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ANOMALOUS ASPECTS OF NEW GUINEA SEISMICITY *

by

I. D. RIPPER

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SUMMARY

In terms of plate tectonics, New Guinea is theoretically the site of the highest rate of global collision: relative movement between the Australian and Pacific Plates is 10.7 cm/yr on an azimuth of 075°, which is in marked contrast with a previously determined seismic slip rate of 2.3 cm/yr.

Subduction of the Pacific Plate beneath Irian Jaya is not apparent from the available evidence: earthquake activity is restricted mainly to depths less than 70 km, although some activity occurs down to 150 km; the earthquake distribution has no Benioff zone characteristics; and a volcanic arc and oceanic trench are absent.

These anomalies may be explained by considering that the edge of the Australian Plate is the southern boundary of the Irian Jaya zone seismicity which extends on an azimuth of 075° from the Banda Sea trench to the western end of the Bismarck Sea seismic zone. It is suggested that the seismically active section of Irian Jaya is a buffer plate or zone of shear and buckling within the collision triple junction of the Australian, Pacific, and Eurasian Plates.

The existence of strike-slip earthquakes through east New Guinea and the Solomon Sea region supports the theory that sinistral shear is the mode of collision between the Australian and Pacific Plates. The South Bismarck and Solomon Sea Subplates act as buffers within the collision zone and derive their motions from the shear couple.

1. INTRODUCTION

New Guinea is considered to be on the northern margin of the Australian Plate. It is colliding with the Pacific Plate on an azimuth of about 075° at a rate of about 10.7 cm/yr (Le Pichon, 1968, 1970). At least two minor plates are within the collision zone: the South Bismarck and Solomon Sea Subplates. At Irian Jaya the Pacific and Australian Plates appear to be in direct contact.

Seismograph stations recently installed in Papua New Guinea by the Australian Bureau of Mineral Resources (BMR) and the Geological Survey of Papua New Guinea have vastly improved the accuracy with which PNG earthquakes can be located, but Irian Jaya has, up to August 1973, no seismographs. Seismographs are needed close to the earthquake epicentre to obtain an accurate depth estimate. The Irian Jaya earthquake of 10 October 1961 is a good example of what may happen when only distant stations are considered in the hopecentre determination: the International Seismological Summary placed the earthquake depth at 274 km, but BMR has relocated the hypocentre to a depth of 35 km by including results from nearby stations. On the basis of this result, other Irian Jaya earthquakes are being relocated. Hence although good definition of Papua New Guinea seismic zones is now being obtained, the apparent diffuseness of Irian Jaya seismicity may well be partly caused by inadequate station coverage.

Plates 1 - 6 show the seismicity of the New Guinea region between 1964 and 1972. Only hypocentres computed from 15 or more P-wave arrival times have been plotted. The seismicity is divided into depth zones so that a better understanding of the seismic trends at all depths may be obtained. Plate 7 shows the currently active volcanoes, the trenches, and the possible plate boundaries in the region.

Plates 8 and 9 show the earthquake focal mechanism solutions obtained by Ripper (in prep. a).

Several features of New Guinea seismicity and volcanism which are anomalous in relation to the theory of plate tectonics are discussed in the following sections and are listed below:

1. The absence of a seismic Benioff zone and other subduction indicators in Irian Jaya, despite the high rate of collision of the Australian and Pacific Plates (Plate 1-6).
2. The discrepancy between the tectonic collision rate (10.7 cm/yr; Le Pichon, 1968) and the seismic slip rate for Irian Jaya (2.3 cm/yr; Davies & Brune, 1971).
3. The apparent kink in the Bismarck Sea seismic zone (Plates 1 and 2).
4. The presence of Tuluman volcano near Manus Island, in the Bismarck Sea (Plate 7).
5. The lack of seismicity below the active Manam Island volcano (Plates 1 to 7).
6. The continuation of the South Bismarck Volcanic Arc and the New Britain inclined seismic zone across northern New Guinea, beyond the junction of the Solomon Sea and South Bismarck Subplates (Plates 1, 2A and 7).
7. The seismic lineation parallel to the Markham Valley, but more than 70 km below it (Plate 4).
8. Intermediate-depth earthquakes south of the Markham Valley, west of the Huon Gulf (Plates 4 and 5A).
9. The low level of seismicity throughout the volcanic southeast Papua region (Plates 1-6).
10. The vertical dip of the Bougainville seismic zone (Plate 1-6).

2. IRIAN JAYA SEISMICITY

Denham (1969), Johnson & Molnar (1972), and others have considered that Irian Jaya is a subduction zone, with the Pacific Plate being subducted beneath the Irian Jaya continental margin. This hypothesis is supported by:

1. The rate of approach of the Australian and Pacific Plates, which, at 10.7 cm/yr, is the highest rate of collision of all the major global plates.
2. Overthrust focal mechanisms of Irian Jaya earthquakes (Plate 8B; Johnson & Molnar, 1972).

Subduction is opposed by:

1. The absence of a seismic plane dipping southwest beneath Irian Jaya (Plate 1-6).
2. The absence of a volcanic arc (Plate 7). Marchant (1969) has pointed out that the Irian Jaya gap in current southwest Pacific volcanism extends from the Halmaheras at 129°E to Bam Island at 145°E.
3. The absence of an oceanic trench, normally associated with a continent-ocean subduction zone (Plate 7).

It may be argued that subduction of the Pacific Plate at Irian Jaya is just beginning, so that the Benioff zone, trench, and volcanism have yet to appear. For this to be so, subduction would be currently ceasing at some other place on the line bearing 075° through Irian Jaya. Although subduction may have occurred at the West Melanesian Arc during the Quaternary (Karig, 1972), the lack of deep or intermediate seismicity associated with the arc (Plates 1-6) suggests that there is no rear end of a lithospheric slab currently disappearing into the asthenosphere. However, the hypothesis of very recent subduction would be supported if the active Tuluman volcano near Manus Island, in the Bismarck Sea, is typical of island arc volcanism. A strong objection to the transfer of subduction to Irian Jaya is the active volcanism of the South Bismarck Volcanic Arc and the recent volcanism of the New Guinea highlands. Although the highlands volcanism may not have been associated with subduction (Johnson, Mackenzie? & Smith, 1970) it implies that New Guinea has been associated with the active margin of the Australian Plate during the Quaternary.

Another alternative to subduction is that the collision mechanism may be similar to that in the Himalayan region, where India is colliding with Asia at a rate of about 5.6 cm/yr (Le Pichon, 1968); this agrees with the seismic slip rate of 5.6 cm/yr calculated by Davies & Brune (1971). The collision is continent-continent. As in Irian Jaya, the Himalayan region has neither trench nor volcanism, and earthquake depths are less than 300 km.

The objections to this hypothesis are as follows:

1. The collision at Irian Jaya is continent-ocean, so that a trench and volcanic arc system would be expected.
2. The collision rate in Irian Jaya is double that of the Himalayan region, so that strong subduction or obduction should be present.

