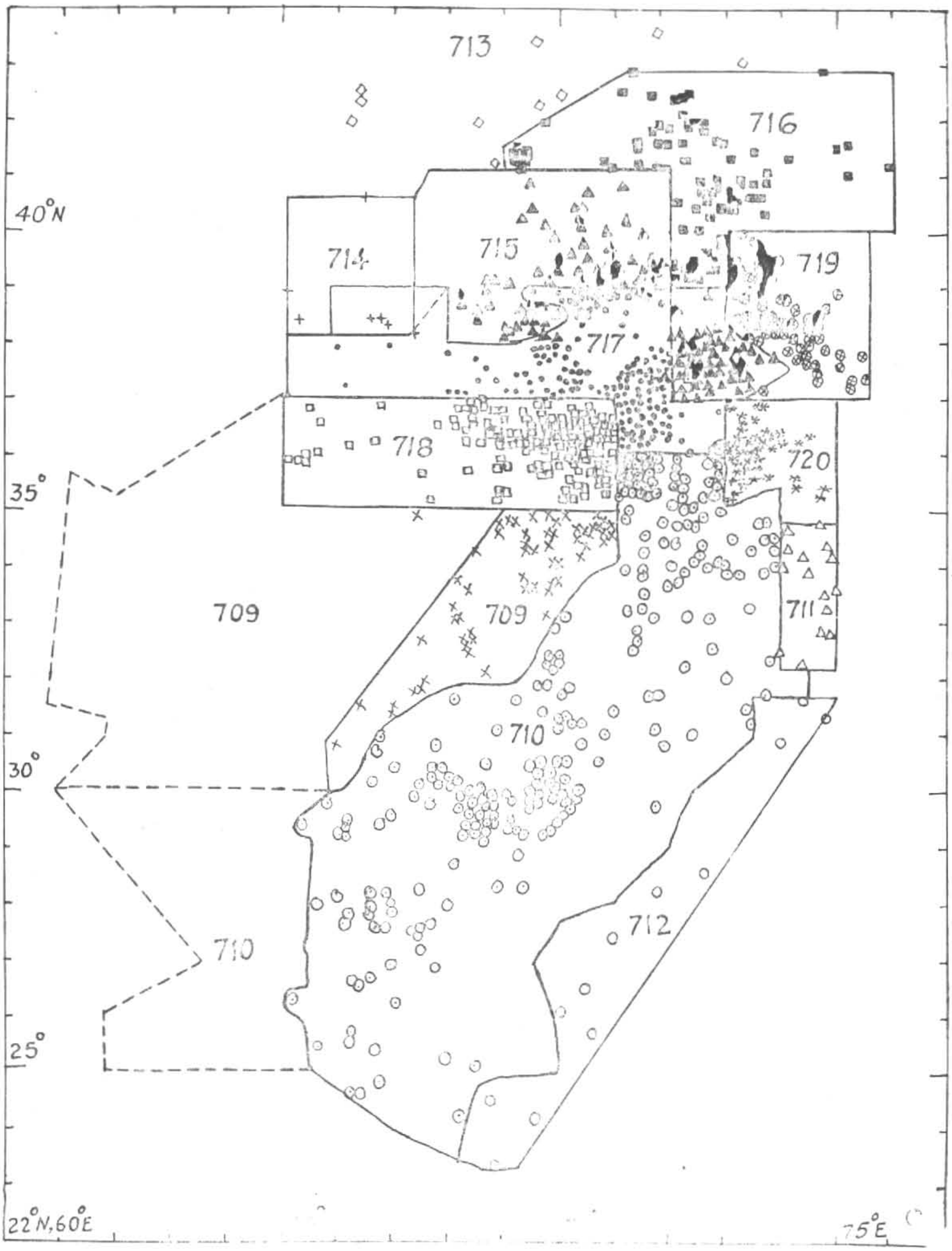
713
716
40°N
714
715
719
717
718
720
35°
709
709
711
710
30°
712
710
25°
22°N, 60°E
75°E

Fig. 1

tude in microns/period in seconds) for the ith station, then for n observations :

$$m = \sum_{i=1}^{n} \frac{(Q+q)_i}{n} - 3 \qquad (1)$$

in which it is assumed that q has been determined from observations on short period vertical instruments and the station corrections have been neglected.

Data from 1964 up to 1973 have been collected for each of the seismic (47, 48) and geographical regions (709-712, 713-720) and plotted in Figs. 1 and 2 respectively.

3. Magnitude correlation

Magnitude calculations are generally recognised by seismologists as not being in a very satisfactory state till date. Different scales are in use and it is very difficult to combine different magnitude determinations. It has been observed that there is discrepancy in the magnitudes compiled for the same event from ISC, NEIS, MOS, Que and other international agencies. There are many factors contributing to such discrepancies. One important point is that in the distance range 14 to 17 degrees the Gutenburg Q factor changes from 7·0 to 5·9 at the 25 km depth level. The slightly different location and hence distances and possible differences in interpolation and round off procedure may account for the differences.

It is seen from a collection of data from 1964 to 1973 for the regions under study, that there are many events for which ISC determinations for magnitudes are not available, whereas atleast one of the other agencies, *viz*., NEIS, MOS, Que is available. This is true for events of magnitude 5 or even more. Such data, cannot be ignored; but if collected, will give heterogeneity. To remove the heterogeneity, correlations between the ISC magnitude and that of other agencies, *viz*., NEIS, MOS (M_b and M_s), Que both for crustal and subcrustal events have been drawn by fitting ten degree polynomials by the method of least squares with the help of IBM 360/44 computer. Since earthquakes are random variables in statistical sense and radiation factor plays an important role for each event, this method, as such, cannot be considered to be a fool-proof method of conversion. However, considering the uncertain factors which determine the energy and thereby the magnitude of an earthquake, this method can be considered fairly satisfactory for estimation of magnitudes required for our study.

