SOME ASPECTS OF THE EARTHQUAKE OCCURRENCE IN THE SOUTHEAST OF CUBAN ISLAND

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Abstract

Fifty two months of data of small earthquakes originated in an area of 6000 km^2 in the Southeast of Cuban Island were analyzed in order to determine the space distribution of events and their temporal behavior.

It was established that an earthquake swarm originated at the South of Guantanamo Bay corresponded to a sequence of foreshocks of the earthquake of December 26,1972.

It was concluded that the swarm is distinguished by a clustering of earthquakes, which temporal distribution showed a bay-form and also that the main shock was originated in the return of this bay to its initial level.

Introduction

By means of standard seismograph records, 844 natural seismic events were detected in an small seismic zone, located in the Southeastern region of Cuba, covering the period from Octuber 1, 1968 to January 31, 1973.

This zone placed within 19º30'N to 20º00'N and 75º00'W to 76º06'W corresponds to the neighborhood of Santiago de Cuba City, which has been destroyed or seriously damaged several times by earth quakes with epicenters in the same area (Alvarez, H. and Menéndez, L.,1969). The seismic activity of this zone is related to the relative motion between the Caribbean and Americas plate (Molnar, P. and Sykes, L.R,1969). The last great earthquake with magnitude 6.8 Richter, was felt in Santiago de Cuba with intensity VIII MSK on February 3,1932.

From historical data it is known that intense earthquakes in this region were always preceded by a sequence of fore-

shocks showing a diminishing in the interarrival time and gradual increase of intensity which could be a particular characteristic of this zone useful for earthquake prediction.

In relation with all above mentioned, this paper presents the zone under investigation, the space distribution of events, the temporal distribution for three intervals of S-P less or equal thant 6.5 sec and the analysis of a — foreshocks sequence for the earthquake on December 26,1972.

Space distribution of earthquakes

Fig. 1 shows a clowd of epicenters into a relatively quiet field. Epicenters are concentrated in an small plate bounded north by a deep fault exteiding along the coast; limited west by a deep fault nearly perpendicular to the above mentioned one near 76º06'W; it is bounded South by the Northern border of Bartlett Trough and East, 75º 00'W by a - tectonic dislocation almost perpendicular to the coast line extending along the submarine mountain range. This tectonic dislocation has been interpreted as a deep fault by gravimetric methods but attending to hypocenters disposition may be also interpreted as a crust landslide.

In the map a cluster of earthquakes at the South of Rio Carpintero Seismic Station within an S-P range from 1.0 sec to 1.4 sec and an interval of depth from 4 km to 8 km is observed. Southermore a second group with depths between 13 km and 35 km and S-P from 2.0 sec to 3.0 sec appears.

South East of Rio Carpintero Station, in an interval of S-P between 3.0 sec and 4.0 sec, and South West in an interval of S-P within 3.0 see and 6.5 sec a cluster of earthquakes with a more variated distribution of depths appears.

The most important cluster at the South of Guantanamo Bay, with an S-P interval between 10.5 sec and 11.5 sec and a

depth range within 70 km and 80 km. The focal zone of this cluster has an elliptic form with mayor axis of 45 km - length and minor axis of 25 km length.

The hypocenters distributions are quiet diferent in the - north and south parts (fig. 2). In the north part hypo- - centers are located in an small interval of depths and with the increase of distance to the South, the depth shows an - increase with a clear interval within 33 km and 70 km. This means that in general the seismic activity in the south - direction takes place at greater depths. This case agrees with what observed (Molnar and Sykes, 1969) for the Bartlett Trough near Puerto Rico and Hispaniola, but is in contra- - diction with that happening in many seismic regions located in submarine depressions, were hypocenters increase their- depth towards the continents.

In the seismoactive part of the zone located West of RCC - station within 75º45'W and 76º06'W (fig.3), diferent depths within 12 km and 45 km are observed without remarkable depth changes in any direction. Eastwards of 75º45'W however, a - certain tendency to depth increase of foci is observed. It is a second interesting fact does not concide with the ob- - served one (Molnar and Sykes, 1969), for the region near - - Puerto Rico and Hispaniola in the Bartlett Trough.

