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THE JUNE 21, 1967 EARTHQUAKE SERIES AT FAIRBANKS, ALASKA: AFTERSHOCK LOCATIONS, DEPTHS AND MAGNITUDES

by

Eduard Berg, Larry Gedney, Susumu Kubota, Ken Hanson and Jurgen Kienle

SCIENTIFIC REPORT

July 1967

Supported by

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH

Grant 701-66

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Principal Investigator

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ABSTRACT

Aftershock recordings have been obtained to determine the extent of the fracture area which using some 50 shocks, was found to be an area of 10 x 15 km with the major axis roughly oriented in a NW-SE direction. Hypocenter depth varies from 6 to 19 km, with most of the shocks being confined to a depth of 10 to 13 km. It was found that the Jeffreys-Bullen velocities, V_p = 5.56 and V_s = 3.37 km/sec, represent a close approximation of the velocities in the area. Presented also are the telemeter network readings from June 21, 1800 GMT to July 14. These readings include the aftershocks of magnitude 2.5 and upward.

TABLE OF CONTENTS

	Page
Abstract	i
Table of Contents	ii
List of Figures	iii
List of Tables	iv
General Information	1
Geology	1
Seismicity	2
Epicentral area, aftershocks	3
Crustal velocities	4
Table of aftershocks (explanation)	4
Explanation of Readings	5
Acknowledgements	6
References	7

LIST OF FIGURES

Fig. 1 Seismic stations: Telemeters and permanent.

Fig. 2 Permanent station PJD, Temporary stations, ELI, GEO, BAD, CLB.

Fig. 3 Epicenters of small aftershocks, stations used: ELI, PJD, GEO, 22-23 June 1967.

Fig. 4 Epicenters of small aftershocks, stations used: PJD, GEO, BAD, 23-24 June 1967.

Fig. 5 Epicenters of small aftershocks, stations used: PJD, GEO, CLB, 26-27 June 1967.

Fig. 6 Epicenters of small aftershocks and focal depth in km, stations used: PJD, GEO, BAD, 21 July 1967.

Fig. 7 Hourly number of Earthquakes recorded at PJD.

Fig. 8 Six hourly number of Earthquakes recorded at PJD.

LIST OF TABLES

Table 1 Severe Central Alaska Earthquakes

Table 2 Station Locations

Table 3 Network Readings

General Information

On June 21, 1967 four earthquakes occurred in the immediate vicinity of Fairbanks between 1804 and 1825 GMT. The first shock had a magnitude of 5.6, the second registered 4.3, the third and largest was 6.0 and the last one was magnitude 5.3. These magnitudes have been obtained from the Standard Wood Anderson horizontal Torsion Seismometers at the McKinley station MCK. The magnitudes obtained from MCK, at some 130 km distance from the epicentral area, are in substantial agreement with those reported for the three larger shocks by Pasadena: in chronological order, 5 1/2, 6 and 5 3/4 (Taylor, 1967).

The series of "main" shocks was immediately followed by a large number of aftershocks. Pedro Dome was the nearest permanent station in the network. At that station 70 earthquakes and possibly more were recorded during one hour period following the initial disturbances. The rate diminished to about 30 per hour on June 25 and was down to roughly 10 per hour in early July. Many of the larger shocks with a threshold around magnitude 2 1/2 have been felt in Fairbanks (see Figs. 7 and 8).

Also, many small aftershocks with magnitudes larger than zero have been located on the south eastern side of Fairbanks with a small tr_parted network over the epicentral area.

Geology

The Tanana Valley area is included in the general, large scale fault systems of Alaska; it is located north of the Denali fault and north of the Alaska Range. The area is mainly composed of alluvial fan deposits, abandoned flood plain alluvium, swamp deposits and of flood plain alluvium in the vicinity of the aftershock area.

Some three to four miles north of the epicentral area is an area of perennially frozen silt, and to the north of that, the Birch Creek schist of the Yukon-Tanana plateau begins (see Péwé et al. 1966). Immediately north of the highest concentration of epicenters are some very small outcrops of intrusive igneous rocks and basalt.

No known fault crosses the surface here, however the authors think that there is a good possibility of a buried north-east, south-west trending fault (dipping to the south). Along this fault the aftershocks occurred. The trend of this possible fault is outlined on the surface by the forementioned outcrops (see Pewe et al. 1966). On the other hand the aftershock area is situated on the northern edge of a Bouguer gravity low. However, the orientation of this gravity low is WSW-ENE, about 45° to the trend of the posulated buried fault.