4. Seismo-tectonics of the region

From airphoto mosaics, Wellman (1968) studied the active wrench faults of Afganistan and Pakistan and recognised the Herat (north of Kabul) and the Chaman (south of Kabul) as major active wrench faults. Based on geological evidences Wellman (1968) concluded that the Herat is a right lateral fault. His conclusions are, in agreement with recent ground displacements associated with earthquakes. Numerous other transcurrent faults have been inferred by Wellman in areas where field work has not suggested them (Falcon 1967).

The tectonic design of Baluchistan in the southern zone of Pakistan consists of Makran coastal ranges, Makran ranges and Kirthar range of Persia while the Siahan range is probably linked with the mountain range of east Persia. The Kirthar ranges are exposed in Pakistan and trend NE-SW.

The active Chaman fault extends from Kirthar and Siahan ranges upto close to Kabul and taking a NE-SW trend joins the Herat fault, its furhter extension is known as Herat-Panjahsir (NE-WSW trending deep seated magasuture). It ultimately extends into the Hindukush ranges (NNE-SSW, Ganssar 1976). Above 35° N the Murree thrust towards the southern foothills of Pakistan, mainly separates the lower and upper tertiaries. At times it is equated with Krol thrust of lesser Himalayas in India, it is because, the Murree thrust is concealed by the Krol thrust in many parts of the Himalayas. Another major tectonic discontinuity in Kashmir Himalayas is known as the Salkhala thrust which is equated to Main Central thrust.

To the south of Karakoram range there exists a major suture which starts from south of Chalt, passes through Rakhaposhi and shows a NW-SE trend. It is possibly extendible to Ladakh suture.

From southwestern Pamir knot the Hindukush mountains fan out northeast-southwest to east-northeast-westsouthwest strike. The northern branch consists of folded Mesozoic and predominantly tertiary sediments, while the southern branch consists of highly complicated metamorphic rocks and intrusions of granodiorities forming core of Hindukush (Ganssar 1964). A large number of earthquakes occur in a limited zone between 70° to 72°E and 36° to 37°N in Hindukush mountains making it one of the most intriguing seismic zone of the world.

Tectonics of Pamir knot has been of great importance amongst seismologists. From this knot migration of mountain ranges starts in the immediate vicinity forming a series of converging valleys and ravines. The Garm seismic zone which extends approximately between 38° to 40°N and 69° to 72°E forms a part of this region.

The Tien Shan mountain ranges consist of an ancient platform that has been subjected to much

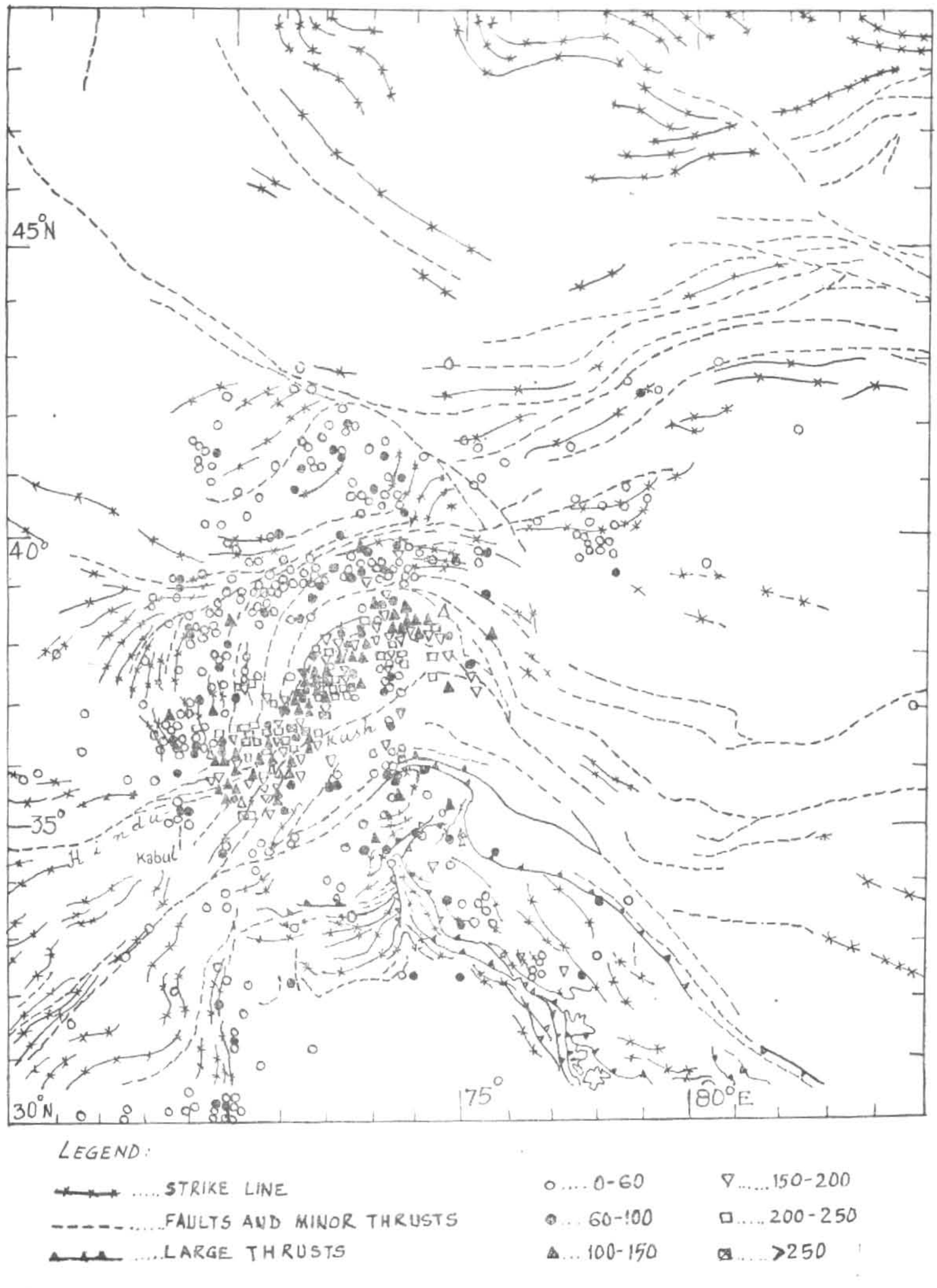
45°N
40°
35°
30°N
75°
80°E
Hindu Kush
Kabul
LEGEND:
..... STRIKE LINE
..... FAULTS AND MINOR THRUSTS
..... LARGE THRUSTS
..... 0-60
... 60-100
... 100-150
..... 150-200
..... 200-250
..... >250

