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DEPARTMENT OF
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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record No. 1973/109

SIMPSON DESERT EARTHQUAKE
CENTRAL AUSTRALIA, AUGUST 1972

by

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* Department of Economic Geology, University of Adelaide, South Australia, and

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ABSTRACT

In August 1972 a shallow earthquake of magnitude ML = 6.2 took place in the Simpson Desert region of central Australia. First-motion studies suggest a predominantly strike-slip focal mechanism for the main shock with one nodal plane paralleling the ENE trend of the aftershock sequence, which extended for about 120 km. The pressure axis for the main earthquake was approximately horizontal and N-S. This is the direction required to generate the earthquake zones in South Australia, and is suggestive of a simple regional stress pattern over the centre of the Australian Continent .

INTRODUCTION

Until recently little has been known about the earthquake patterns, and consequent current tectonic activity, in the centre of Australia. This arises because there are few seismograph stations suitable for monitoring local and regional earthquakes and because of the low population density for recording tangible earthquakes during historic times. However, with the development of the University of Adelaide's regional network of seismographs (Sutton & White, 1968; Stewart, Slade & Sutton, 1972) the patterns of earthquake activity in South Australia (SA) are emerging and it has been proposed (Stewart & Mount, 1972) that the seismicity associated with the Adelaide Geosyncline can be represented as a series of broad zones of dextral shearing.

North of the SA seismic zones a definite seismic lineation has been identified in the Canning Basin (Everingham, Gregson & Denham, in prep.), but it is not clear how this feature relates to the earthquake activity elsewhere in the continent. Of particular importance is the significance of the Simpson Desert region in the southwest of the Northern Territory (NT) which, since 1937, has been one of the most seismically active areas of the Australian continent (Figs 1, 2).

The first accurately located earthquake of moderate size there took place on 18 August 1972. This earthquake was large enough to generate several locatable aftershocks and also to enable a focal mechanism to be derived.

Epicentres and magnitudes

The main earthquake of 28 August was well recorded by seismographs in Australia and overseas. All the aftershocks had magnitudes less than 4 (ML) and most were detected only by seismographs in SA and the NT, at epicentral distances ranging from 300 to 1100 km. The only known foreshock (on 18 August) and some of the aftershocks were recorded only at the nearest station, ASP.

P-wave data from 18 Australian regional stations were used with the Herrin travel-times (Herrin et al., 1968) to give an epicentre for a surface focus at 24.93 (±0.06)°S, 136.39 (±0.08)°E. The residuals for the nearest stations (ASP and those in SA) were generally large, however, implying that the travel-times or the final iterative solution were erroneous. The Environmental Research Laboratories (ERL) epicentre (see EDR No. 50, 1972) was 24.92 (±0.03)°S, 136.93 (±0.12)°E, and the focal depth 59 ± 6 km. In this solution the P times from 9 of the nearest 10 stations were rejected because they gave high negative residuals. The preferred hypocentre of 24.74 (±0.09)°S, 136.92 (±0.12)°E, focal depth 7 km, was obtained by using a program based on local SA travel-times and crustal structure (Stewart & Sutton, 1971). Only the SA stations and ASP were used to determine this hypocentre, but the time residuals were small and the identifications of phases were satisfactory.

The difference of about 70 km between this epicentre and that determined by ERL may reflect the presence of some large-scale upper mantle inhomogeneity across the Australian continent (e.g. associated with the West Australian shield) or may result from the focal mechanism of the earthquake. If the latter were true the difference in epicentres suggests that the solution from the local stations gives an epicentre close to the initial fault break while the ERL solution is closer to the region of maximum energy release. However, the concept of an 'epicentre' for a large shallow earthquake with an extensive fault-plane area (such as the main shock) can be misleading. The adopted epicentre probably represents the point at which the rupture commenced, and hence indicates that the fault propagated mainly to the southwest.