Seismicity

The general Fairbanks area had several severe shocks of magnitude 7 or over in the past 60 years, when seismic instrumentation existed to record such disturbances. The following table gives the most severe ones reported by Davis and Echols (1952).

Table 1 Severe Central Alaska Earthquakes

Date	Time	Coordinates		Magnitude
27 Aug 1904	21 56 06	64°N	151°W	7 3/4
7 July 1912	07 57 36	64°N	147°W	7.4
22 July 1937	17 09 29	64° 3/4 N	146° 3/4 W	7.3
16 Oct 1948	02 09 50	63.8°N	148°1 W	7

The last one however is not reported by Gutenberg and Richter (1954).

The energy release for Alaska had been calculated by Berg (March 1965) and the energy release map shows that on the average the Fairbanks area releases as much energy (10^{22} ergs/60 years/2° NS and 4° EW) as parts of the Aleutians.

Epicentral Area, Aftershocks

The occurrence of many aftershocks in the Fairbanks area led to the study reported here. Three seismic stations were operated in the immediate vicinity of the aftershock area to determine the hypocenter locations. Figure 2 shows the permanent telemeter station Pedro Dome together with the temporary stations ELI, GEO, BAD and CLB. Only three of these stations were occupied at any one time - there being no equipment available for more. The PJD station was recorded at the Geophysical Institute Telemeter terminal as was GEO. The viewer of the Develocorder used at the telemeter terminal allows a time resolution better than 1/10 of a second. The third portable station was first operated at ELI on June 22-23 (GMT) in a mobile operation. The time reference was crystal and WWV controlled. Recording speed for several hours was approximately 30 cm/min. Figure 3 shows the first epicenters thus located. The next day (23-24 June GMT) the station at BAD was operated right in the epicentral area. Figure 4 shows the epicenters obtained that day during a few hours of recording.

A third location still further to the southeast (CLB, Fig. 2) was occupied on June 26/27. Epicenters located from that day are presented in Fig. 5. On 21 July high speed recording (30 cm/min) was carried out at BAD to see if there was any major shift in activity. Figure 6 shows the epicenters and depth of focus for the four well recorded earthquakes occurring on that day.

Despite the quite different position of the mobile station, there is no significant difference in either epicenter or focal depth determination.

The focal depth ranges from 6 to 19 1/2 km, with mostly 10-13 km. There is only one exception: the one shock recorded northwest of GEO and southwest of ELI (see Fig. 4) with depth > 25 km.

Crustal Velocities

Since most of the hypocenters fall in a depth range of 10-13 km, a single layer crust with V_p = 5.56 km/sec and V_s = 3.37 km/sec was assumed for the calculation (Jeffreys-Bullen first layer). Crustal structure investigation in the southern part of the Tanana Valley, close to the Alaska Range, revealed closely related P wave velocities of 5.27 and 5.80 km/sec in the upper part of the crust (to be reported in another paper).

For some of the best-recorded small shocks with clear P and S phases on all three stations, PJD, GEO, and BAD, the origin time determined from the S-P times and P arrivals and using the aforementioned velocities give differences for the origin time between stations of less than 0.1 sec. This difference would lead to a possible error of the hypocenter locations of the order of 1/2 km. However, it is thought that a more realistic error would be 2 to 3 km, based on origin time differences of 0.2 to 0.3 sec. The origin time error between stations not only includes possible reading and timing errors but also errors which might be introduced by a slide-rule calculation. Therefore, the J-B velocities must be a very close approximation in the upper part of the crust in the Fairbanks area.

Table of Aftershocks

Table 3 contains a reproduction of the telemeter network reading for the period from the first shock on June 21 to July 14. Only the major

aftershocks have been read on a routine daily basis. Some of the conventional MCK stations readings are also included. Figure 1 and Table 2 give the station locations.

Table 2

Name	Code	Latitude	Longitude	Altitude
Tanana	TNN	65°15.4'N	151°54.7'W	504 m
Big Mountain	BIG	59°23.4'N	155°13.0'W	562 m
Sheep Creek	SCM	61°50.0'N	147°19.7'W	1020 m
Pedro Dome	PJD	65°02.1'N	147°30.5'W	740 m
Black Rapids	BLR	63°30.1'N	145°50.[illegible]'W	
McKinley	MCK	63°44.0'N	148°56.0'W	

Because it was easier to reproduce all readings rather than select only the Fairbanks shocks, all have been included in the listing.

Explanation of Readings

Column 1-3: station code, disregard each line starting with ZAP. The line starting 000 contains the magnitude and tenths of magnitude for "local" shocks in columns 40 and 41, respectively.