Fig.

subsidence, uplift and fracturing (block-fracturing). The present episode of uplift started perhaps in the early tertiary time; however, the rate of it has increased greatly during Neogene and Quarternary (Gzovsky *et al.* 1960). The reported uplift following recent earthquakes indicates that high activity is still in progress.

5. Recurrence curves

The widely accepted magnitude-frequency relation of a given group is that the logarithm of the number of events in a region at each magnitude level is assumed to be linearly proportional to magnitude and can be represented mathematically:

$$\log_{10} N = a - bM \qquad (2)$$

where N and M represent the number of events for a certain class between $M+dM$ and $M-dM$ for a relatively large time interval; a and b are constants. Many investigators calculated the values of a and b and interpreted them in terms of seismicity and tectonics for different regions (Riznechenko 1959, Hsu 1971, Tandon and Chatterjee 1968 and Miyamura 1962). The value of a depends mainly on the period of observations and the level of seismicity of the observed region and, therefore, can be regarded as an index of the mean seismic activity for a particular seismic region (Hsu 1971). The constant b does not depend theoretically on the period of observation and could be regarded as a characteristic parameter for each seismic region. According to Miyamura (1962) and Mogi (1967) the b value is directly dependent on the tectonic characteristics of each seismic region, differing significantly from one seismic region to the other.

The collected data from each of the geographical region has been homogenised by the method outlined above. After the data has been brought to the standard level of ISC, the same was normalised for an area of 10^4 sq. km per year. The normalised data has been plotted on a semi log graph paper with $\log_{10} N$ as ordinate and M as abscissae. The data has been plotted at a magnitude interval of 0·1 for each of the regions both for crustal and subscrustal events separately.

6. Discussion

6.1. *Seismic region 47—Baluchistan*

(*i*) 709 — *Afghanistan*

The epicentral distribution of this region exhibits a northeast-southwest trend and running parallel to Chaman and partly to Herat fault system of the region. Rest of the region is practically aseismic throughout the ten years' period. In order to assess the seismicity of a particular region, epicentral distribution in space and times should be uniform. In view of this requirement, part of the region, where seismic activity was confined to, as demarcated by contour, was investigated. The region is characterised by crustal events only.

The plot of the log number of the total events against the unified magnitude for crustal events represents recurrence line (Fig. 3) having b value as 1·019 which is close to the average of the global value of 0·95 (Mc Guire 1977). The cluster of points at higher magnitude levels could be attributed to small population density in the range. It is worth mentioning that no event greater than magnitude 5·3 occurred during comparatively long span of period of 10 years. Shocks of magnitude less than 4·5 were below the detectibility level of the reporting observatories and as such were not considered for the recurrence curve.

(*ii*) 710 — *Pakistan*

In Fig. 1, we see that the seismic activity was uniformly distributed along the northeast-southwest direction bounded by Lat. 24·5°-36°N and Log. 65·5°-74°E. However there are few isolated pockets of seismic concentration particuarly close to the Hindukush belt.

Inversion of data to the recurrence curves both for crustal and subcrustal events shows a bit high degree of scatter, particularly to that of crustal events (Fig. 4). Even though the b value for crustal events is close to unity (1·142), the same is higher (1.264) for intermediate depth-shocks. The higher value in the latter case can be attributed to its association to the tectonics of Hindukush-Karakoram range region. The a value, on the contrary, is higher for crustal events implying more number of events.

(*iii*) 711— *Southwestern Kashmir*

(*iv*) 712—*India-Pakistan border region*

No attempt was made to draw the recurrence curves for these regions due to scanty data.

The seismic activity of the Afghanisatan and Pakistan is closely associated with the Herat fault and Chaman fault, the entire length of the latter being active. The northeast-southwest seismic zone off coast of Pakistan marks the Murray Ridge (Mathewa 1965) and possible connection of this ridge with the Chaman fault zone is strongly contemplated. The strong concentration of activity in the farthest northeast region is closely associated with the Hindukush-Karakoram range.

