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Statistical Analysis of Photogeological Linear Features Cape Preston Area,

Western Australia

by

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STATISTICAL ANALYSIS OF PHOTOGEOLOGICAL LINEAR FEATURES CAPE PRESTON AREA, WESTERN AUSTRALIA.

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Contents

SUMMARY

Bedding information and linear features were annotated on air photographs.

To analyse the azimuthal distribution of linear features, polar graphs were prepared for the whole area and, separately, for the Archaean, Proterozoic and Cainozoic outcrops and for Cape Preston itself.

In each polar graph, preferred orientations can be related either to bedding or to fracturing. The northwest direction seems to be the most exempt from linear features.

INTRODUCTION

Purpose of this study is to assist, with information from photogeological linear features, in the preliminary geological study of Cape Preston area, which is being investigated to determine its suitability as a site for a nuclear-excavated harbour.

The area is covered by Commonwealth air photography 1968.

Camera: Wild RC9, focal length 88.45 mm ($3\frac{1}{2}$").
Flight altitude: 7,600 m (25,000').
Nominal scale (at sea level): 1:86,000.
Time: 18th May, from 1115 to 1145 hours.
Forward overlap: 80%.

Every second photograph was used to obtain stereoscopic coverage with 60% forward overlap.

The photo-coverage has satisfactory resolution but the tonal contrast is poor; for this reason a number of linear features may have gone undetected but, because of the uniform effect throughout the area, the statistical distribution should not have been influenced. However, no additional information has been achieved by the use of photography at 1:41,000 nominal scale flown in 1957.

The photo-interpretation was carried out on overlays, by means of a scanning mirror-stereoscope equipped with a 3-magnifications binocular. The information was then compiled on one sheet by matching details from the various photographs, to obtain a photo-scale map; no plotting device was used, therefore the position of ground features is not planimetrically correct.

METHOD

Linear features were annotated on the air photographs and analysed according to methods described by Blanchet (1957), Lattman (1958) and Lattman - Matzke (1961).

The following types were annotated:

1 - Alignments of topographic features: abrupt changes of topographic level along a line; straight, incised valleys and stream courses; straight, slightly elevated ridges.

2 - Vegetation alignments: alignments of trees or shrubs; linear gaps in the vegetation pattern; abrupt changes of vegetation type or density along a line.

3 - Soil tone alignments: differently-toned lines in a uniform soil pattern; straight boundaries between differently-toned soils.

Lineations due to bedding are distinguished from the other linear features on the map (Fig. 1).

Care was taken to avoid misleading factors, such as shadow alignments. Some features of human origin may have been included, but they are so sparse as not to materially affect the results.

All linear features were classified into azimuth classes by means of a two-dimentional optical filter (LaserScan, trademark of Conductron Co., Michigan) designed for the velocity and frequency filtering of seismic data.

This device (Dobrin et al, 1965) uses a laser beam as light source. When the beam is passed through a transparency, a diffraction pattern is produced which, with suitable lenses, can be converted back into an image of the original transparency. By obstructing portion of the diffraction pattern with suitable filters, it is possible to remove from the reconstructed image those elements having particular orientations. The final image is then photographed.

In the present study, a photographic reduction of the total field of linear features was processed through a 350^{o} filter; by rotating the filter, 18 azimuthal classes of 010^{o} amplitude were obtained. The number of linear features in each class was then computed in terms of percentage of the total number and plotted into polar graphs against the sector bearing.

Polar graphs (Fig. 2) were prepared for the total area and, separately for the Archaean, the Proterozoic, the Cainozoic of the area, and for the Proterozoic outcrop of Cape Preston.

DISCUSSION

Archaean rocks (Fig. 1) crop out in the southeastern corner of the area; they are steeply dipping volcanic and sedimentary rocks (shale and siltstone) associated with iron ores. The local structural trend is north-northeast.

The western side of the area is occupied by Proterozoic rocks: basic and intermediate lavas, and shale and siltstone with iron ores. The structural trend is about north at Cape Preston and about north-northeast to the south, with beds steeply dipping towards west and west-northwest.

The area between Archaean and Proterozoic outcrops is a wide plain covered by recent coastal, aeolian and alluvial deposits. Archaean granitic rocks are exposed in some creek beds.

The information given above was inferred from the Dampier and Barrow Island geological map 1:250,000 (Kriewaldt, 1964).

In addition, bedding traces were mapped from the air photographs. At the Cape Preston outcrop, the strike is 350° to 355° and the dip is 20° to 30° west. To the south, the strike trends towards a north-northeasterly direction and the dips are steeper. Archaean strata show a northeasterly strike, to the north of the mapped outcrops, and rotate towards north-northeast to the south; dips are steeply northwest.