In contrast to the good agreement between plate collision rate and seismic slip rate for the Himalayan region, the seismic slip rate for Irian Jaya is significantly less than Le Pichon's plate collision rate of 10.7 cm/yr. Davies & Brune (1971) obtained a slip rate of 2.3 cm/yr for

Gutenberg & Richter's (1954) Region 16 (New Guinea), and Everingham (1974) obtained a regional slip rate of 3.9 cm/yr for the longitude range 130–145°E. The discrepancy might be explained if shear is involved in the collision, for much of the shear movement could occur by flow without fracture; shear focal mechanisms have been obtained (Wickens & Hodgson 1967; Johnson & Molnar, 1972), and in the San Andreas Fault region, where seismicity is restricted to depths of less than 20 km (Bolt, Lomnitz, & McEvilly), all relative motion below 20 km occurs by flow.

The triangular outline of Irian Jaya seismicity (Plates 1 and 2A) suggests the existence of a buffer plate, as has been postulated for the Himalayan region by Roman (1973). The buffer plate's boundary with the Australian Plate would be the southern boundary of Irian Jaya seismicity, which is a line bearing about 075° between the Banda Sea Trench and the western end of the Bismarck Sea seismic zone. The buffer plate's role would be to absorb and distribute the triple collision of the Pacific, Australian, and Eurasian Plates. Its motion would involve:

1. Internal shear.
2. Internal buckling and overthrusting, illustrated by the Irian Jaya earthquakes with overthrust solutions (Plate 8B).
3. Internal rotations.
4. Movement relative to the Australian Plate. The Irian Jaya Subplate is being pushed ahead of the Pacific Plate into the Banda Sea region, creating a chaotic tectonic spiral which begins at the Banda Sea Trench and extends through Ceram, the Celebes, and Halmahera.

3. BISMARCK SEA SEISMIC ZONE

The Bismarck Sea seismic zone marks the border between the South Bismarck Subplate and the North Bismarck Subplate. Johnson & Molnar (1972) have computed a sinistral shear slip rate of 7.5 cm/yr for the zone.

The zone is either at least 100 km broad so that the shear is spread widely and involves considerable non-seismic movement, or is non-linear (Plates 1 and 2). Southeast of Manus Island, the seismic zone appears to have an anomalous kink, which, if real, implies a mechanism other than east-west sinistral shear. However, earthquake focal mechanisms support the hypothesis of sinistral shear (Johnson & Molnar, 1972; Ripper, in press a) although the nodal planes of the solutions are not precisely parallel to the zone.

If Tuluman volcano, between the zone and Manus Island (Plate 7), is not associated with subduction at the West Melanesian Arc, it may be associated with east-west shear fractures across the Bismarck Sea north of the zone.

4. NORTHERN NEW GUINEA SEISMICITY

The complexity of the South Bismarck Subplate/Australian Plate boundary is annoted below:

1. It contains a line of volcanoes which forms part of the South Bismarck volcanic arc - extending from Rabaul (New Britain) to Bam Island (northern New Guinea); (Plate 7).
2. The Northern New Guinea Basin consists of geosynclinal Miocene sediments upthrust to heights in excess of 4000 m to form the Adelbert, Finisterre, and Saruwaged Ranges /and/ the Cromwell Mountains of the Huon Peninsula.

3. The mountain ranges are bordered on the south side by the Ramu-Markham Valley, below which is a vertical seismic zone between the anomalous depths of 70 and 150 km. Focal mechanisms of earthquakes in the zone are both shear and normal.
4. Between the depths of 50 and 230 km, the dipping New Britain seismic zone extends uniformly into the Huon Peninsula region (Plates 3-5). It dips northward from the Huon Peninsula to a maximum depth of 230 km beneath Long Island volcano. Focal mechanisms are both overthrust and shear (Plate 8). The shear is sinistral if the fault plane extends roughly east-west.
5. The intermediate-depth seismicity does not underlie the western end of the volcanic arc, where Manam Island is currently the most active volcano of the arc.
6. South of the Markham Valley, earthquakes occur between depths of 70 and 200 km (Plates 4 and 5A), and form a seismic zone dipping southwestward from the Huon Gulf beneath Mount Yelia volcano.

Tectonic theories of the nature of the boundary include:

1. Subduction of the South Bismarck Subplate beneath New Guinea (Denham, 1969). The objections to this theory are: (a) the intermediate depth earthquakes south of the Markham Valley appear to be related to the Solomon Sea/Australian Plate boundary because they deepen westward from the Huon Gulf; (b) the main seismic zone dips northward from the

Huon Peninsula to the volcanic arc; and (c) the trench normally associated with continent-ocean subduction zones is absent.

2. Krause (preprint) discussed the boundary in detail, and preferred slow subduction in the southeast, and either a low rifting, zero movement, dextral (right lateral) shear, or subduction in the northwest. However, Ripper (in press a, b) has obtained both sinistral and normal fault focal mechanisms for earthquakes below the Markham Valley.

3. Dewey & Bird (1970) mentioned the boundary as a possible continent-subduction zone collision in the Miocene. When the continental margin reached the trench, sediment rapidly filled the trench, subduction ceased, and the trench sediments were uplifted into the mountains of the Northern New Guinea Basin.

4. The present volcanic arc is of Quaternary age. A current continent-subduction zone collision involving the New Britain arc should have deep-focus seismicity showing the downward passage of the oceanic lithosphere. Johnson & Molnar (1972) considered that a continent-subduction zone collision has occurred involving the South Bismarck Volcanic Arc, and that the oceanic crust has doubled back beneath the continent while the continent is pushing the South Bismarck subplate northward. The existing intermediate-depth seismicity, and lack of deep-focus seismicity are incompatible with this hypothesis.

5. The continuity of the South Bismarck Volcanic Arc from Rabaul in New Britain to the Schouten Islands of northern New Guinea suggests that the western section of the arc was

originally related to subduction of the Solomon Sea Subplate, and that the arc has since sheared westward across New Guinea during the Quaternary. Although some westward movement is likely, the hypothesis is rejected because the arc would have moved 300 km in one million years, a rate of 30 cm/yr, which is too high. In addition, volcanoes at the western end of the arc would be the least active, not the most active as Manam Island volcano has been this century (Johnson, Taylor, & Davies, 1972).

It seems that the northern New Guinea margin is a zone of compression between the Australian and South Bismarck Plates, but with little subduction or shear movement.

5. SOUTHEAST PAPUA- SINISTRAL SHEAR ZONE

Johnson & Molnar (1972) computed that the Solomon Sea Subplate is moving at 7 cm/yr on an azimuth of 325° relative to the Australian Plate. They noted however that the level of seismicity in southeast Papua is anomalously low. An escape from this dilemma is to postulate considerable shear flow without fracture. The active volcanism of southeast Papua indicates that the region is tectonically active, but as earthquake depths do not exceed 60 km in southeast Papua the volcanism is not associated with subduction.

The tensional Woodlark Basin (Milson, 1970), and the south-westward-dipping earthquake zone west of the Huon Gulf support a northwest-motion of the Solomon Sea Subplate causing sinistral shear throughout southeast Papua. Luyendyk, Macdonald, & Bryan (1972) obtain a northerly motion for the Solomon Sea Subplate, but this does not accord with the south-westward-dipping seismic zone.

6. BOUGAINVILLE - VERTICAL SUBDUCTION

One of the difficulties of plate tectonics is the mechanism of supposed downturn of the 100 km thick lithospheric plate from its horizontal direction of motion to plunge into the mantle. This difficulty applies particularly to the subduction of the Solomon Sea Subplate at Bougainville, where the seismic zone plunges vertically into the mantle to a depth in excess of 500 km between the trench and Bougainville (Plates 1-6). Below 500 km, earthquakes also occur in an anomalous pocket north of Bougainville, at 4.5°S, 155°E (Plate 6). This pocket of deep-focus seismicity is unlikely to be associated with subduction of the Pacific Plate because the leading edge of the Ontong Java Plateau, in the Pacific Plate, collided with the Solomon Island Arc in the late Miocene (Kroenke, 1972).