6.2. *Seismic region 48 —Hindukush*

(*i*) 715 — *Tadzhikistan*

The Tadzhikistan region has interesting geological and seismic set up. The epicentral distribution shows a uniform concave upward alignment starting from 38°N and 69°E, moving northeasterly direction makes a semi-circular bend leaving a striking seismicity gap in the isolated pocket of 38·2°-39°N, 72°-73°E and joining ultimately the syntaxial bend of Hindukush-Pamir region. The high concentration of seismic activity in the northeasterly direction of Hindukush region is noteworthy. The

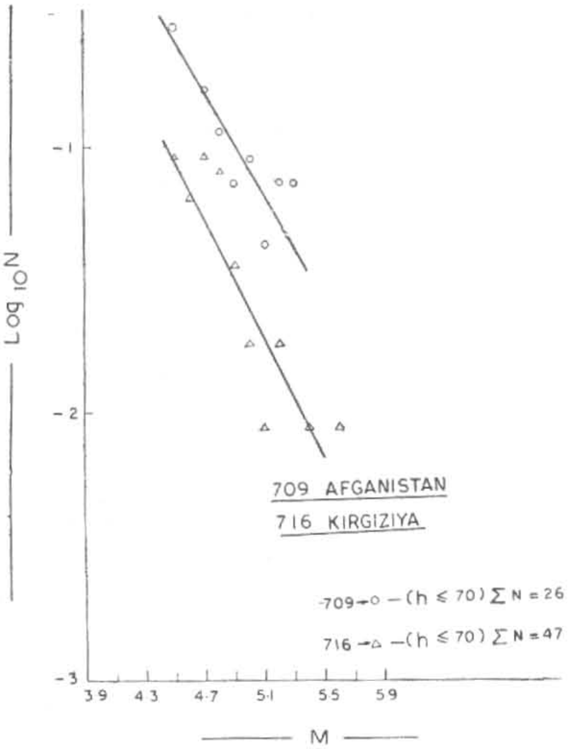

Fig. 3

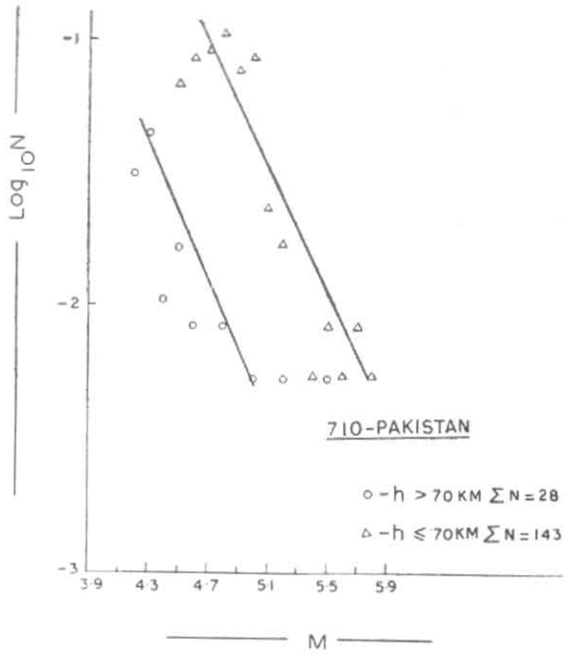

Fig 4.

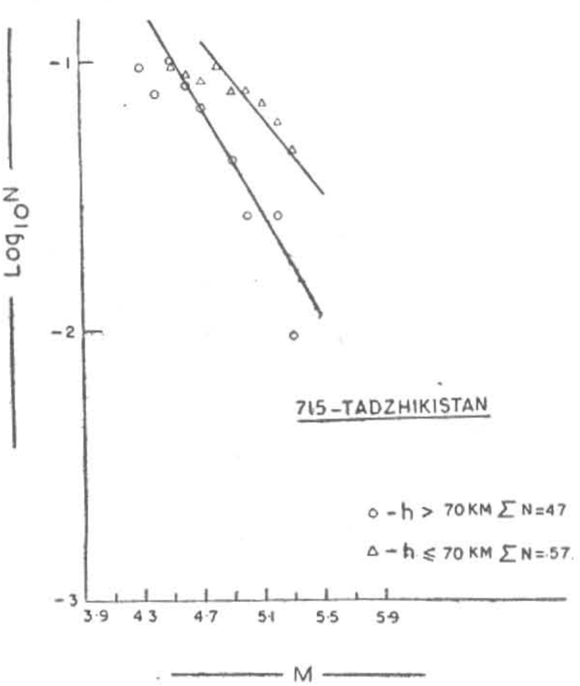

Fig. 5

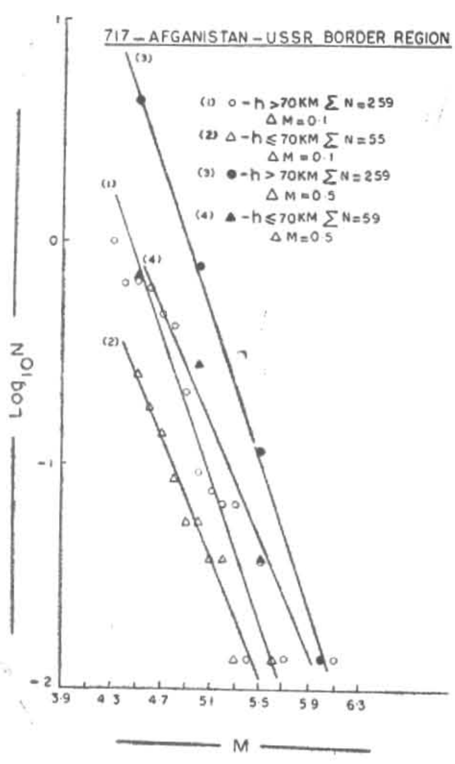

Fig. 6

seismic activity of this region is closely linked with uplift of Tien-Shan mountain system.