Although 15 aftershocks were recorded at ASP within 24 hours of the main earthquake, only those listed in the Table were recorded (until the end of 1972) by enough stations to be located. The mean standard errors are 0.17° in latitude, 0.23° in longitude, and 6 km in depth. These earthquakes are plotted in Figure 2 together with the previous known earthquakes from the region (Burke-Gaffney, 1951; Sutton & White, 1968; USCGS, EDR51, 1968). All the large (ML$\geq$ 6.0) earthquakes shown in Figure 2 (apart from the 1972 shock) date from the period 1937-1941, and their epicentres may be in error by up to 1°. Nevertheless, they are evidence of persistent significant seismic activity in the same region as the 1972 sequence.

All magnitudes listed in the Table have been converted to ML from a local scale used in SA (Stewart et al., 1972). The scale was established to allow for the effects of local crustal structure and seismograph response, and generally gives consistent results up to distances of about 1000 km. The main earthquake had a magnitude of about ML = 6.3 from local stations and the ERL body-wave magnitude was MB (ERL) = 5.6. The body-wave magnitude MB is found from MB(ERL) by

$$MB = MB(ERL) + 0.7$$

using an approximate relation given by Båth (1966). Hence the ML magnitude obtained from ERL data, and using Gutenberg & Richter's (1956) conversion formula ($MB = 1.7 + 0.8ML - 0.01ML^2$), is about 6.2. Gibowicz (1972) suggested that for shallow New Zealand earthquakes the relation between ML and MB(ERL) is

$$ML = 1.17\ MB(ERL) - 0.43$$

If this result applies to Australia the ERL estimate may be converted to give ML = 6.1. Thus the different methods of calculating magnitudes yield very consistent values for the main earthquake and suggest that ML = 6.2 is a reasonable estimate. Despite the relatively large magnitude no report was received of the earthquake having been felt. However, the nearest habitation was about 200 km from the epicentre and it is unlikely that an intensity greater than MM4 would have been experienced there from an earthquake of magnitude ML = 6.2. Furthermore since the main event took place close to noon local time most people would not be in positions favourable to feel any slight shaking.

Epicentral distribution

The epicentral distribution from the 1972 sequence plotted in Figure 2 displays remarkable linearity, allowing for possible errors in location. The distribution is similar to that observed after many large earthquakes, e.g. 1964 Alaska (Page, 1968), 1970 Madang (Everingham, in press 1973), and 1970 Canning Basin (Everingham, Gregson & Denham, in prep.), in which the main event occurred near one end of the aftershock zone, and the aftershocks clustered at both ends. In these examples, it was suggested that the distribution of aftershock epicentres was largely governed by the primary faulting associated with the main earthquake. Liebermann & Pomeroy (1970) state that the belt of aftershocks defines the extent of primary faulting of large earthquakes, the long axis of the aftershock zone being a better estimate of the length of faulting at depth than the observed length of surface faulting. A relation given by Wyss & Brune (1968) suggests that for an earthquake with ML = 6.2 the length of faulting would be about 60 km. This is about half the length of the aftershock zone in the Simpson Desert. The displacements during the main earthquake may have been as large as 30 cm (after Chinnery, 1969). However, the epicentral region has not been examined for surface breakage.

There are no identifiable trends in the hypocentral depths for the sequence although it appears that all earthquakes were shallow, within 10 km of the surface.

An attempt has been made to correlate the trend of the epicentres (and presumably of primary faulting) with the known geology and geophysics of the region. There appears to be no correlation between the gravity and magnetic anomalies and the main epicentral trend, but the sequence is situated near the northwest edge of the Eromanga Basin (Geological Society of Australia, 1971: Tectonic Map of Australia and New Guinea, 1:5 000 000, Sydney) where a significant increase in basement depth delineates the basin.

Focal mechanism and tectonic hypothesis

A focal mechanism solution for the main earthquake was obtained from first-motion data from 58 short-period stations; the stereo projection of the lower focal hemisphere is shown in Figure 3. The solution obtained is consistent with predominantly left-lateral strike-slip faulting and an almost N-S pressure axis. Five stations in the western quadrant (FUR, HFS, LEM, MUN, and SUD) give anomalous results (dilatations) but they are surrounded by several stations that give compressional first motions and hence they have been ignored in determining the focal parameters.