7. MODE OF COLLISION OF THE AUSTRALIAN AND PACIFIC PLATES, NEW GUINEA REGION

Carey (1958) suggested that a sinistral shear is active through New Guinea. More recently Davies & Smith (1971) suggested that the present response to the Australian-Pacific Plate collision is probably a sinistral shear along the line of the Solomon Islands, New Ireland, and Manus Island, with sub-plate rotation in the Bismarck and Solomon Seas. The collision model proposed below is similar.

1. The Australian and Pacific Plates are approaching at about 10.7 cm/yr on an azimuth of 075° in the New Guinea region (Le Pichon, 1968, 1970). At the southeast Solomon Islands, the azimuth of approach is about 090°.
2. The mode of collision is sinistral shear.
3. The shear follows the Bismarck Sea seismic zone eastwards from the Irian Jaya buffer plate.

4. At New Britain, the shear is transferred through the New Britain subduction zone into sinistral shear through southeast Papua.
5. The northern margin of New Guinea is a zone of compression accommodating the difference in azimuth of the Bismarck Sea seismic zone (090°) and the azimuth of plate approach (075°).
6. The azimuth of shear in southeast Papua is about 110° while the azimuth of plate approach is about 085°. The difference in azimuth is accommodated at the Bougainville subduction zone.

In this model the northern New Guinea margin and Bougainville, although seismically active, are both tectonically secondary to the shear zones. The South Bismarck and Solomon Sea Subplates are buffer plates within the sinistral shear collision zone, and derive their motions from the shear couples.

8. CONCLUSIONS

The installation of seismographs in the Papua New Guinea region during the last few years has improved the accuracy of earthquake hypocentre and focal mechanism determinations, which have allowed a clearer insight into the detailed structure of the seismic zones.

The apparent absence of subduction beneath Irian Jaya is explained by the existence of a buffer plate encompassing the seismically active section of Irian Jaya. The border of the buffer plate with the Australian Plate is the southern boundary of Irian Jaya seismicity: the line bearing 075° between the Banda Sea Trench and the Bismarck Sea seismic zone. The buffer plate absorbs the triple collision of the Pacific, Australian, and Eurasian Plates through internal shear, buckling, overthrusting, and rotation, including non-seismic movement.

It is proposed that other anomalous aspects of New Guinea may be better understood if the collision between the Australian and Pacific Plates in the New Guinea/Solomon Islands region is basically a sinistral shear, with considerable shear without fracture in southeast Papua and the broad Bismarck Sea shear zone. The South Bismarck and Solomon Sea Subplates, act as buffers within the collision zone between the Australian and Pacific Plates, and derive their relative motions from the shear couple across this zone. The northern New Guinea and Bougainville zones, although highly seismic, are secondary to the sinistral shear zones, their roles being to make adjustment for the differences in azimuth of the shear zones and the azimuth of approach of the Australian and Pacific Plates.

9. REFERENCES

BOLT, B.A., LOMNITZ, C., & McEVILLY, T.V., 1968 - Seismological evidence on the tectonics of central and northern California and the Mendocino escarpment. Bull. seismol. Soc. Amer., 58, 1725-67.

CAREY, S.W., 1958 - The tectonic approach to continental drift. In: Continental drift - A symposium, 177-355, Geology Department, University of Tasmania.

DAVIES, G.F., & BRUNE, J.N., 1971 - Regional and global fault slip rates from seismicity. Nature Physical Sciences, 229, 101-7.

DAVIES, H.L., & SMITH, I.E., 1971 - Geology of eastern Papua. Bull. Geol. Soc. Amer. 82, 3299-312.

DENHAM, D., 1969 - Distribution of earthquakes in the New Guinea-Solomon Islands region. J. geophys. Res., 74, 4290-9.

DEWEY, J.F., & BIRD, J.M., 1970 - Mountain belts and the new global tectonics. J. geophys. Res., 75, 2625-47.

EVERINGHAM, I.B., (1974) - Large earthquakes in the New Guinea-Solomon Islands area, 1873-1972. Tectonophysics, 23, 323-38.

GUTENBERG, B., & RICHTER, C.F., 1954 - SEISMICITY OF THE EARTH AND ASSOCIATED PHENOMENA. Princeton University Press.

JOHNSON, R.W., MACKENZIE, D.E., & SMITH, I.E., 1970 - Short papers on Quaternary volcanic areas in Papua New Guinea. Bur. Miner. Resour. Aust. Rec. 1970/72 (unpubl.).

JOHNSON, R.W., TAYLOR, G.A.M., & DAVIES, R.A., 1972 - Geology and Petrology of Quaternary volcanic islands off the north coast of New Guinea. Bur. Miner. Resour. Aust. Rec.1972/21 (unpubl.).

JOHNSON, T., & MOLNAR, P., 1972 - Focal mechanisms and plate tectonics of the southwest Pacific. J. geophys. Res., 77, 5000-32.

KARIG, D.E., 1972 - Remnant arcs. Bull. Geol. Soc. Amer., 83, 1057-68.

KRAUSE, D.C., (preprint) - Crustal plates of the Bismarck and Solomon Seas.

KROENKE, L.W., 1972 - Geology of the Ontong Java Plateau. Hawaii Institute of Geophysics Rep. 72-5.

LE PICHON, X., 1968 - Sea-floor spreading and continental drift. J. geophys. Res., 73, 3661-98.

LE PICHON, X., 1970 - Corection to paper by Xavier Le Pichon: 'Sea-floor spreading and continental drift'. J. geophys. Res., 75, 2793.

LUYENDYK, B.P., MACDONALD, K.C., & BRYAN, W.B., 1973 - Rifting history of the Woodlark Basin in the southwest Pacific. Bull. Geol. Soc. Amer., 84, 1125-34.

MARCHANT, S., 1969 - A photogeological assessment of the petroleum geology of the northern New Guinea Basin, north of the Sepik River, Territory of New Guinea. Bur. Miner. Resour. Aust. Rep. 130.

MILSOM, J.S., 1970 - Woodlark Basin, a minor centre of sea-floor spreading in Melanesia. J. geophys. Res., 75, 7335-9.