Temporal distribution of earthquakes

Fig. 4 shows temporal distribution of earthquakes for monthly periods of three S-P intervals corresponding to zones of spa- ce clustering of earthquakes. It can be noted that the form of the three curves shows simultaneous variations in the same direction during almost the whole period and starting mainly from the beginning of 1971.

Activity in the region of S-P equal or less than 0.5 sec - - shows variations in a range of a mean value of 18 events in a months, except for the first 6 months of 1971, and a mean

value of 2 events per month and a minimum of 1.

Analysis of temporal path of these three regions develops interesting from July, 1971 to December, 1972. A gradual return to minimum till February 1972 is clear and then a smooth increase till July is seen, sharply getting to maximum in August and keeping this value till December when a new decrease starts.

This increase, sharply getting its maximum value in August, is coincident with the beginning of an earthquake swarm -- South of Guantanamo Bay keeping the above mentioned maximum level during its whole period.

Hereoff may be inferred that seismic activity has a general character in this zone and therefore a relation between different focal zones exist, being this an evidence for the presence of a commom physical cause of these variations in activity.

Earthquake swarm of Guantanamo Bay

In July 1972 an earthquake swarm was registered by means of standard seismograph records in RCC station, which developed in an small crust volume South of Guantanamo Bay with S-P -- interval between 10.5 sec and 11.5 sec. This focal region -- corresponds to the East boundary of the seism ic zone South of Cuba. Earthquakes were distributed within an area of 530 km^2, approximately 9 percent of total area.

This earthquake swarm of at least 142 foreshocks in the magnitude range 2.0 to 4.0 and a main shock with magnitude equal 5.0.

For annual time distribution (fig. 5,a,b,c) it is seen that the region appearing in broken line had no seismic activity till 1972, i.e., in 42 months preceding the beginning of -- swarm, seismic activity was absent. However in fig. 5,d a -- cluster of earthquakes is observed, the importance of which is further analyzed from the point of view of earthquakes --

prediction.

Mogi (1969) established that if some special features in seismic activity before a great earthquake are found, they may give a key to predict the occurrence of great earthquakes. Until now the increase of seismic activity before a great earthquake has been supposed by many investigators but only in a few cases great earthquakes were certainly preceded by some foreshocks. Among these cases there is one interesting and similar to ours (Ohtake, 1970) about a seismic sequence related with a moderate earthquake with magnitude equal to 5.0. Precisely from this point of view this earthquake swarm is discused.

In fig. 6 (broken line) it can be observed the temporal distribution for monthly periods of foreshocks, which has the following characteristics: it starts in July with 6 events, increase to 7 in August getting a sharp maximum of 55 events in September; in October it starts descending to 38; 29 in November and to a value of 7 in December before the main earthquake on December 26. Such sequence of foreshocks with a number of 143 events in 6 months has been a chain process increase in number of events per unit of time reaching its maximum and a further decrease of process till initial level when the main shock occurs. This strongly supports the hypothesis of soviet investigators (Feodotov,1965; Miashkin et. al., 1972; and others), according to whom the physical cause of the evidence of an earthquake is the progressive increase in number and dimensions of fractures in a certain region and the further decrease of the process by means of the interaction and conection of small fractures in the plane of the main fracture which will originate the main earthquake. Another important characteristic in temporal distribution of fig. 6 is its bay-form and that the main shock does not occur in the maximum of the anomaly, but at its return to initial level and after a calm period of 5 days.

The main shock does not occur in the centre of foreshock region but in the Northern part of the focal zone, being this characteristic similar to the observed one by Ohtake in 1970.

In fig. 6 it is compared too the anomaly of the Guantanamo - Bay focal zone (broken line), with the anomaly of the rest - of the area under investigation (continuous line) and as was above supposed a strong relation between both corresponding curves exist.

The energy release as a function of time during the swarm is showed in the histogram of the fig. 7 in which the summa of log E for monthly periods can be seen. In it, as the above - showed for the temporal path, a sharp increase in September till the maximum and then a paulatine decrease can be observed.

All the events presented an energy index (K) within a range 6.6 to 10.0 and 12.2 for the main shock.

Concluding remarks

The occurrence of a moderate earthquake was preceded by a - sequence of foreshocks which temporal distribution had a bay-form. The main shock occurred in the return of this bay to - the initial level and after a calm period of 5 days. Starting from the standpoint that the main shock and its sequence of foreshocks yielded some changes in the seismic activity of the investigated region, can be deduced that the occurrence of a moderate earthquake which may occur in a focal zone of this - region affects more or less the mechanical state of the crust, causing changes of stress and structure in it.