The nodal plane striking NE is well defined between the Antarctic and New Zealand stations, and the strike of this plane can vary by only $\pm3^{\circ}$. Although the plane striking NW is poorly defined by the first motions on each side of it, the condition of orthogonality restrains its strike also to about $\pm3^{\circ}$. The spatial distribution of the aftershocks indicates that the nodal plane striking NE is the fault plane since the strike of the longitudinal axis of the aftershock sequence (54°) and that of the plane (53°) almost coincide.

The suggested mechanism contains a small component of thrusting, which implies overthrusting from the south. This trend is opposite to that required to form a boundary fault to the Eromanga Basin and hence suggests that the Simpson Desert seismicity is associated with comparatively recent tectonism.

Stewart & Mount (1972) hypothesized - mainly from seismic evidence - that a zone of fracturing extends from the comparatively active seismic region of SA to the Canning Basin in Western Australia. They showed that the directions of motion along the broad fracture zones of SA are mainly strike-slip (Fig. 1), but the seismic quiescence between 128 and 136°E precludes the delineation of any active tectonic features in that region.

The focal mechanism solution from the main Canning Basin earthquake of March 1970 (Everingham, Gregson & Denham, in prep.) provides evidence for thrust faulting with the pressure axis approximately NE-SW and perpindicular to the zone of aftershocks. This evidence suggests that the regional stress pattern must change across the quiescent zone.

It is clear that most of the seismic activity between 135 and 140°E can be explained by a regional stress field resulting from a predominantly N-S pressure axis. The seismic zones probably occur along old zones of weakness - such as the edges of an old proto-continent or the edges of large basins. However, the movements along the zones are small and do not amount to more than 0.1 cm/yr. The cause of the regional stress cannot be determined, but it may be associated with the collision of the Indian/Australian plate along its northern margin, changes of spreading rate along the Australian-Antarctic ridge, or a separate tectonic environment within the Australian continent. At this stage we do not believe that the data are sufficient to confirm or disprove any of these alternatives.

ACKNOWLEDGEMENTS

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TABLE

SIMPSON DESERT, EARTHQUAKES, 1972 CENTRAL AUSTRALIA

Date	Origin Time UT			Lat. °S	Long. °E	Depth km	Magnitude ML
Aug. 28	02	18	51.6	24.72	136.92	7	6.2
"	02	35	00.3	24.72	136.75	9	3.6
"	02	52	03.0	24.63	136.98	0	2.7
"	03	33	17.4	24.65	136.91	8	3.1
"	04	55	50.7	25.00	136.31	8	2.3
"	07	26	48.0	25.08	136.28	0	1.9
"	08	13	45.9	25.11	136.18	8	1.6
"	12	28	06.6	25.05	136.57	6	2.5
Aug. 30	17	54	08.4	25.06	136.22	10	2.1
Sept. 4	20	34	48.0	24.53	137.06	9	2.3
Sept. 11	22	10	13.2	25.12	136.20	6	1.6
Sept. 19	02	22	05.4	25.11	136.17	5	1.6
"	03	11	31.2	24.99	136.38	5	1.9
Sept. 20	00	03	21.8	25.05	136.34	6	2.1
Oct. 4	10	37	00.6	25.08	136.40	9	3.1
Dec. 17	20	02	27.7	24.95	136.45	5	3.0