The recurrence curves (Fig. 5) for both curstal and subcrustal events show that the detectibility of subcrustal events below magnitude 4.5 is poor while all crustal events below the magnitude level 4·8 are not reported. This lead to points corresponding to less than such magnitudes fall below the curves; otherwise inversion of data is satisfactory. However, the isolated single event of magnitude 5·3 having depth greater than 70 km falls much below the line and was not considered in fitting the curve.

It is interesting to note that while the *b*-value (1·080) for crustal events is close to unity, it shoots upto 1·475 for subcrustal events. This high value exhibits higher seismic activity of the region and brings out unsteady state of subcrustal layers (Welkner 1965, Aki 1965).

(*ii*) 716 — *Kirgiziya*

The epicentre distribution in this region is scattered in a wide range and exhibits concentration of seismic activity in the NW-SE direction and close to Talas-Fergahana rift.

The recurrence curve for crustal events shows more or less a good fit to the data (Fig. 3). It may be noted that during the decade no event greater than magnitude 5·6 took place in this region. The *b*-value is also very less, exhibiting less degree of seismic activity in this region.

(*iii*) 717—*Afghanistan-USSR border*

The epicentre distribution in this region shows that besides a few isolated events, the activity is mainly concentrated to the region bounded by 37°-39°N, 71°-72°E leaving a gap in the seismic activity in the northeast direction of the Hindukush active zone. The activity is closely related to Hindukush and adjoining mountain system of the Alpine range.

The high population density of seismic activity enabled us to fit the recurrence curves with high degree of goodness of fit (Fig. 6). The lines for subcrustal events show that the detectibility of shocks of magnitude 4·3 and above is fairly good. The steep line representing a high *b*-value of 1·60 which represents pronounced unsteady nature of the subsurface tectonic features of the region. The *a*-value is also as high as 6·990. Similar is the case for crustal events which exhibits high *a* and *b* values as 5·255 and 1·325 respectively. This high degree of activity is associated with active Hindukush-Karakoram ranges.

Having investigated the recurrence curves for $\triangle M=0\cdot1$, it is examined whether or not by change in sampling interval of magnitudes, the controversial interpretation of *b*-value changes. Recurrence curves for both crustal and subcrustal events have been drawn for $\triangle M=0.5$. It is seen that in both the cases there is no significant change in *b* value. Whatever little changes shown are within the standard error of *b* value calculated. But the high value of *b* is obtained in all attempts of changing the sampling interval of magnitudes. This attempt could be made due to availability of high population density of magnitudes for all ranges. Curves also exhibit that the subcrustal events are much more in number than its counterpart, *viz*., crustal shocks.

(*iv*) 718 -- *Hindukush*

This is the most interesting zone of the seismic region 48. The remarkable locations of foci in the pocket almost along the line 36.3°N stretching more or less in the east-west direction shows a sudden subduction zone and unsteady state of the region (Fig. 2). The zone is concentrated along the great circle 36·3°N and is bounded by the length 69·7°-71·5°E meridian. The average focal depth for this zone is more than 200 km and extend to about 300 km. In the vicinity of 71·5° E the general N45°E-S45°W trend of the Pamir appears — the seismic zone being 36°N, 70°E to 38°N, 73°E. The focal depths are shallower (less than 200 km) and generally fall within the range 100 to 200 km. At the intersection of two zones, the seismicity scatters and is more complex.

The seismic activity of Hindukush roughly remains invariant with time. Richter (1969) conjectured that all the current earthquakes are in the nature of aftershocks—a view based on the phenomenon that the seismic activity is continuous with time and the sources are rather concentrated.

The recurrence curves (Fig. 7) show the subcrustal events are much more in number than crustal events. This reflects the activity of the zone already discussed above. Due to large amount of data, the goodness of fit is very high for both cases. The *b* value for crustal and subcrustal events are rather high, *viz*., 1·435 and 1·250 as also the *a*-value 5·835 and 5·427 respectively. These high values are comparable to that of Afghanistan-USSR border region and thereby reflecting high order of seismicity of the region. The detectibility of shocks below magnitudes 4·5 and 4·7 for crustal and subcrustal events is low and were left out. Here also the sampling interval of magnitudes was changed to $\triangle M=0\cdot5$ and recurrence curves drawn. No appreciable difference in *b*-values as compared to its counterpart of $\triangle M=0\cdot1$ was noticed (Table 1).

(*v*) 719 — *Tadzhikistan-Sinkiang border region*

The epicentre distribution shows a NW-SE direction of the grid and joins the Hindukush ranges of activity. To the northeast direction there is strikingly seismicity gap. The seismic activity in this region is associated with that of 715 and 718 regions. The recurrence curves for both crustal