Column 4 through 9: year, month, date

Column 10, 21, 32, 51, 59: indication of I (impulsive) or E (emergent) for the following phase.

Column 11-13: first ground motion, C-compression, D-dilation.

Column 14-20: arrival of first P phase; hours, min, sec, and tenth.

Column 25-31: arrival of second P phase; hours, minutes are not repeated unless changed.

Column 33-39: arrival of third P phase; hours, minutes are not repeated unless changed.

Column 52-58: arrival of first S phase; hours, minutes are not repeated unless changed.

Column 60-66: arrival of second S phase; hours, minutes are not repeated unless changed.

Acknowledgements:

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SEISMIC STATIONS

GEOPHYSICAL INSTITUTE, UNIVERSITY OF ALASKA

● TELEMETER STATION
⊙ OTHER STATION

FOR SALE BY U. S. GEOLOGICAL SURVEY, FEDERAL CENTER, DENVER, COLORADO OR WASHINGTON 25, D. C.

Figure 1

Fig. 2 Permanent Station PJD
Temporary Stations ELI, GEO, BAD, CLB

5 0 5 10 15 20 25 KILOMETERS

CONTOUR INTERVAL 200 FEET
DASHED LINES REPRESENT 100 FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

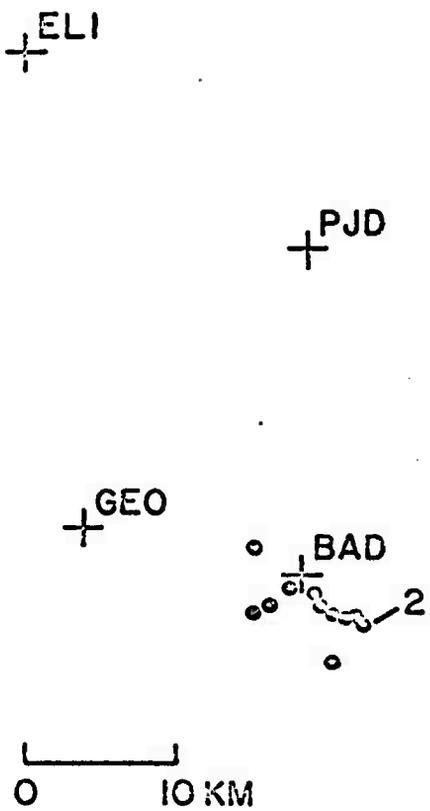

Fig. 3 Epicenters of small aftershocks. Stations used: ELI, PJD, GEO, 22-23 June 1967.

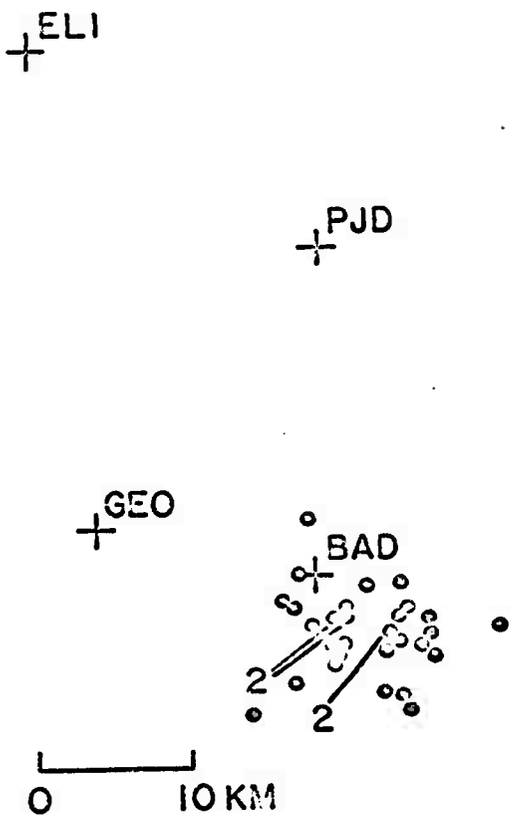

Fig. 4 Epicenters of small aftershocks. Stations used: PJD, GEO, BAD, 23-24 June 1967.