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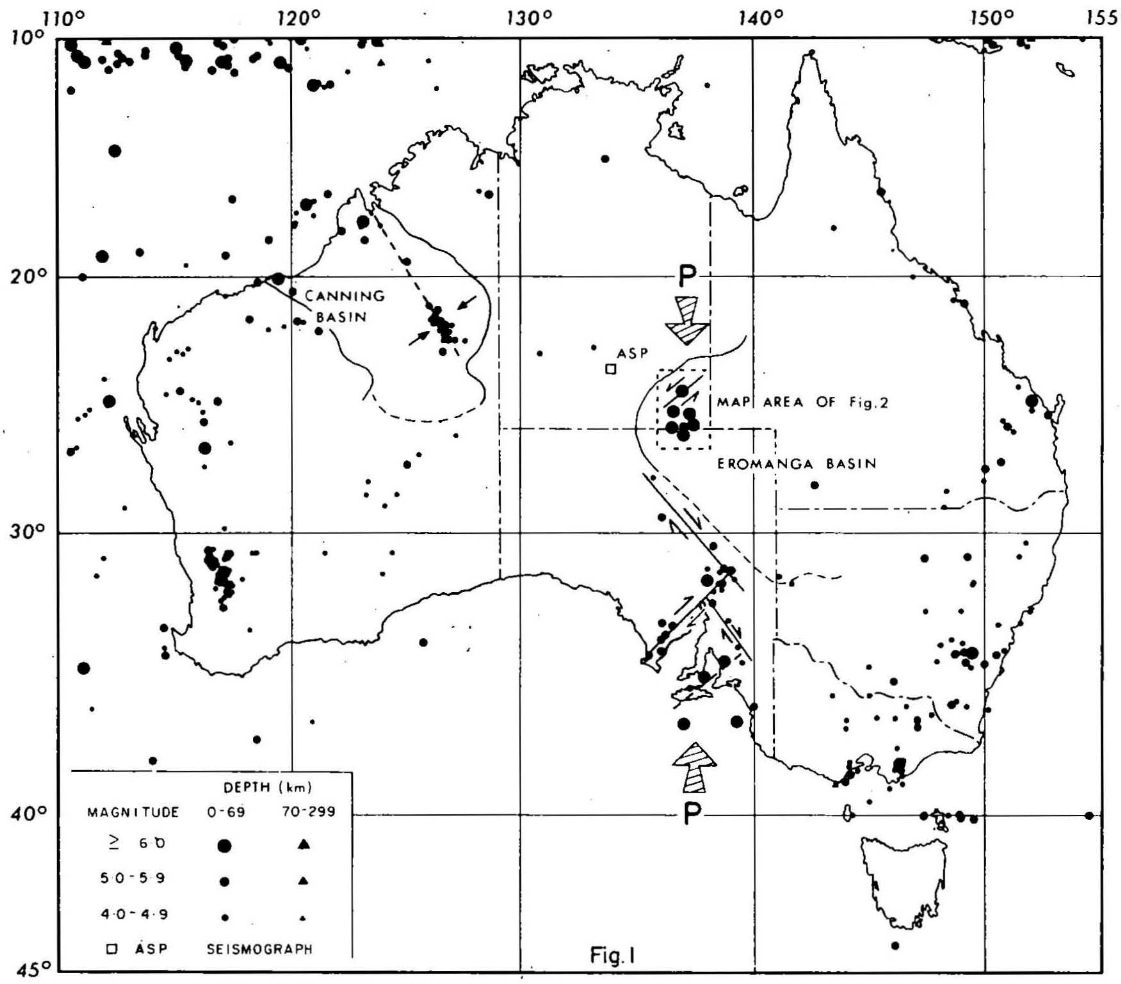
FIGURE CAPTIONS

FIGURE 1. Known earthquakes, Australian region 1900–1971, Magnitude 4.0 or greater.

FIGURE 2. Earthquakes in the Simpson Desert region 1900–1972. Open symbols represent pre-1972 earthquakes; all shocks are presumed to originate in the crust.

FIGURE 3. Focal mechanism solution for main event of 28 August 1972. The numbers represent the strike and dip of the poles or axes.