The above mentioned conclusions may give the key for the prediction of the next great earthquake in the Southeast Cuban - Seismic zone on the base of investigation of small earthquake behavior from the point of view of their clustering in space

and time and the possible relation between the sequence of events in the diferent focal zones.

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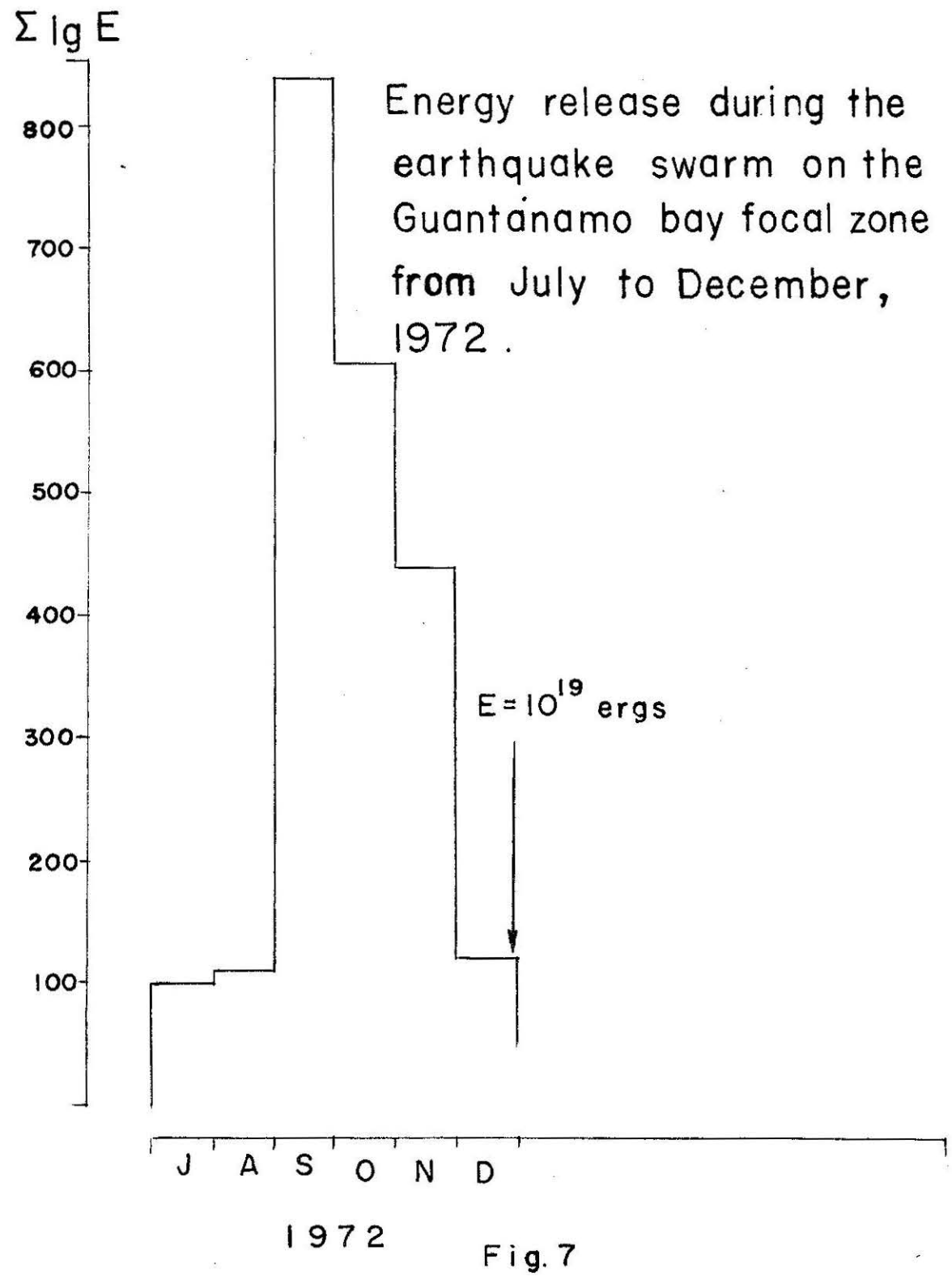
Σ lg E
800
700
600
500
400
300
200
100
Energy release during the earthquake swarm on the Guantánamo bay focal zone from July to December, 1972.
E=10^19 ergs
J A S O N D
1972