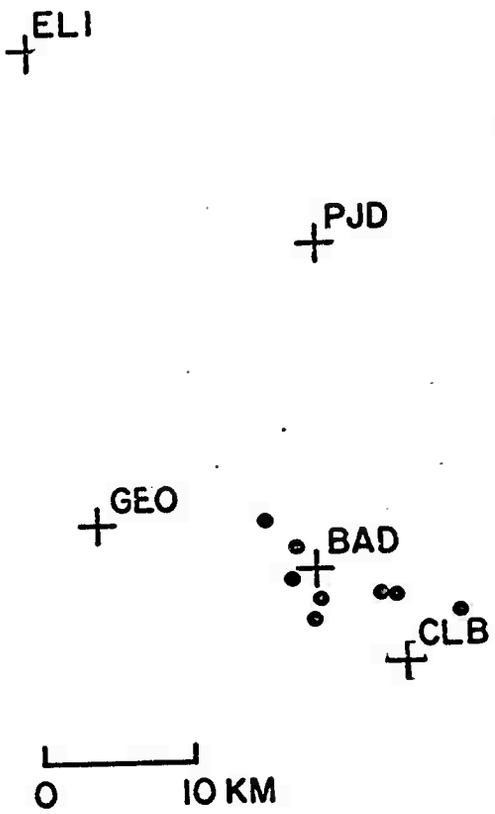

Fig. 5 Epicenters of small aftershocks, stations used PJD, GEO, CLB, 26-27 June 1967.

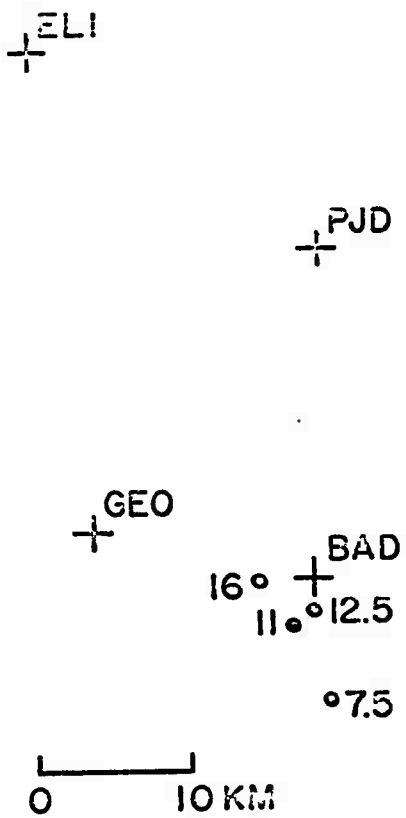

Fig. 6 Epicenters of small aftershocks. Stations used PJD, GEO, BAD, 21 July 1967