TABLE 1

Seismic/geographical region	Depth $h \leq 70$ km							Depth $h > 70$ km						
	a	σa (±)	ϵa (±)	b	σb (±)	ϵb (±)	$\triangle M$	a	σa (±)	ϵa (±)	b	σb (±)	ϵb (±)	$\triangle M$
47. Baluchistan	5·623	1·150	0·469	1·464	0·089	0·036		3·313	2·902	1·026	1·181	0·224	0·079	
(i) 709-Afghanistan	4·243	0·801	0·359	1·019	0·075	0·033								
(ii) 710-Pakistan	4·144	2·336	0·739	1·142	0·143	0·045		3·840	1·386	0·693	1·264	0·149	0·074	
48. Hindukush and Pamir	5·124	1·279	0·426	1·317	0·083	0·027		6·000	0·859	0·230	1·50[illegible]	0·014	0·004	
(i) 715-Tadzhikistan	4·164	2·193	0·090	1·080	0·177	0·079		5·637	2·248	0·849	1·475	0·179	0·068	
(ii) 716-Kirgiziya	3·726	0·945	0·386	1·075	0·078	0·031								
(iiia) 717-Afganīstan-USSR border region	5·255	2·016	0·713	1·325	0·147	0·052		6·990	1·509	0·455	1·600	0·091	0·028	
(iiib) 717- Do.	5·406	3·056	1·764	1·263	0·306	0·176	0·5	8·285	0·720	0·360	1·718	0·059	0·030	0·5
(iva) 718-Hindukush region	5·835	2·912	1·302	1·435	0·263	0·118		5·427	2·335	0·738	1·250	0·155	0·049	
(ivb) 718- Do.	5·127	2·101	1·213	1.363	0·210	0·121	0.5	6·598	2.411	1·205	1·357	0·230	0.115	0·5
(v) 719-Tadzhikistan Sinkiang border region	2.020	1·969	0·696	0·700	0·141	0·050		2·055	2·007	0·605	0·650	0·122	0·037	
(via) 720-Northwestern Kashmir	4·215	2·049	0·618	1·056	0·121	0.036								
(vib) 207* Do.	5.742	1·904	0·673	1·143	0·129	0·046								

*Aftershock sequence

TABLE 2

720 — Northwestern Kashmir

	Magnitude																					
	3·8	3·9	4·0	4·1	4·2	4·3	4·4	4·5	4·6	4·7	4·8	4·9	5·0	5·1	5·2	5·3	5·4	5·5	5·6	5·7	5·8-6·0	6·2
1964(1)																						
1964(2)										1												
1965(1)												1	1									
1965(2)																						
1966(1)																						
1966(2)																						
1967(1)																						
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1968(2)																						
1969(1)																						
1969(2)																						
1970(1)																						
1970(2)																						
1971(1)				1(Q)									1									
1971(2)																						
1972(1)								1	1			1										
1972(2)							2		3	5	7	1+ 1(N)	1	3	3	2	1		1	1		1
1973(1)	1			1(Q)						1	1(Q)											
1973(2)						1					1			1								

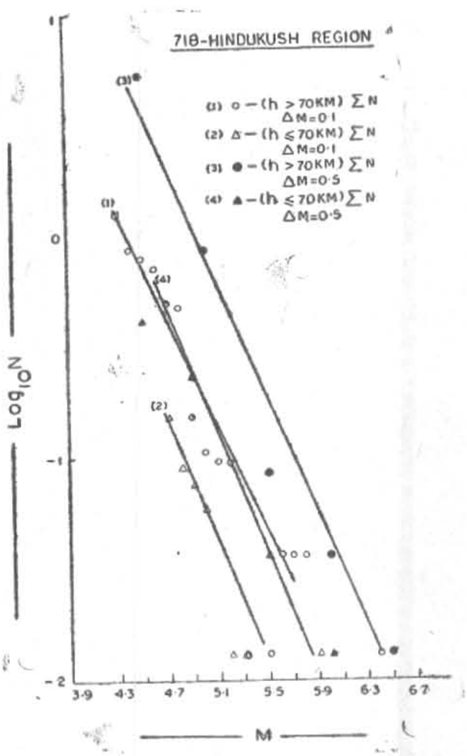

Fig. 7

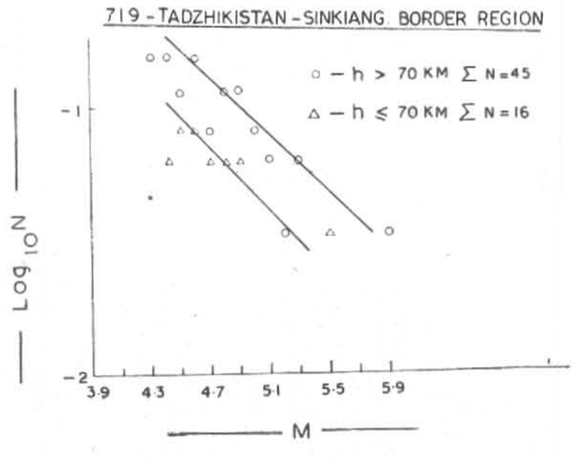

Fig. 8

and subcrustal earthquakes show unusually low values of b, *i.e.*, 0·70 and 0·65 respectively (Fig. 8). However, due to comparatively less number of events the scattering of data of both the curves is pronounced. The detectibility of subcrustal events is as low as of magnitude 4·3 whereas for crustal events 4·5.

(*vi*) 720 — *Northwestern Kashmir*

The northwestern Kashmir region represents seismic activity confined to the Hindukush-Karakoram range and more or less the other part remains inactive. The region experienced an earthquake of magnitude 6·2 on 3 September 1972 after long spell of complete quiescence. This phenomenon supports the view after a period of seismicity gap, a bigger event is most likely to occur. The region is characterised by shocks originating within the crust and very few were of subcrustal origin.

However, recurrence curves for crustal events only for the whole period of 10 years as well as that of aftershocks have been drawn (Fig. 9). It is seen that although the aftershock activity increased the a value considerably from 4·215 to 5·742, the b value changed from 1·053 to 1·143.