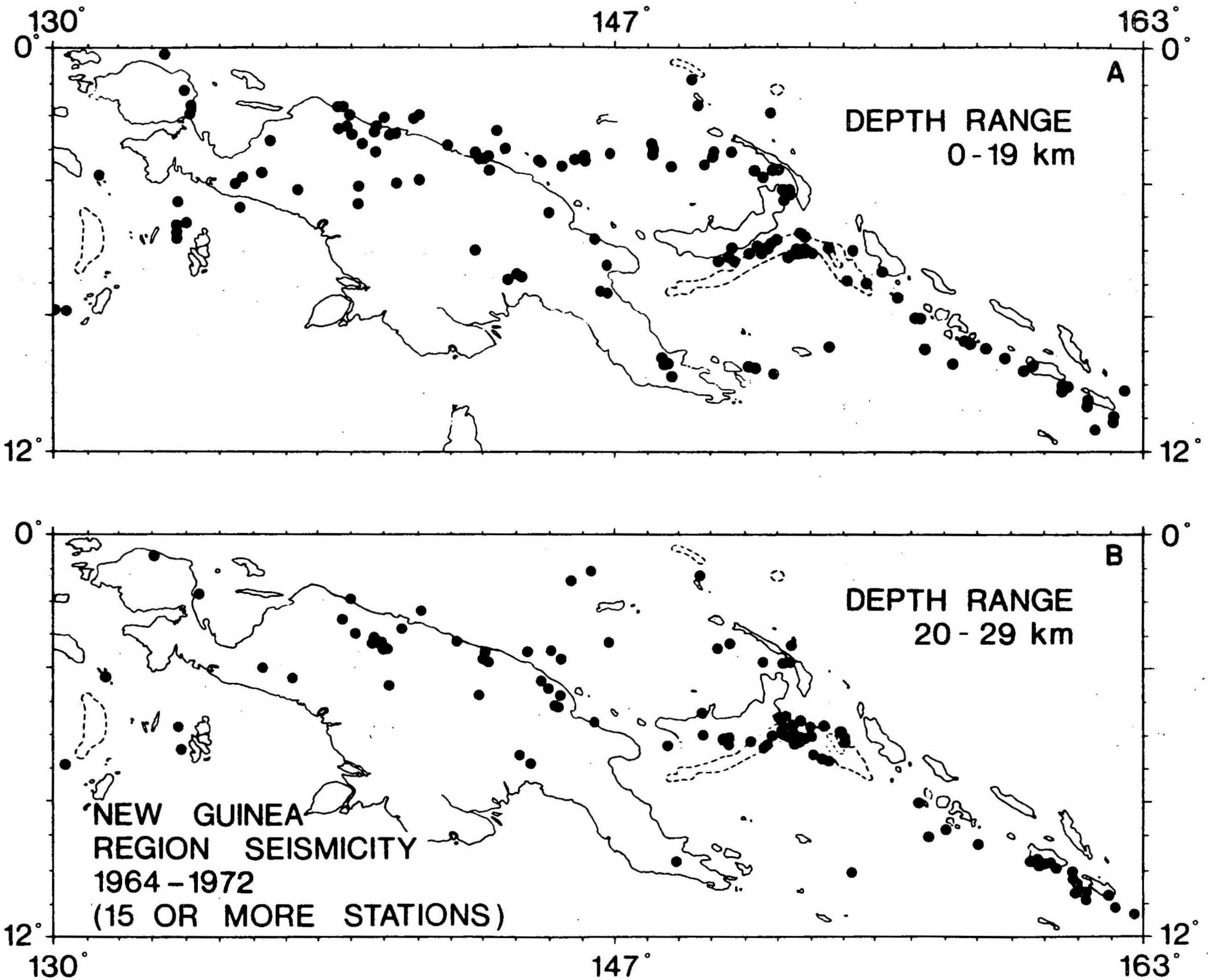
RIPPER, I.D., in press a - Earthquake focal mechanisms in the New Guinea/ Solomon Islands region 1963-1968. Bur. Miner. Resour. Aust. Rep. 178.

RIPPER, I.D., in press b - Earthquake focal mechanisms in the New Guinea/ Solomon Islands region, 1969-1971. Bur. Miner. Resour. Aust. Rep. 192.

ROMAN, C., 1973 - Buffer plates: where continents collide. New Scientist, 57, 180-181.

WICKENS, A.S., & HODGSON, J.H., 1967 - Computer re-evaluation of earthquake mechanism solutions. Publ. Dom. Obs. Ottawa 33 No. 1.

PLATE 1



NEW GUINEA
REGION SEISMICITY
1964 - 1972
(15 OR MORE STATIONS)

Record No. 1975/47

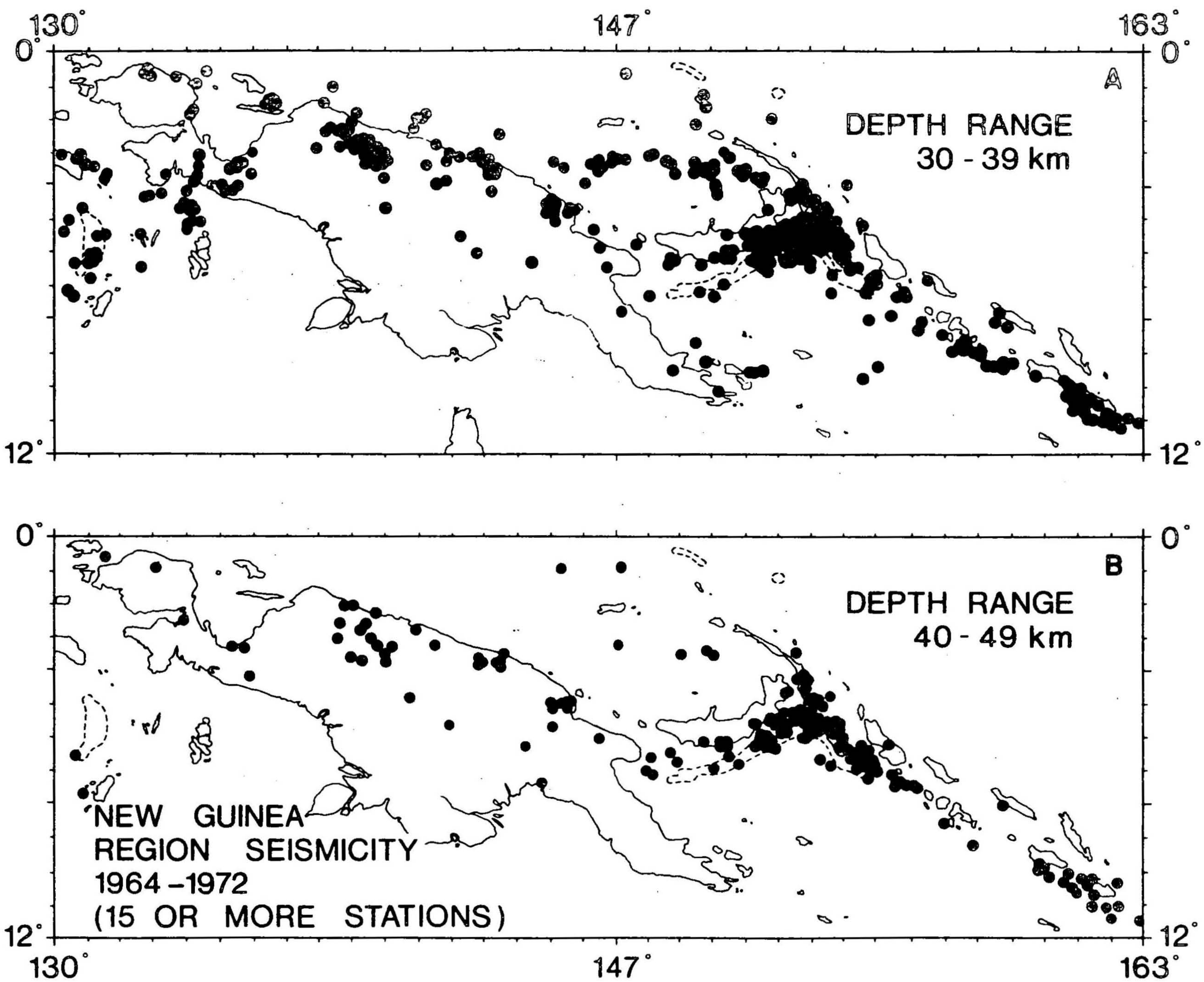
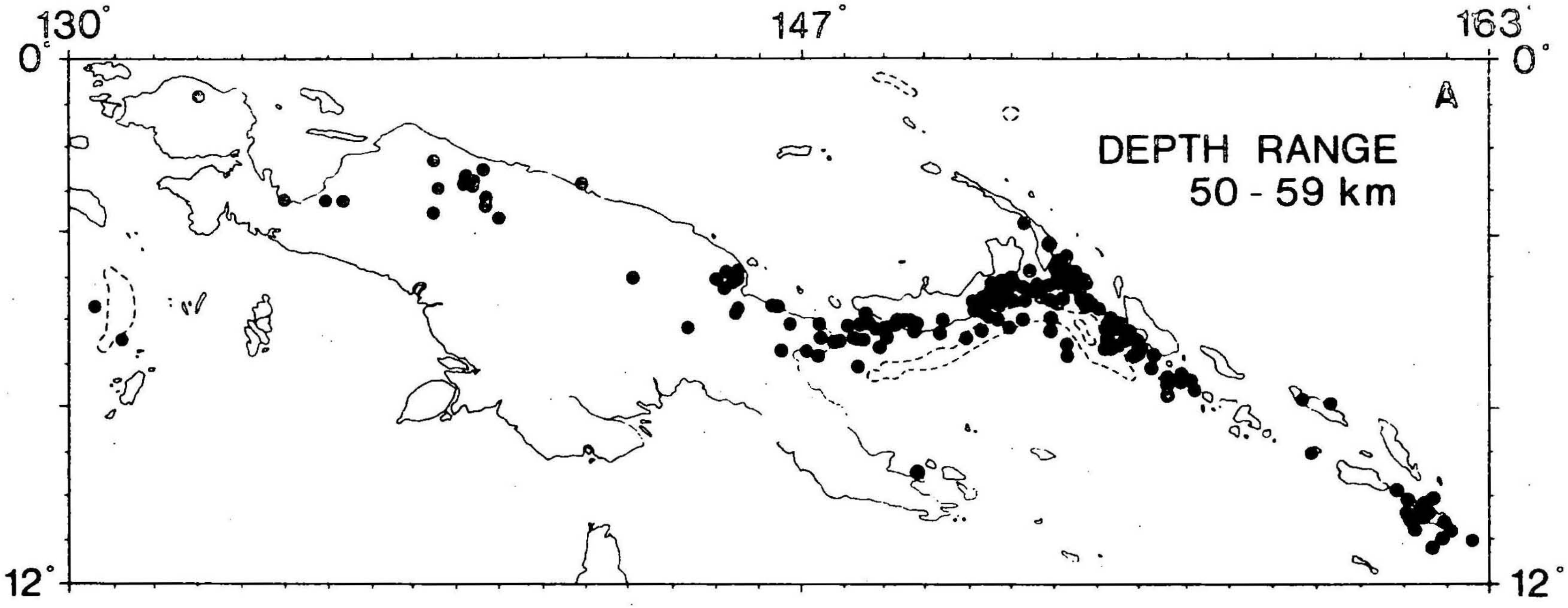