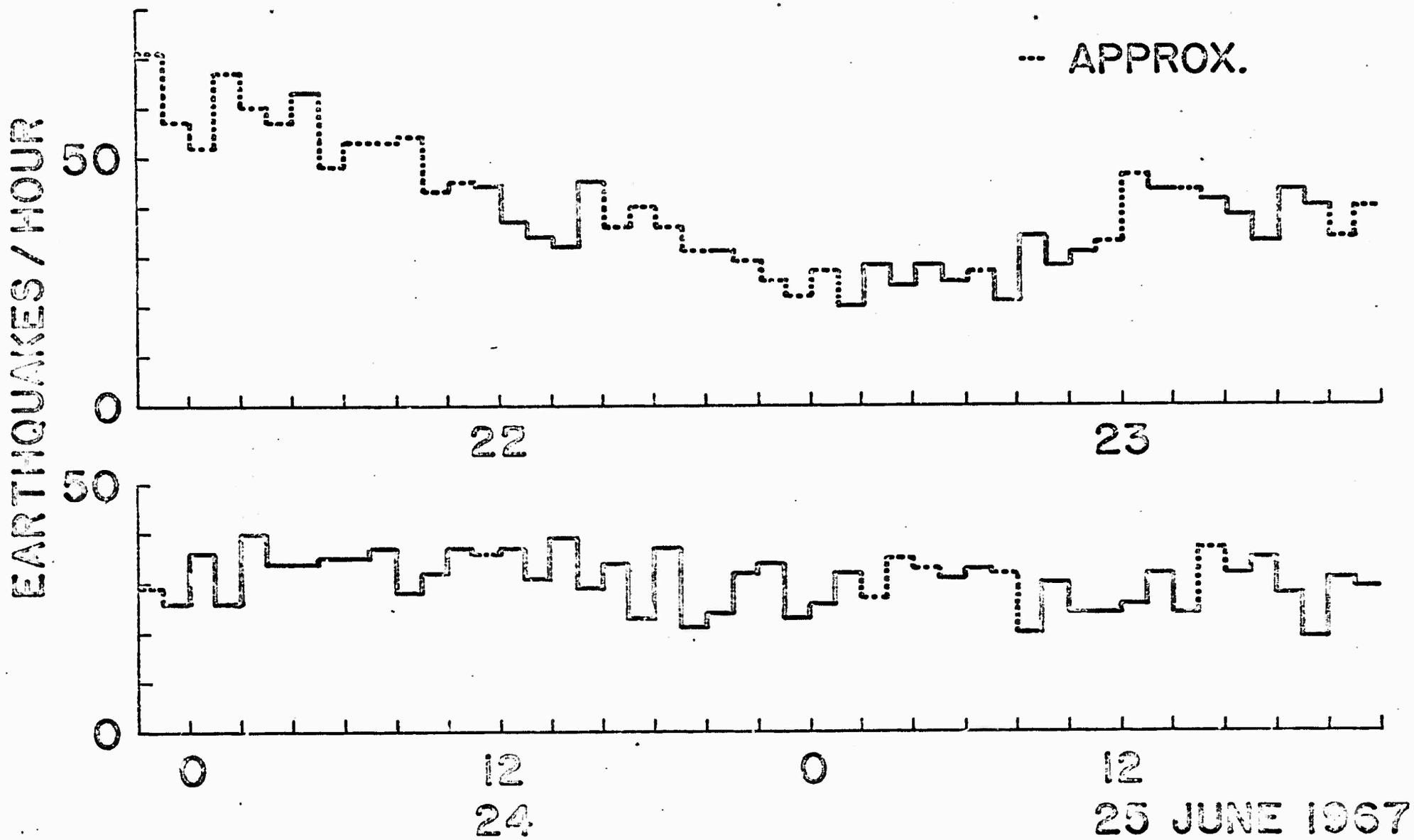

Fig. 7 Hourly number of earthquakes recorded at PJD

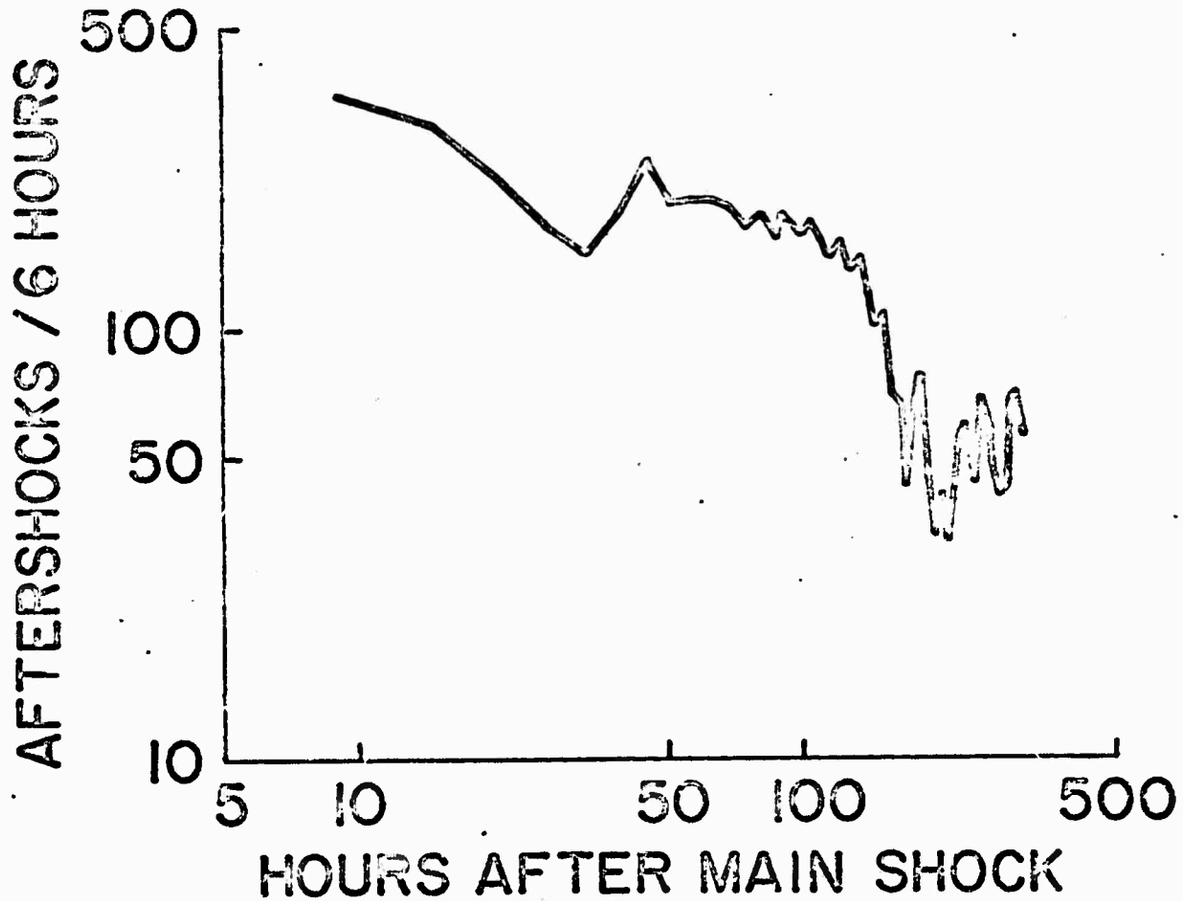

Fig. 8 6 hourly No. of earthquakes recorded at PJD.