713 — *Kazahastan*

714 — *Southeastern Uzbekistan*

No attempt was made to investigate the tectonics of these regions from the interpretation of a and b values due to very low population density of data.

The composite Figs. 10 to 12 respectively represent recurrence curves already drawn for crustal and subcrustal events. These figures show that b value is not constant, but vary from one region to the other. The variations observed in the present study is limited to the range 0.65 to 1.60 and thereby represent different seismicity levels of the regions.

6.3. *Seismic region 47*

Fig. 12 represents the recurrence curves for the whole of seismic region 47-Baluchistan (709-712). The a and b values for crustal shocks are as high as 5.623 and 1.464 while for subcrustal shocks they represent comparatively lower values 3.313 and 1.181 respectively. This implies that in this region as a whole crustal activity is more pronounced than subscrustal activity.

6.4. *Seismic region 48*

For the whole of the seismic region 48(713-720) the recurrence curves were drawn both for crustal and subcrustal shocks (Fig. 13). However in the figure the magnitude axis for crustal events has been laterally shifted to avoid overlapping of points.

Contrary to seismic region 47, the subcrustal events represent higher a and b values, *viz.*, 6.00 and 1.50, while the crustal shocks show 5.124 and 1.317 respectively. The higher values of a and b represent more activity and higher seismicity level in the subcrustal zone. However in both the cases the b value is higher than the average global value.

Focal mechanism solutions (Rietsema 1966, Sobobva 1968, Shirokova 1967, Fitch 1970, Tandon and Srivastava 1975) for earthquakes having foci around 200 km depth in the Hindukush seismic zone derive the following conclusions :