Fig. 7

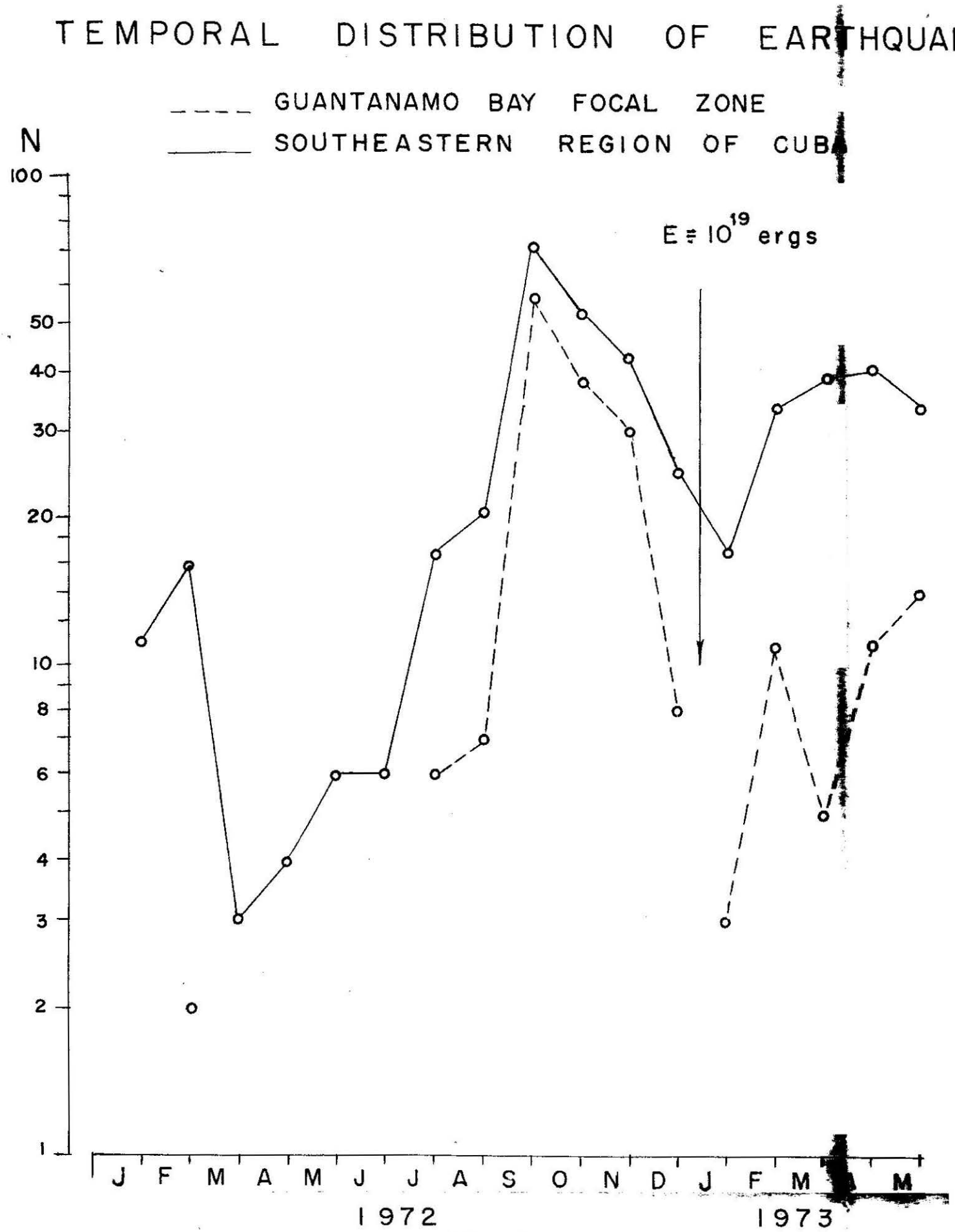
TEMPORAL DISTRIBUTION OF EARTHQUAKE
GUANTANAMO BAY FOCAL ZONE
SOUTHEASTERN REGION OF CUBA
N
100
50
40
30
20
10
8
6
4
3
2
1
E = 10^19 ergs
J F M A M J J A S O N D J F M M
1972
1973