TABLE 3

Station	Year	Date	First Motion	Time P	Time P	Magnitude (After 000 first 3 col.) Others period of P.		Time S	Period of S	
00067	2			1806						
PJD67	62			1804555						
MCK67	621			1805129						
BLR67	621	ID		1805146						
TNN67	621	IC		1805222						
SCM67	621	ID		1805375						
BIG67	621	EC		1806265					14450	
ZAP				2359						
00067	621			1814						
MCK67	621	I		1813265						
BLR67	621	ID		1813275						
SCM67	621	ED		1813510						
BIG67	621	I		1814404					14900	
ZAP				2359						
00067	621			1825						
MCK67	621	I		1825088						
BLR67	621	ID		1825111						
SCM67	621	ED		1825325						
ZAP				2359						
BLR67	621	I		1841415						
SCM67	621	ID		1842087				463	11 12	
BLR67	621			1844429						
SCM67	621	D		1844534			I	322	8 8	
BLR67	621	ID		1858205					2 60	
TNN67	621	I		1858329						
PJD67	621	I		1859313						
BLR67	621	I		1905149					3 45	
TNN67	621	E		1905249						
BLR67	621			1906404			I	594	3 12	
SCM67	621	ID		1907024	IC	068		451	8 11	
00067	621			1909		3				1
BLR67	621	I		1909247					4240	1
TNN67	621	ID		1909346						1
SCM67	621	I		1909470					6 6	1
ZAP				2359						
00067	621			1913		2				1
PJD67	621	I		1912436						1
BLR67	621	ID		1913028					6210	1
TNN67	621			1913111						1
SCM67	621	E		1913371					7 2	1
ZAP				2359						
BLR67	621	I		1917163					3 10	1
00067	621			1921						1
PJD67	621	I		1920347						1
BLR67	621	I		1920564					3 57	1
TNN67	621	E		1921064						1
ZAP				2359						
00067	621			1957		2				1
BLR67	621	I		1957213					L18	1
TNN67	621	I		1957301						1
SCM67	621	I		1957435					4 4	1
ZAP				2359						
00067	621			2005						1
PJD67	621	I		2004577						1
BLR67	621	I		2005169					4 75	1
TNN67	621	I		2005285						1
ZAP				2359						
00067	621			2033						
PJD67	621			2033041						
BLR67	621			2033231						

```
SCM67 621     2033476                                                  11L17
ZAP           2359
00067 621     2059                    29                                                1
PJD67 621I    2058473                                                                   1
BLR67 621I    2059066                                                  6195             1
TNN67 621I    2059176                                                                   1
SCM67 621I    2059192ID       232                                      7  4             1
ZAP           2359
00067 621     2109                    31                                                1
PJD67 621I    2108509I                                                                  1
BLR67 621I    2109109                                 I     331        4420             1
TNN67 621I    2109184                                                                   1
ZAP           2359
BLR67 621I    2149178                                       380        4540             1
SCM67 621     2149404I        444                                      8 12             1
00067 621     2154                    31                                                1
PJD67 621     2153563                                                                   1
BLR67 621ID   2154158                                                  4255             1
TNN67 621ED   2154230         279                                                       1
SCM67 621ID   2154403                                                  7  5             1
ZAP           2359
BIG67 621ID   2217003 TEL                                                                1
SCM67 621ID   2217207 TEL                                                                1
BLR67 621ID   2217297 TEL                 7 28                                           1
TNN67 621ID   2217310 TEL                                                                1
PJD67 621ID   2217332 TEL                                                                1
00067 621     2231                    37                                                1
PJD67 621I    2230364                                                                   1
BLR67 621ID   2230567ID       587                                                       1
TNN67 621ID   2231042                                                                   1
SCM67 621ID   2231210ID       255                                      5 45             1
ZAP           2359
00067 621     2332                    49                                                1
PJD67 621I    2331526                                                                   1
BLR67 621ID   2332115IC       134                                                       1
TNN67 621IC   2332193                                                                   1
SCM67 621ID   2332347I        361IC   404                              11165            1
ZAP           2359
BIG67 621ID   2337311                                                                   1
SCM67 622E    0119599                                       375        4 13
00067 622     0128
PJD67 622I    0128141
BLR67 622E    0128278                                 E     54         2 21
SCM67 622     012835
ZAP           2359
00067 622     0158
PJD67 622I    0156310
BLR67 622E    015852                                                   2 20