PLATE 2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147°
163°
0°
12°
A
DEPTH RANGE
50 - 59 km

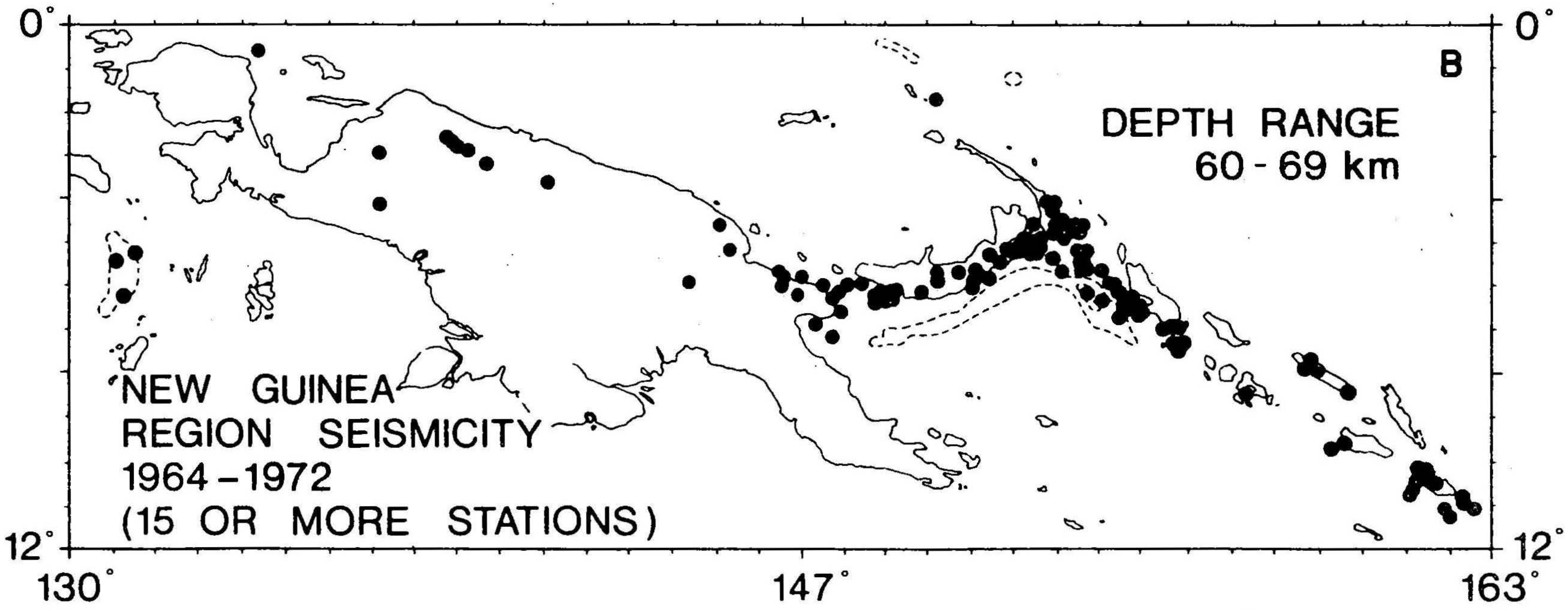

0°
12°
130°
147°
163°
B
DEPTH RANGE
60 - 69 km
NEW GUINEA
REGION SEISMICITY
1964 - 1972
(15 OR MORE STATIONS)