Faults were annotated where traces of vertical displacements or conspicuous linear features were seen. Their number and extent are small. Unpublished geophysical work has shown the existence of northerly and northeasterly trending faults with considerable throw within the sediments of the Carnarvon Basin and the adjoining areas.

On the areas of bedrock outcrop, two categories of linear features were mapped from the air photographs: a) lineations due to bedding and b) fracture traces; fracture traces, at this scale, may be individual joints widened by weathering, or the topographic expression of parallel joint sets. On Recent deposits, where bedding is not visible, the distinction between (a) and (b) does not exist; generally lineaments in the underlying bedrock are transmitted upwards and expressed at the surface as linear features. This process is probably facilitated by compaction of the covering sediments. Investigation into the origin and structural significance of the linear features can only be made by consideration of their azimuthal distribution and correlation with outcrop data.

Because of the limited size of the area being investigated, no attempt is made to interpret the pattern of linear features in terms of their structural meaning; this would be beyond the purpose of the study. Thus only a formal description is given, to point out the preferred local directions of rock fracturing. An exception is made for the Cainozoic polar graph, which appears to be very interesting.

A total of 831 linear features was annotated on an area of approximately 350 square kilometres (135 square miles), three quarters of which is covered by Recent deposits. When only the bedrock outcrops are considered, the total number of linear features is 518, the lineations due to bedding being 102 and the fracture traces 416.

The average abundance of fracture traces displayed by bedrock outcrops is therefore 4.6 fracture traces /Km^2 (12fr. tr./ sq.mi.). Even considering the reducing effect produced by the small scale and poor contrast of the air photographs, this value is rather small when compared with the results from similar studies on other areas.

The azimuthal distribution of linear features over the total area (Fig. 2) displays two broad groupings roughly trending north and northeast. Within these, the two dominant directions are 005° to 025° and 055° to 075°; the former is the bedding trend, the latter is the dominant trend of fracture traces. The northwest direction is almost free of linear features.

This very general picture can be better analysed by describing separately the patterns of linear features for the stratigraphic units present in the area.

The lineations due to bedding are represented in the Archaean and in the Proterozoic polar graphs by the 005° to 025° groups; and also, by minor lateral extensions of these groups, towards east (up to 045°) in the Archaean and towards west (up to 335°) in the Proterozoic.

Fig. 1 shows that very few fracture traces fall into these groups. They may be related, in part, with the north- and northeast- trending faults of the Carnarvon Basin.

If we disregard the lineations due to the bedding, the Archaean polar graph shows two dominant trends of fracture traces in the sectors 285° to 305° and 335° to 355°. In the Proterozoic polar graph, the dominant trend is spread about 070° (from 045° to 105°) and only few fracture traces are present in other directions.

The Cainozoic polar graph displays a fair symmetry about an axis trending 020°. The dominant trend, 355° - 035°, corresponds with the groups related to bedding in the Archaean and Proterozoic polar graphs, spread in both directions. A minor concentration of linear features is almost perpendicular to this trend. Two secondary trends, the 325° - 345° and the 045° - 075° intersect at angles which are bisected by the dominant trend and, consequently, by the minor concentration.

Such a configuration is very close to the idealized joint pattern which should be expected on an anticline where the maximum principal stress is horizontal and the intermediate principal stress is vertical (see, for example, Badgley, 1965, p. 100, fig.s 4-3 and 4-4). In the Cape Preston area, the maximum principal stress should be 020°, the minimum principal stress should be 110° and the intermediate principal stress should be perpendicular to them and vertical.

Vertical wrench faults, as defined by Anderson (1951, p. 2), should occur in these conditions, and form acute angles to the direction of maximum stress (Moody and Hill, 1956). Accordingly, the presence of vertical wrench faults may be expected in the 325°-345° and 045° - 075° directions.

The origin of the geometrical orientation shown by the Cainozoic pilar graph might be related to the emplacement of the Archaean granite or, perhaps, to subsequent tectoism.

To emphasize local features in the area of maximum interest, a polar graph was prepared for the Proterozoic outcrop of Cape Preston. Only 44 linear features were mapped from the air photographs in this area; to avoid excessive scattering, they were classified into 6 azimuth classes of 030° amplitude. Lineations due to bedding fall into the 345° to 015° class. Fracture traces have dominant directions from 345° to 075°. Only 4 fracture traces (9.1% of the total) are present in the 315° to 345° sector and 2 (4.5% of the total) in the 285° to 315° sector.