Fig. 6

Earthquake hipocenters proyected onto a vertical section of the latitudinal plane

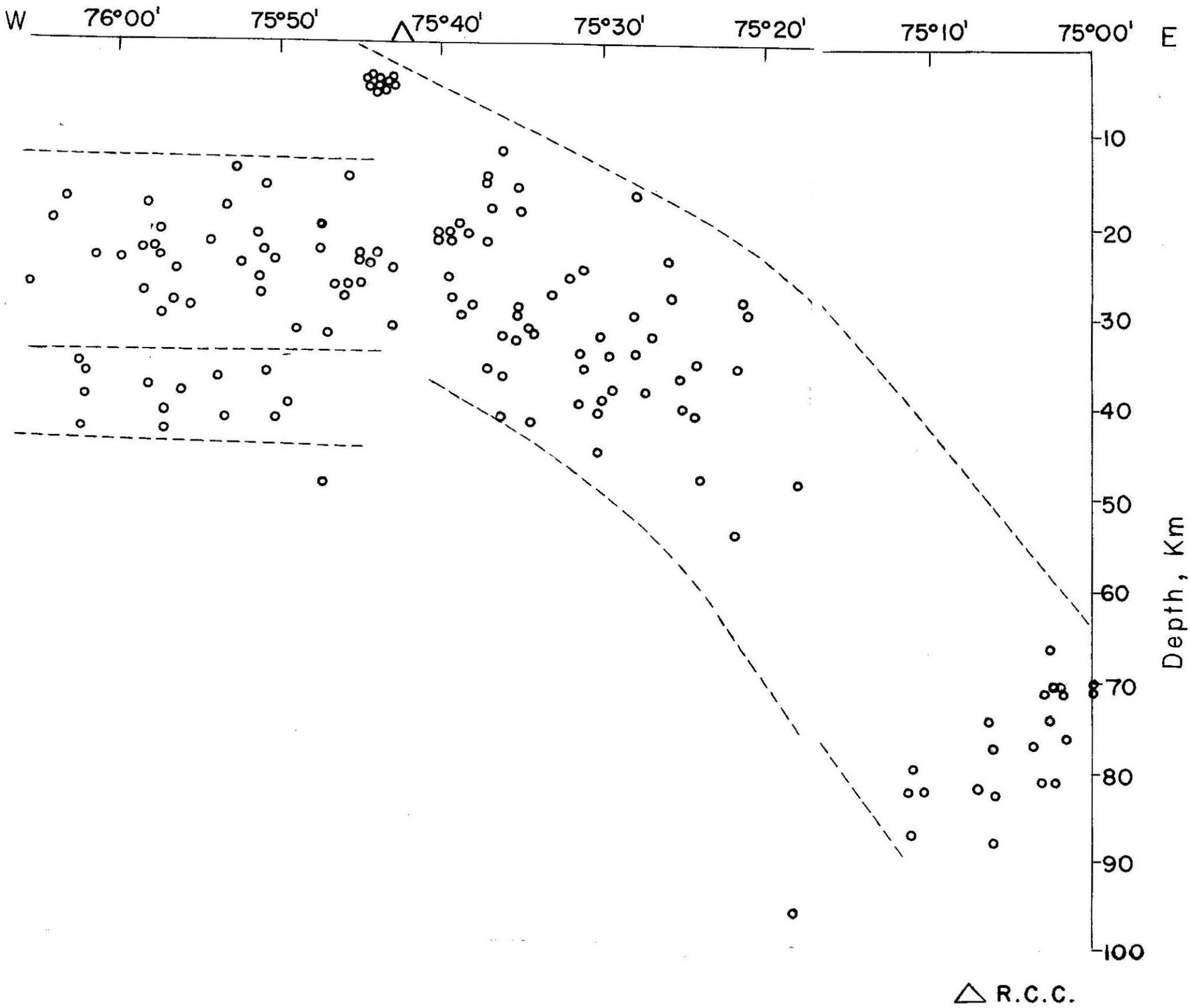

Fig. 3