PLATE 3

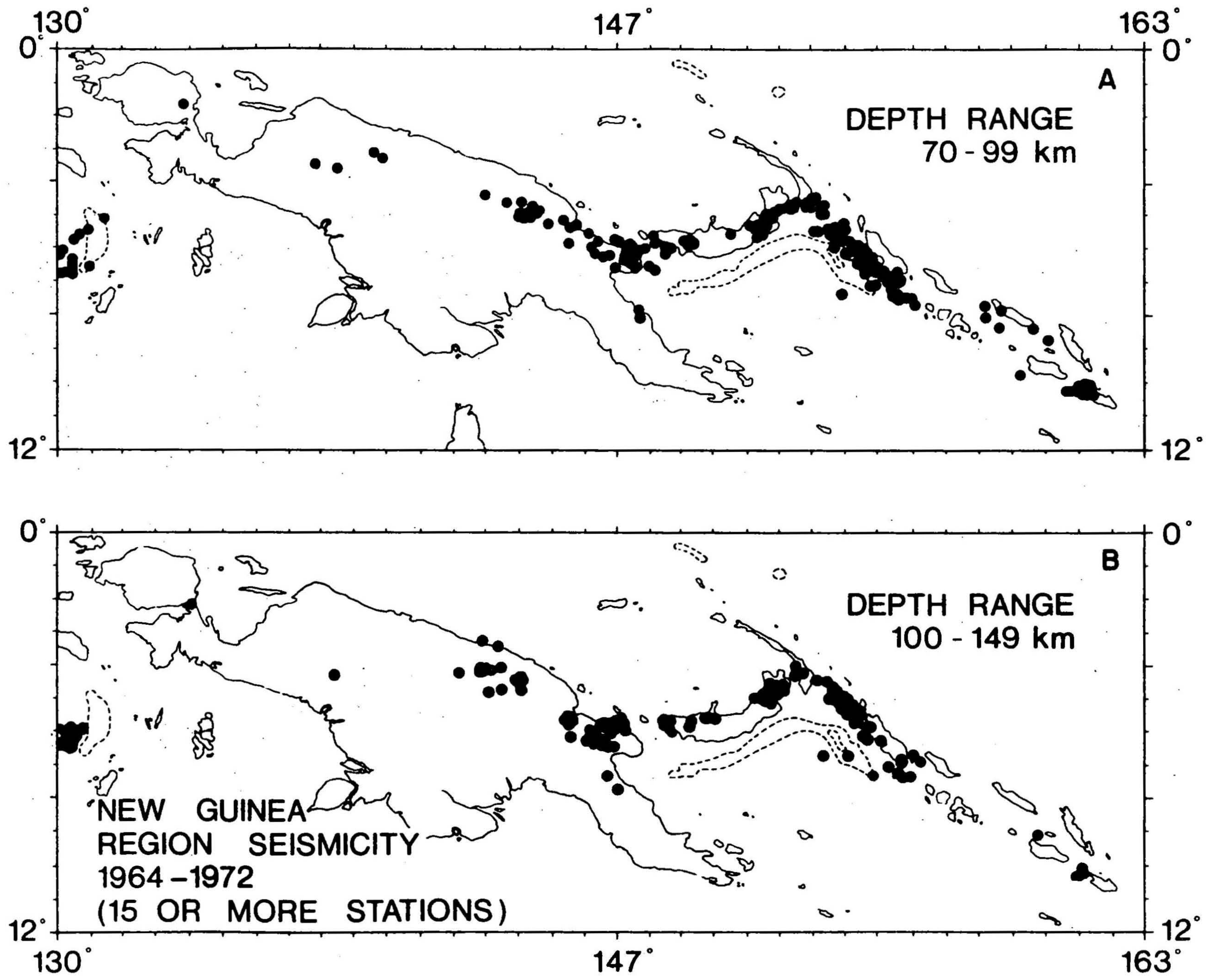

130°
147°
163°
0°
12°
A
DEPTH RANGE
70 - 99 km
B
DEPTH RANGE
100 - 149 km
NEW GUINEA
REGION SEISMICITY
1964 - 1972
(15 OR MORE STATIONS)

PLATE 4

Record No 1975/47

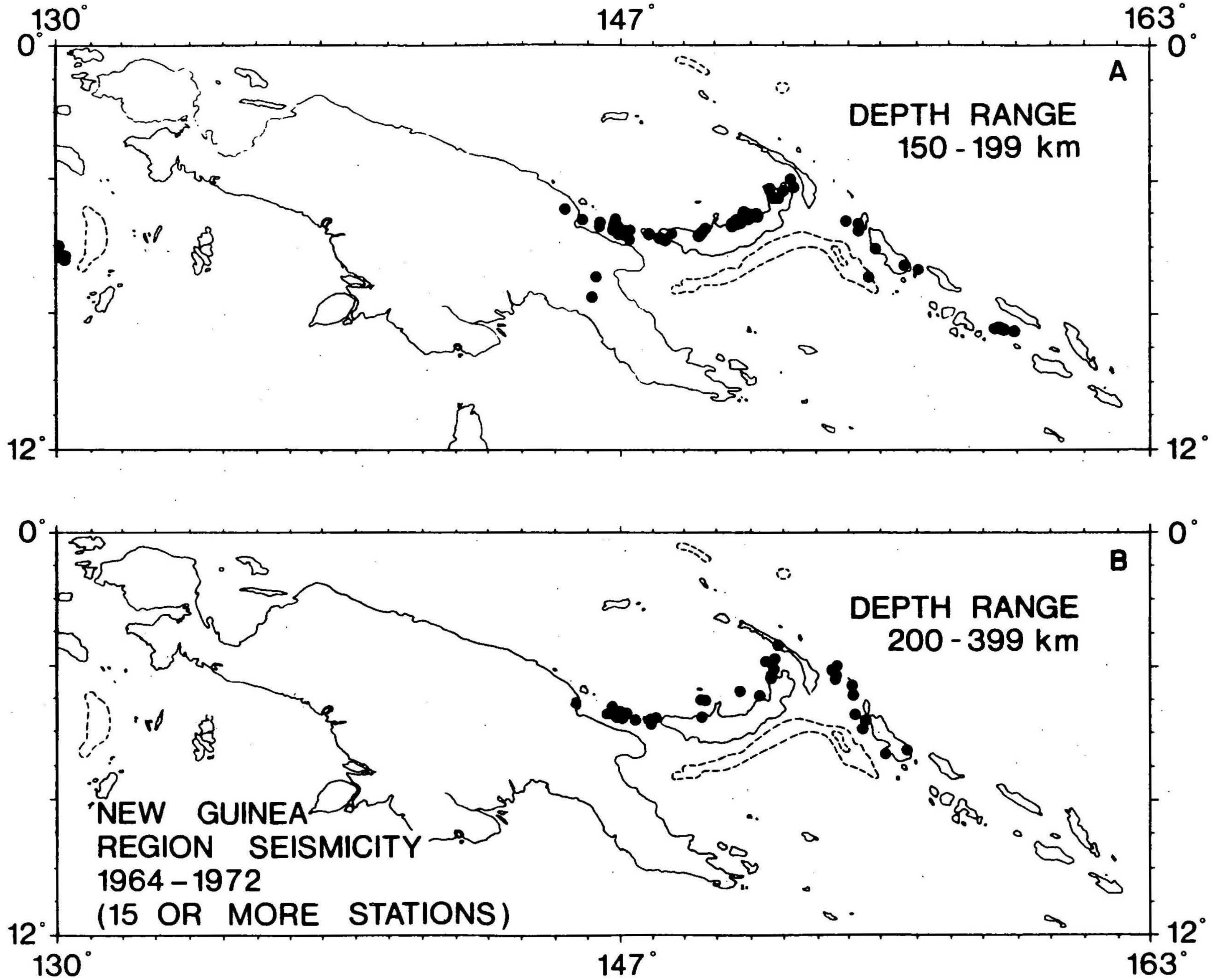
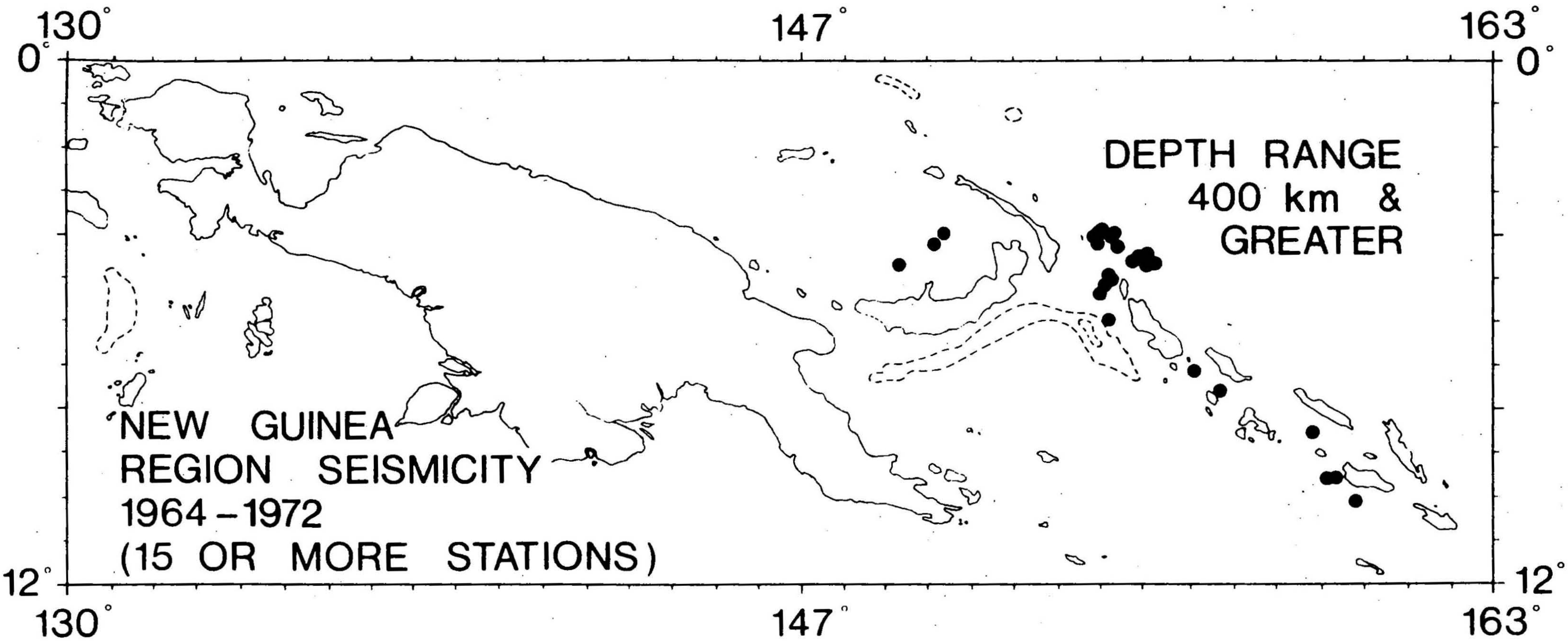