CONCLUSIONS

Since the average abundance of photogeological fracture traces on bedrock outcrops is 4.6 fr.tr./Km^2 (or 12 fr.tr./sq.mi.) the area should be considered as moderately fractured.

The bedding strike at Cape Preston is 350° to 355° and the dip is 20° to 30° west. The remaining outcrops show rather constant northeasterly to north-northeasterly strikes with steep dips facing northwest and west-northwest.

The fracture pattern of the whole area shows preferred trends in the northeast quadrant, whereas the northwest direction seems to be the freest from fracture traces. In particular, the azimuthal distribution at Cape Preston outcrop shows the least concentration in the 285° to 315° sector.

The hypothetical considerations suggested by the Cainozoic polar graph might be worth further investigation. In particular, the possible occurrence of recent tectonism and the supposed presence of wrench faults in the area could be of interest.

The faults revealed by geophysical surveys in the Carnarvon Basin could be an important factor, if they extend to the Cape Preston area.

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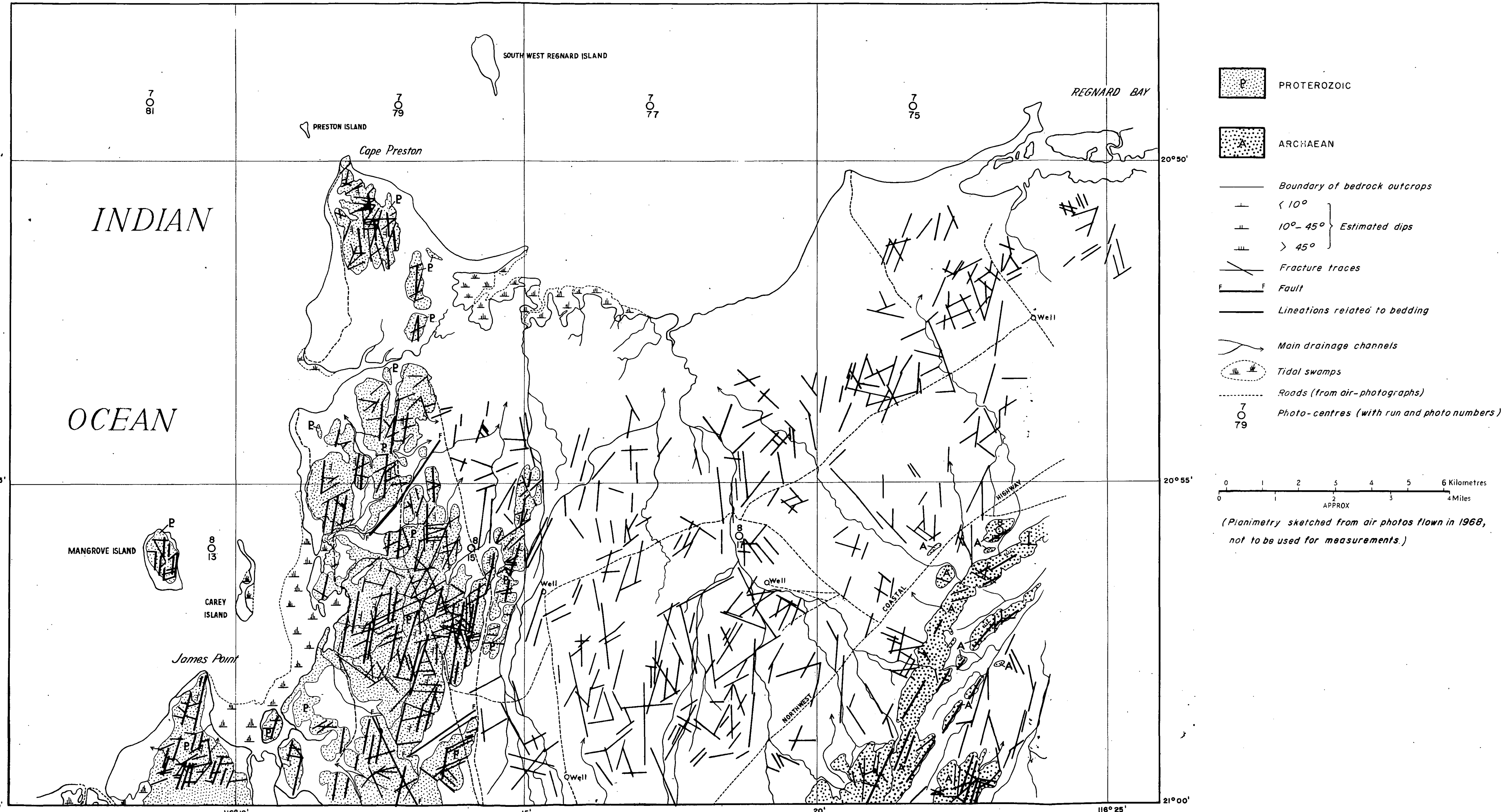
TOTAL FIELD OF LINEAR FEATURES

FIG. 1



(Planimetry sketched from air photos flown in 1968, not to be used for measurements.)