KNOWN EARTHQUAKES, AUSTRALIAN REGION 1900-1971, MAGNITUDE 4 OR GREATER

To accompany record no 1973/109

A/B9-86-2A

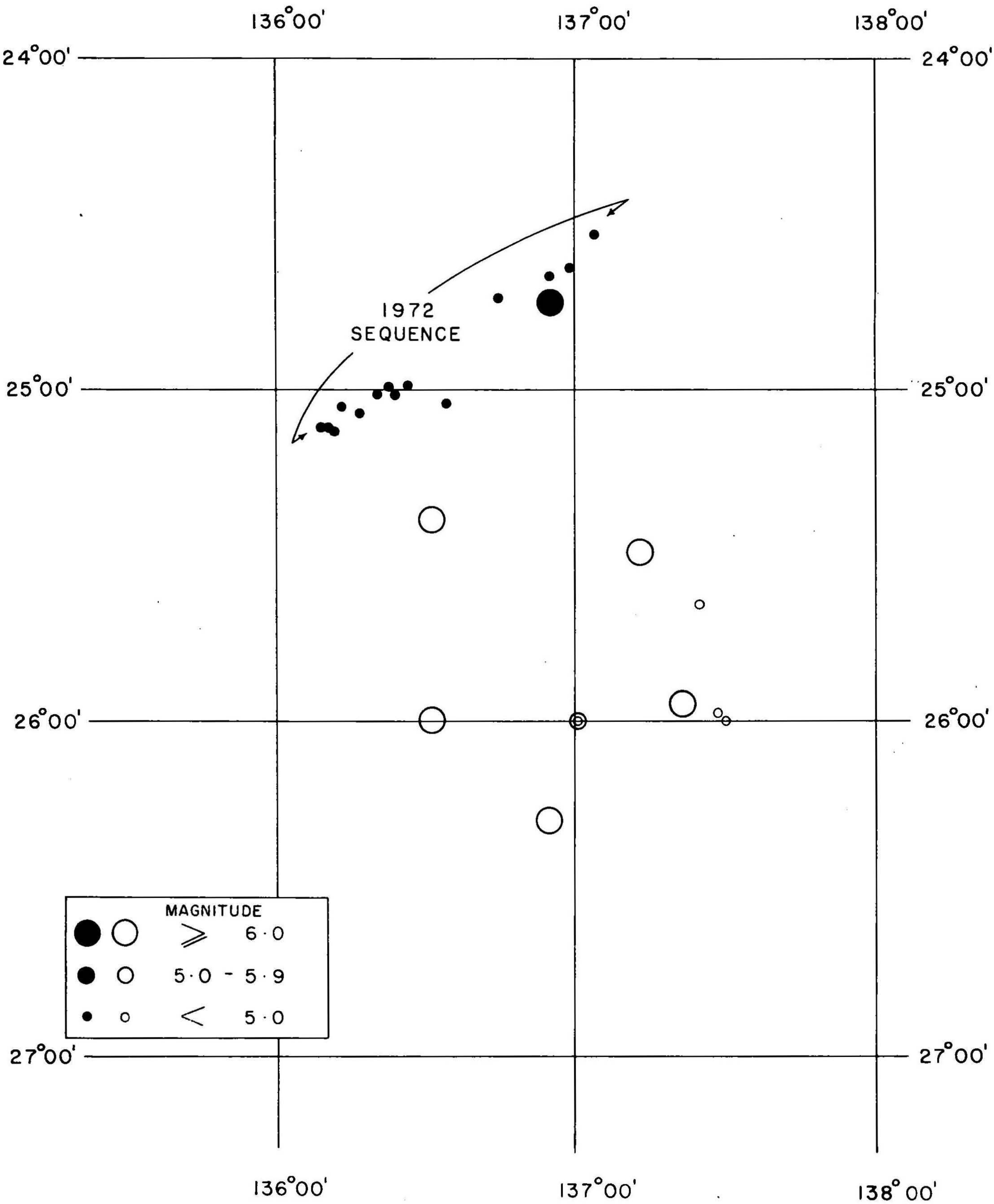


Fig. 2

EARTHQUAKES IN THE SIMPSON DESERT REGION 1900-1972. OPEN SYMBOLS REPRESENT PRE-1972 EARTHQUAKES; ALL SHOCKS ARE PRESUMED TO ORIGINATE IN CRUST