TNN67 622     0158497
ZAP           2359
00067 622     0228
PJD67 622ID   0228299
GEO67 622IC   0228292E        308                     E     321I     329
BLR67 622ID   0228519                                 E    2907      3120
TNN67 622EC   0228583
ZAP           2359
00067 622     0244
GEO67 622IC   0243461                                 1     490
PJD67 622ID   0243468
BLR67 622E    0244093                                 E     26         4 45
```

```
ZAP          2359
00067 622    0305
GEO67 622IC  0304376                                  E    405I    409
PJD67 622I   0304385
BLR67 622I   0305001                                                  2 30
TNN67 622ED  0305109
ZAP          2359
00067 622    0028        648      1477    37
PJD67 622I   0028011
BLR67 622I   0028207
TNN67 622ED  002828
SCM67 622E   002844                                      2926         2135
ZAP          2359
00067 622    0031                         36
PJD67 622I   0031091
BLR67 622E   0031299
TNN67 622E   0031355
SCM67 622E   003151                                      3234         8 16
ZAP          2359
00067 622    0046        648      1472    31
PJD67 622ID  0045271
BLR67 622IC  0045487
TNN67 622E   0045551
SCM67 622E   0046081                                       53         6  9
ZAP          2359
00067 622    0100                         31
PJD67 622I   0100069
BLR67 622E   0100297
TNN67 622E   010036
SCM67 622E   010054                                  E  01346         6  8
ZAP          2359
00067 622    0119                         31
PJD67 622I   0119123
BLR67 622    011933
TNN67 622    011939
ZAP          2359
00067 622    0306
GEO67 622E   0305485
PJD67 622I   0305499                      2 90
TNN67 622E   0305342
BLR67 622E   0306201
ZAP          2359
00067 622    0317
GEO67 622E   0316424
PJD67 622I   0316434
BLR67 622E   0317041                      2 35
TNN67 622E   0317148
ZAP          2359
00067 622    0332
GEO67 622I   0332081
PJD67 622I   0332089
BLR67 622E   0332314
TNN67 622E   0332291                      2 45
ZAP          2359
00067 622    0340
GEO67 622I   0339568
PJD67 622ID  0339585
BLR67 622E   034017                       2 55
TNN67 622E   0340249
ZAP          2359
00067 622    0511
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GEO67 622I    0510318
PJD67 622I    0510335
BLR67 622E    0511241
TNN67 622E    0511101
SCM67 622E    0511271                    3 15
ZAP           2359
00067 622     1659                      35
PJD67 622ID   1658465
BLR67 622E    1659069
TNN67 622E    1659142
SCM67 622E    1659301                                    4 15
ZAP           2359
00067 622     1410                      38
PJD67 622     1409521
BLR67 622     1410111
TNN67 622     1410172
SCM67 622     1410349                                    4  5
ZAP           2359
00067 622     1859                      50
PJD67 622ID   1857410
BLR67 622IC   1858003
TNN67 622ID   1858073
SCM67 622IC   1858234
BIG67 622E    1859121                                   10 12
ZAP           2359
00067 622     2020                      35
PJD67 622ID   2019214
BLR67 622E    2019406
TNN67 622E    2019470
SCM67 622E    2020034                                    8 12
ZAP           2359
00067 622     2117                      38
PJD67 622ID   2117008
BLR67 622ED   2117208
TNN67 622E    2117281
SCM67 622EC   2117441                                    4 45
ZAP           2359
00067 622     2308                      34
PJD67 622ID   2308170
BLR67 622ID   2308364I       382
TNN67 622IC   2308440I       482
SCM67 622E    2308591                                    4 22
ZAP           2359
00067 623     0307                      27                                3
GEO67 623I    0307082          I    111                                   3
PJD67 623I    0307087                                                     3
BLR67 623E    0307291          E    501                                   3
TNN67 623E    0307368E      401                                           3
SCM67 623E    0307526                                    3  7             3
ZAP           2359
00067 623     0354                                                        3
GEO67 623I    0353537                   28                                3
PJD67 623ID   0353553                                                     3
BLR67 623E    0354116       247 E                                         3
TNN67 623EC   0354209                                                     3
SCM67 623E    0354350                                    3 11             3
ZAP           2359
00067 623     0607                      43                                3
GEO67 623IC   0606279
PJD67 623I    0606293
BLR67 623ID   0606471
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TNN67 623ED  0606528
SCM67 623EC  0607097                                                  90
ZAP          2359
00067 623    0643                        36
GEO67 623EC  0643046
PJD67 623ID  0643057
BLR67 623E   0643253
TNN67 623E   0643328
SCM67 623E   0643499                                                5 25
ZAP          2359
00067 623    1156                        52
GEO67 623IC  1154366
PJD67 623I   1154379