(*i*) A nearly horizontal intermediate axis oriented approximately east-west,

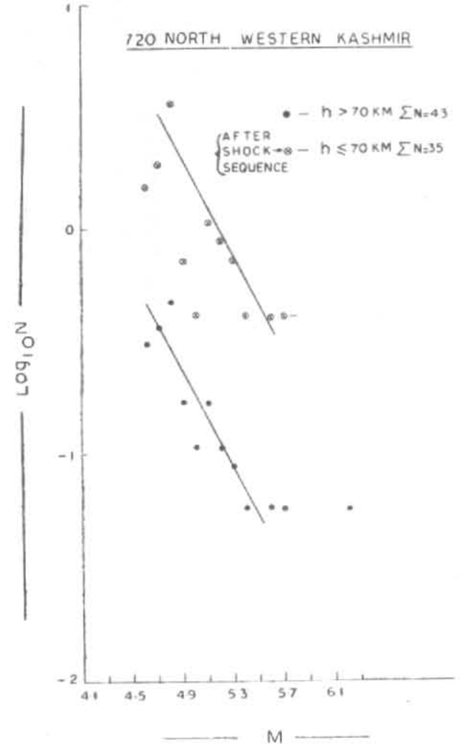

Fig. 9

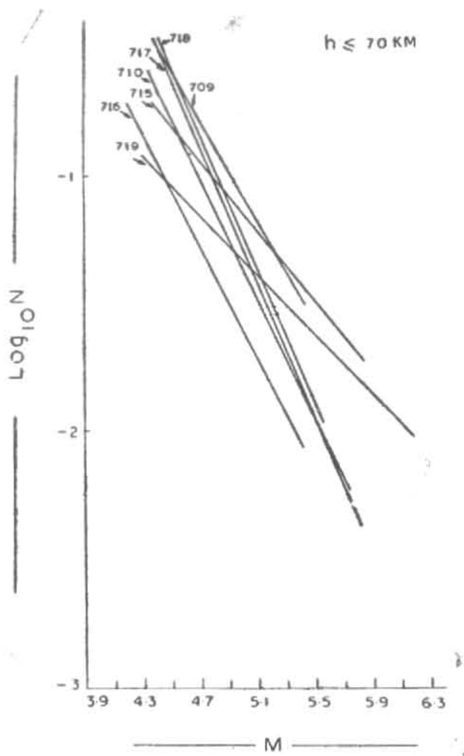

Fig. 10

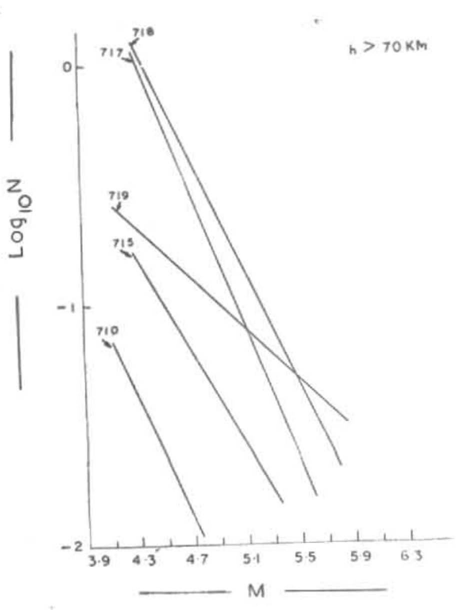

Fig. 11

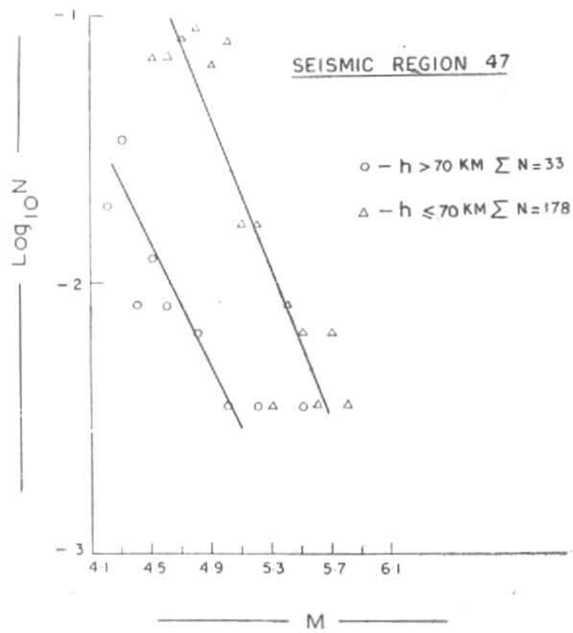

Fig. 12

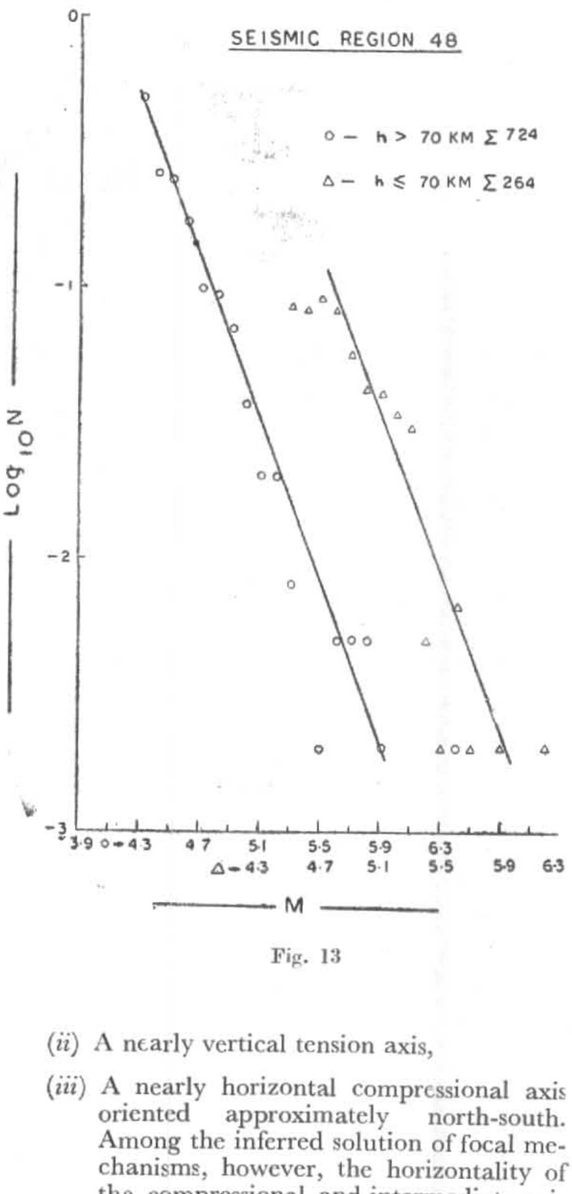

Fig. 13

(*ii*) A nearly vertical tension axis,

(*iii*) A nearly horizontal compressional axis oriented approximately north-south. Among the inferred solution of focal mechanisms, however, the horizontality of the compressional and intermediate axis is more consistent than other trends (Nowroozi 1971). However the tension axis remains always vertical and therefore the contention of Isacks and Molnar (1969) and Molnar *et al.* (1975) that the contorted slab which encloses majority of the earthquakes appear to be sinking to the mantle as result of greater density of the slab, is being supported.

7. Conclusions

From the above investigation following conclusions are drawn:

(1) Both *a* and *b* values change from one region to the other; also *b* value does not change with the change of magnitude interval while a value does.

(2) For assesment of seismic status of a region both *a* and *b* values should be considered and perhaps with equal weight age.

(3) The apparent controversy regarding changes in *b* value have been examined and exhibit divergence from one region to other depending upon the tectonic characteristics.

(4) Judging from both *a* and *b* values the seismicity of regions 715, 717, 718 is higher than that of the adjoining areas.

(5) The subcrustal events, in general, exhibit higher *b* values than crustal shocks. Though the Hindukush region (718) shows opposite trend the whole of Hindukush seismic zone (48) follow the general trend.

(6) Less population density of events shows higher degree of scatter and as such *b* values obtained from such data cannot be relied upon as suggested by Hsu (1971).

(7) Higher *b* value does not necessarily imply higher *a* value (Table 1).

(8) The contorted slab which contains majority of intermediate focus earthquakes of Hindukush seismic zone appears to be sinking into the mantle.

(9) From the distribution of epicentres in space and time the seismicity of the whole region can be broadly divided into the following zones:

(*a*) The seismicity of the Garm region and its extension with an approximate trend of N74°E and extending from 38.5° E between 69° E and 75° E is characterised by shallow events and is associated with the outer Pamir structure.

(*b*) The northeast trend of seismicity of the region 36° N, 70° E to 38° N, 73° E is characterised, in general, due to events with varying depths from 100 to 150 km. The zone passes over the east-west trending, deeper focus seismic zone of Hindukush. Where this zone is above the Hindukush the seismicity is more complex and scattered. This zone does not follow any surface faulting as evidenced by Nowroogzi (1971).

(*c*) Besides a minor seismic zone along 70° E meridian which connects the Garm region of the Hindukush the seismicity between these three zones is appreciably small. The epicentres, which are above 40° N and have a northwest-southeast trend, are related to the Ferghana depression. The epicentes are located close to the known Talas-Ferghana rift.

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