PLATE 5

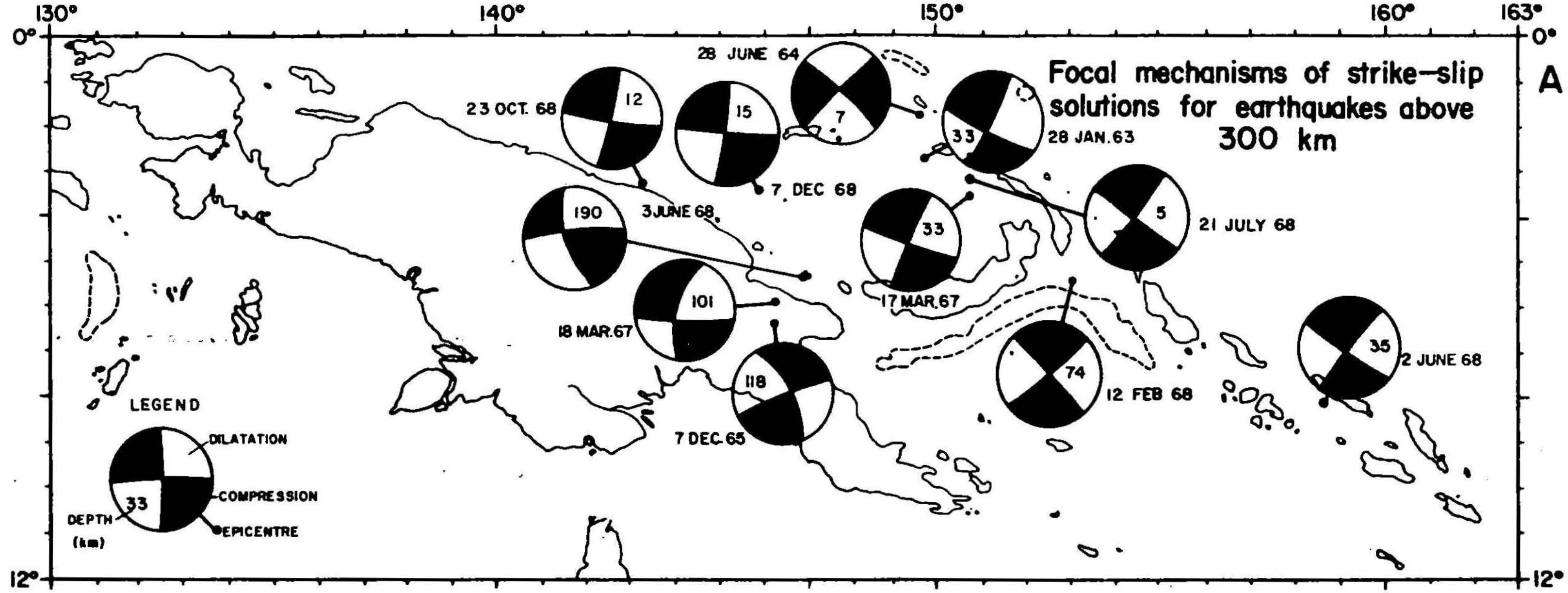
PNG/B9 – 208 – 1AR



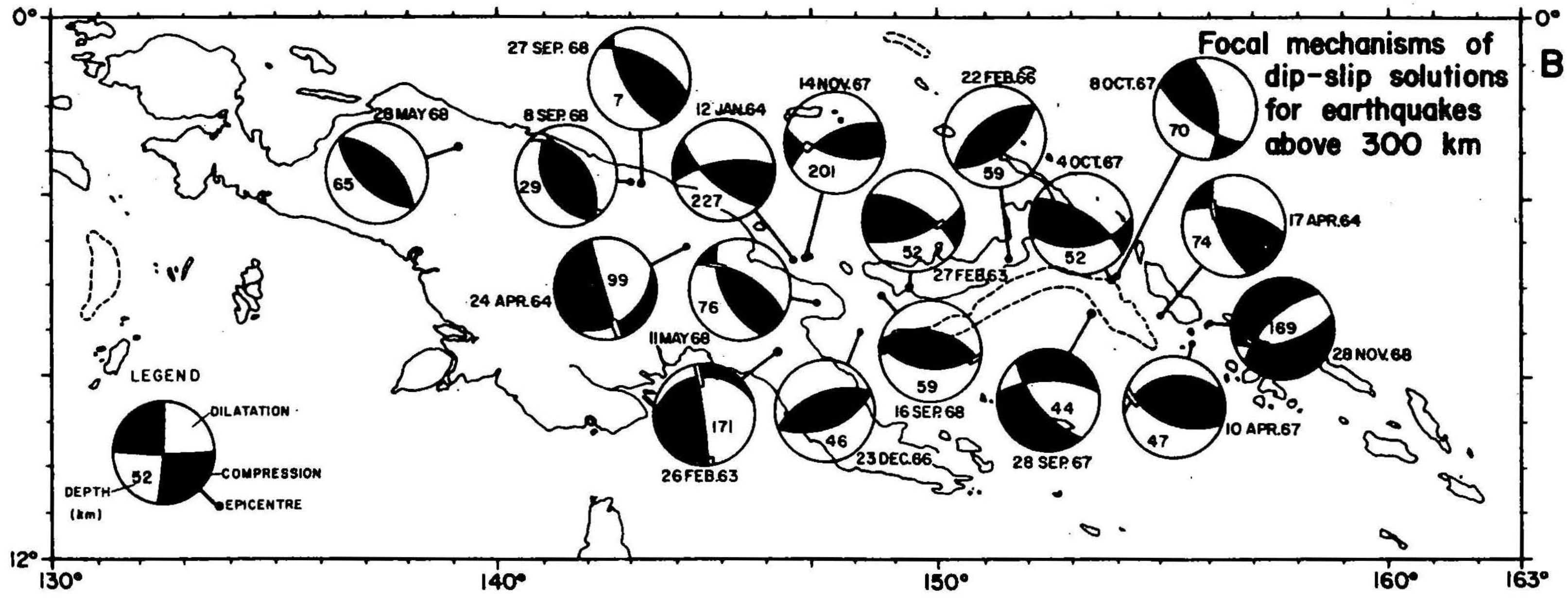
PNG/B9-209-1AR

PLATE 6


PLATE 7
VOLCANOES AND PLATES
KILOMETRES
0 50 100 150 200 250 300
200 METRE BATHYMETRIC CONTOUR
2000 METRE INTERVAL BATHYMETRIC CONTOUR
(Position of bathymetric contours approximate)
NORTH BISMARCK SUBPLATE
MANUS ISLAND
Tuluman
IRIAN JAYA SUBPLATE
Bam Island
Manam Island
(submarine)
SOUTH BISMARCK SUBPLATE
Rabaul
Kar Kar Island
Adelbert Ra
Ramu R
Long Island
Benda
Lolobau
Ulawun
Bamus
Langila
Ritter Island
Pago
Finisterre Ra
Saruwaged Ra
Cromwell Mts
Huon Peninsula
Markham R
Huon Gulf
Mt Yelia
Mt Bagana
BOUGAINVILLE
PACIFIC PLATE
SOLOMON SEA SUBPLATE
Bagga
Simbo
Savo
Mt Lamington
Mt Victory
Mt Goropu
AUSTRALIAN PLATE
(BASED ON PNG/B0-40)
Record No. 1975/47
PNG/B9-228