BLR67 623ID  1154479
TNN67 623IC  1155045
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SCM67 625E   0254144E       155                       E    58        5 20  7
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GEO67 7 1I    1842305
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ZAP           2359
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SCM67 7 1IC   2124416 TEL
BLR67 7 1E    2125042 TEL
00067 7 1     2217                          33
GEO67 7 1ID   2216515
PJD67 7 1I    2217027
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BL.	7	2ED	0919145								
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BIG67	7	2IC	1117342					I	476	2	22

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BIG67 7 21     1220412                                        58
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SCM67 7 2ED    1221118                                        54          5200
TNN67 7 2ED    1221400
PJD67 7 2ED    122144
ZAP            2359
SCM67 7 2E     133244   TEL                12   2
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GEO67 7 21C    1334424                                   I    452
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TNN67 7 2E     1335086
SCM67 7 2ED    1335242          296                                        5 18
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GEO67 7 21C    1624448
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TNN67 7 2E     162518
SCM67 7 2E     162529                                        26115         6  5
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BIG67 7 3E     000629                                    E   0705          3 12
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PJD67 7 3EC    0517118  TEL                 6   9
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BIG67 7 3E   063728                                   I  38205         4  6
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SCM67 7 3ID  1600018                                  I    084         2 22
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SCM67 7 3ED  1715282                                  I    446         4 12
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ZAP          2359
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SCM67 7 4IC  0231022                                        23          3  8
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GEO67 7 4ID  0314315                                        347
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BLR67 7 5ID  1038304                                    544
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SCM67 7 5E   1120019                                                3 11
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BLR67 7 6ID  0506371
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GEO670714ID    1314184                                  E     218
PJD670714I     1314200
BLR670714IC    1314404                                  I     573        3 45
TNN670714E     1314514
ZAP            2359
BIG670714E     1355137ITEL     142          9  3
SCM670714ED    1356128 TEL     166          6  3
TNN670714E     1356285 TEL                  7  4
BLR670714ID    1356346 TEL                  5  6
PJD670714EC    1356388 TEL                  6  2
000670714      1555                        33
GEO670714IC    1554486I        490                   513
PJD670714I     1554502
BLR670714E     155511
TNN670714E     155517
SCM670714E     155535                                                  8  7
ZAP            2359
SCM670714ED    1936525                                  I   37273      3  6
BLR670714ED    1937128
000670714      1953        613      1527   26
BIG670714ED    1952451                                                 3  5
SCM670714E     1952500        533                                      3  9
BLR670714ID    1953125
PJD670714ED    1953256
ZAP            2359
000670714      2133
PJD670714IC    2133004                                  I     234
TNN670714E     213302
BLR670714E     213352                                      3416        3 17
ZAP            2359
PJD670714IC    2139113                                       21        2 25
TNN670714E     213915                                        36
SCM670714E     2228200                                  I    359        2  5
BLR670714EC    2241054                                     4200        3  7
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13. ABSTRACT

Aftershock recordings have been obtained to determine the extent of the fracture area which using some 50 shocks, was found to be an area of 10 x 15 km with the major axis roughly oriented in a NW-SE direction. Hypocenter depth varies from 6-19 km, with most of the shocks being confined to a depth of 10 to 13 km. It was found that the Jeffreys-Bullen velocities, V_p = 5.56 and V_s = 3.37 km/sec, represent a close approximation of the velocities in the area. Presented also are the telemeter network readings from June 21, 1800 GMT to July 14. These readings include the aftershocks of magnitude 2.5 and upward.

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