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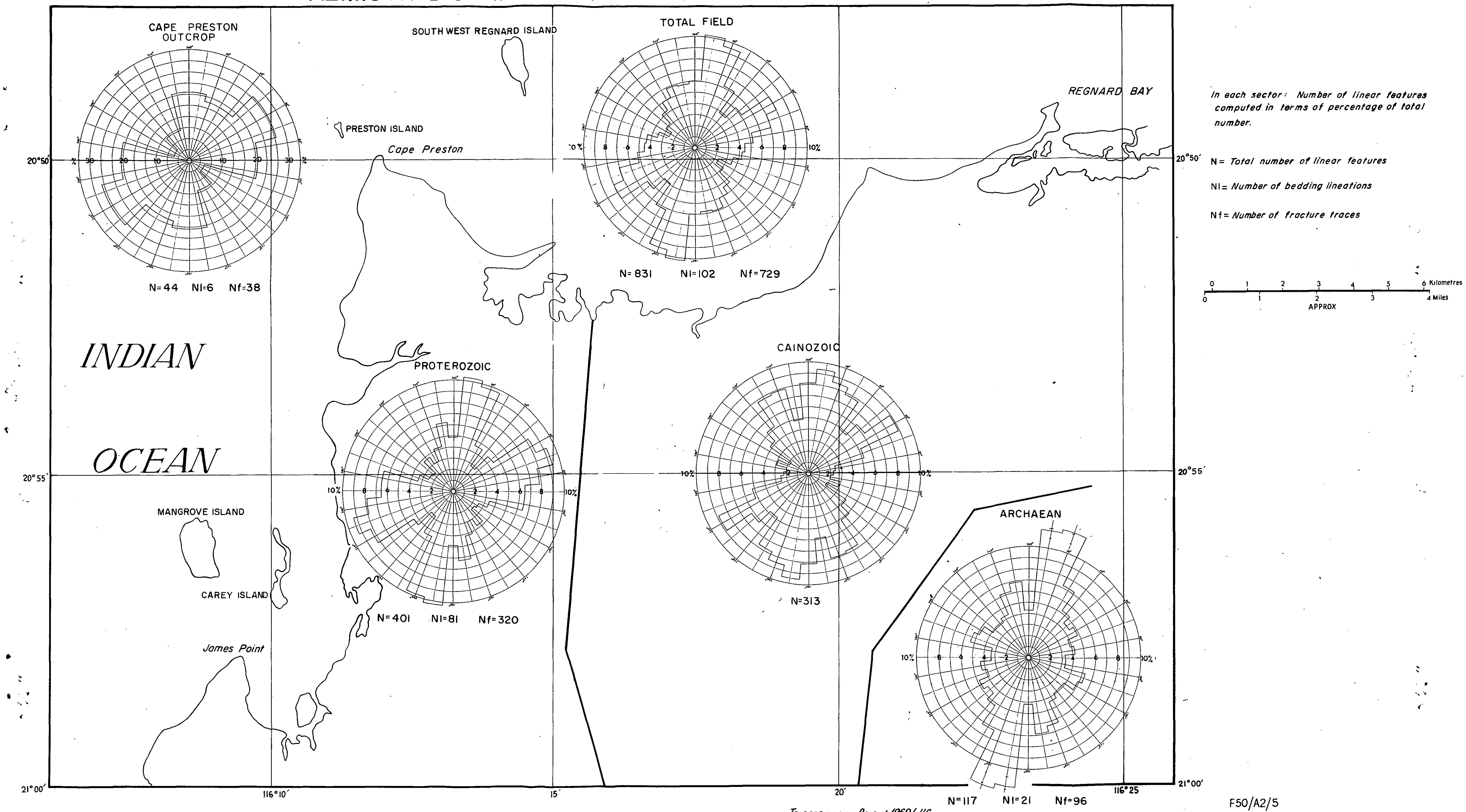
AZIMUTH DISTRIBUTION OF LINEAR FEATURES

FIG. 2



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