A / B9-91A

To accompany record no. 1973/109

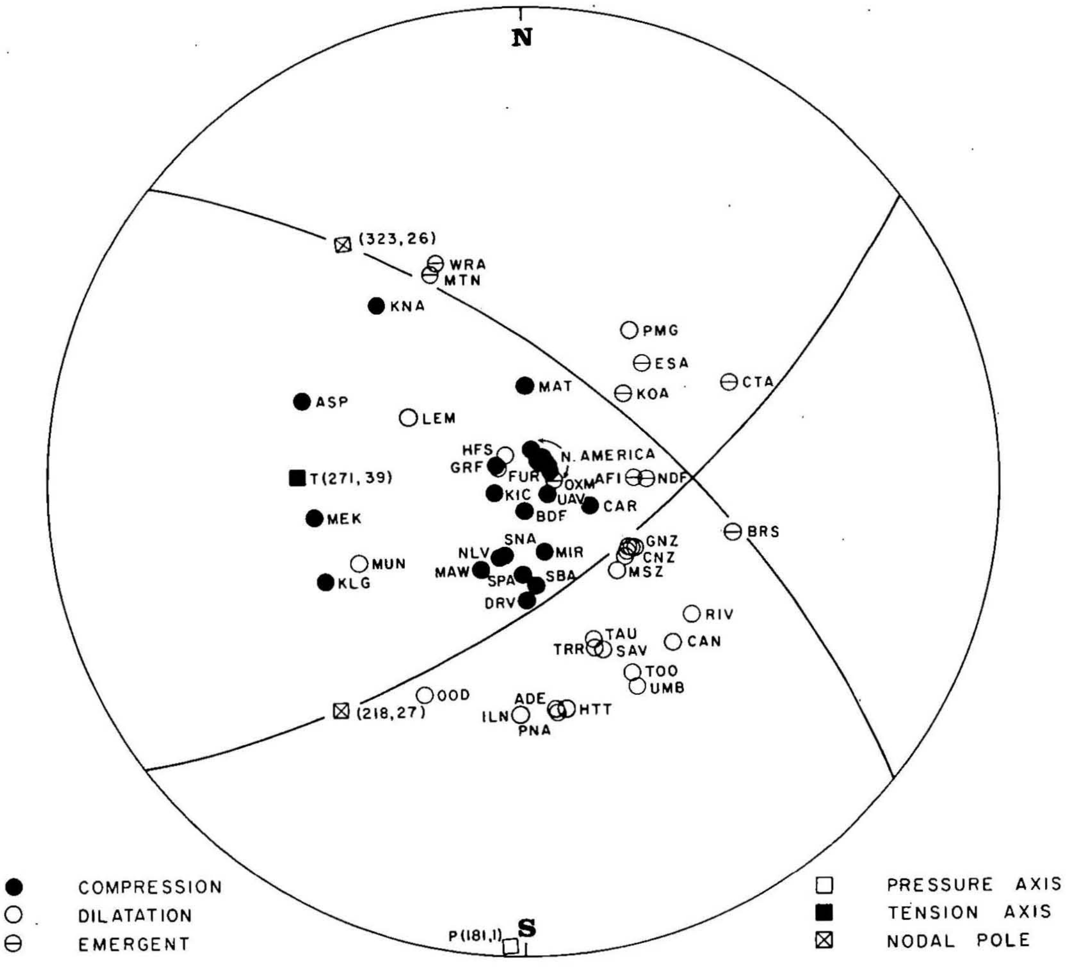


Fig. 3

FOCAL MECHANISM SOLUTION FOR MAIN EVENT OF 28 AUGUST 1972

THE NUMBERS REPRESENT THE STRIKE AND DIP OF THE POLES OR AXES

A/89-90A