130°
140°
150°
160°
163°
0°
12°
Focal mechanisms of strike-slip solutions for earthquakes above 300 km
A
28 JUNE 64
23 OCT. 68
12
15
7
33
28 JAN. 63
7 DEC 68
3 JUNE 68
190
33
5
21 JULY 68
17 MAR. 67
101
18 MAR. 67
118
7 DEC. 65
74
12 FEB 68
35
2 JUNE 68
LEGEND
DILATATION
COMPRESSION
EPICENTRE
DEPTH
(km)



0°
12°
130°
140°
150°
160°
163°
Focal mechanisms of dip-slip solutions for earthquakes above 300 km
B
27 SEP. 68
7
14 NOV. 67
22 FEB. 66
8 OCT. 67
28 MAY 68
65
8 SEP. 68
29
12 JAN. 64
227
201
59
4 OCT. 67
70
52
27 FEB. 63
52
74
17 APR. 64
99
24 APR. 64
76
59
16 SEP. 68
169
28 NOV. 68
11 MAY 68
171
26 FEB. 63
46
23 DEC. 66
44
28 SEP. 67
47
10 APR. 67
LEGEND
DILATATION
COMPRESSION
EPICENTRE
DEPTH
(km)

PLATE 8

Record No. 1975/47

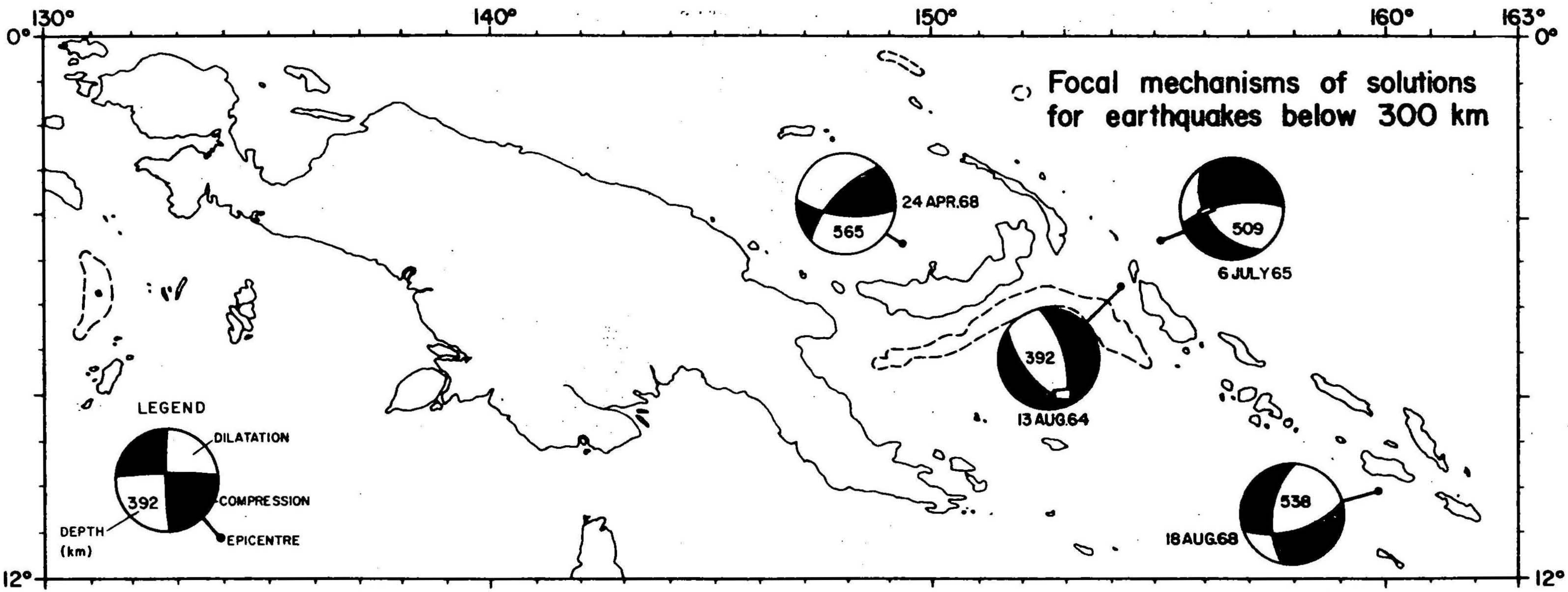


PLATE 9

PNG/B9-219-4A