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REPORT No. 1947/79

PRELIMINARY REPORT ON THE APINAIPI STRUCTURE, PAPUA.

by

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I. SUMMARY

1. The aim of this examination was to map in as much detail as possible the structure of the Apinaipi Anticline, which is situated on the coast of Papua, 100 miles north-west of Port Moresby.

2. A photo-geological map of the area was prepared prior to entering the field and field information was plotted directly on the photographs covering the area.

3. The geomorphology and structure of the area are intimately connected. The anticline is in the form of an elongated dome with a steep Western limb and a gently dipping eastern limb. No structural complications were detected during the survey.

4. The sediments exposed vary in grade size from mudstones to conglomerates generally in narrow bands and outcropping only on ridges and in some creek beds. As a result it is difficult to establish a marker horizon, although an attempt has been made to plot the approximate position of one of the coarser bands in the section.

5. The available information indicates that the structure is worthy of further development and finally it is critically compared with other structures in the area.

II. INTRODUCTION.

A. Situation.

The Apinaipi Anticline is one of the four well defined structures in the area held under permit by Papuan Apinaipi Petroleum Co. Ltd.

The permit area is situated in the coastal area of Papua, 100 miles north-west of Port Moresby and is traversed by the Biaru River as illustrated in the locality map (PAP-1-1).

The Apinaipi structure is situated in the north-east corner of the permit area, immediately north of the village of Apinaipi on the Biaru River.

The permit boundary crosses the structure approximately 5,700 feet north of Haynes Hill. That part of the structure north of this line, approximately ¼ of the outcrop area, lies outside the permit area.

The other structures in the permit area have been named the Oiapu, the Iokea-Apinaipi and the Lesi structures. To avoid confusion Iokea-Apinaipi structure will be referred to in this report as the "Iokea structure".

B. Access.

The natural base for any operations on the Apinaipi structure is Apinaipi Village, situated on the north side of the Biaru River at the junction of the Inawafunga and Akaifu Rivers. Navigation of the Biaru River (except during heavy flood) presents no difficulties as the average flow is about 4 knots with a depth of water suitable for a vessel of approximately 6 feet draft. Limitations on the vessels used to navigate the river are controlled by the bars at the mouths of the River.

During September 1937, 2 fathoms of water were reported over the Biaru Bar at flood tide and not less than 1 fathom at low tide, and similar conditions existed at the Lesi Bar.

It seems probable that the entrances to the river are scoured during the wet season (November-March) and tend to silt-up during the dry season. However, under average weather conditions it seems likely that the bars would be navigable by a vessel of approximately 7 feet draft, throughout the year and beacons could be placed and checked at intervals to delineate the deeper channels.

Access to the Apinaipi structure from the village is without difficulties, except when the river is in flood, during the N.W. Monsoon, when the swampy areas flanking the river are impassible. During the remainder of the year the several tracks available are readily negotiable.

Tracks follow all the ridge-tops, and all parts of the outcrop area can be reached from these fairly readily.

C. Climate and Vegetation.

The Apinaipi area lies within the Papuan dry belt and although the annual rainfall is low it has a well defined wet season. No annual rainfall figures are available for the area, but from information available the seasons appear to be similar to Kairuku (Yule Island, 35 miles south-south-east of Apinaipi) with a wet season during the N.W. Monsoon, and in strong contrast to Kerema (50 miles north-west of Apinaipi) which has a steady rainfall throughout the year, reaching a peak during the S.E. Monsoon.

The monthly rainfalls in inches for Kerema and Kairuku are set out in the following table for comparison. The figures for Kerema are an average over a period of 25 years up to 1939, and those for Kairuku an average for 20 years up to 1939. Rainfall at Apinaipi would probably closely approximate that at Kairuku.

Month	Kerema	Kairuku
January	9.44	9.99
February	8.09	10.28
March	10.68	8.56
April	11.26	5.22
May	16.92	1.53
June	16.33	2.11
July	13.12	1.03
August	13.93	0.65
September	12.47	1.62
October	12.32	1.54
November	9.27	2.92
December	7.35	5.59
Annual Average	141.18	51.04

The area may be described as a dissected elongated dome sparsely timbered and flanked by impenetrable swamp to the north, east and west.

Thick scrub (Photo No. 1) usually difficult to traverse

until a track has been cut, is confined to the fringe of the Biaru River, the small streams draining the Apinaipi Hills and clumps along the swamp boundary. The higher ground is covered with a thick growth of coarse grass (largely Kunai or blade grass) and scattered eucalyptus (Photo 2).

Kapok trees are conspicuous in the scrub areas; coconut and betel nut palms grown in small clumps around the swamp margin, and sago in the swamps.

D. Previous Work.

Geologists of the Anglo-Persian Oil Co., (Mayo and de Verteuil, 1921) examined the Apinaipi Area for the Commonwealth Government in 1921. The present writer agrees with Mayo and de Verteuil that it is difficult to map the beds, due not so much to "scantiness of exposures and indecisive nature of strike ridges" as to the limited range, continual repetition, and possible lensing of the sedimentary types exposed. Contrary to the findings of the Anglo-Persian Report, it is considered that sufficient evidence is available for the determination of the main structural feature of the anticline.

Further reference to this particular area is confined to the unpublished report by Millward (Millward, 1941) of the Australasian Petroleum Co. Pty. Ltd., his information is derived from the work of Mayo and de Verteuil, with a few small additions.

E. Programme.

Camp was established near Apinaipi Village on September 13th, 1947, and an advance reconnaissance of the Apinaipi structure was made in company with Dr. N.H. Fisher, (Chief Geologist, Bureau of Mineral Resources, Geology and Geophysics), Dr. Mason Hill and Mr. Paul Dudley of Richfield Oil Corporation, U.S.A., From September 19th to October 4th, the writer was assisted by Mr. Lionel Haynes representing Papuan Apinaipi Petroleum Co. Ltd.

To facilitate the progress of the work, the camp was moved to a site near Haynes Hill on September 23rd, and the central and northern parts of the structure were covered from this camp site. It should be noted in passing that the main problem in establishing a camp some distance from the river in this area is lack of water, a position which is aggravated by the low rainfall. Water had to be carried a distance of 3½ miles from the village.

F. Survey Procedure.

The main task was the examination, in as much detail as possible in the time available, of the Apinaipi anticline north of the river, concentrating particularly on the delineation of the structure.

Prior to entering the field, strip-tracings of photographs on a scale of 1/20000 and a photo-geological map scale 1/40000, of the whole permit area were prepared, but owing to the relatively poor expression in the outcrops of the geology of the Apinaipi area only a very general idea of the structure was obtainable and nothing decisive in regard to closure at either end of the structure.

During the field work photographs (scale 1/10000) were used and all dip and strike information was plotted direct on the photographs. Each outcrop examined and given a key number (PAP-1-2).

As the field work advanced it was found that progress was greatly expedited by tracing on the photographs, with the aid of a stereoscope, the main ridges and secondary ridges and spurs. This procedure made the identification of a position a simple matter, and saved much time and indecision.

The data for section a-b, c-d was obtained in the field from dip and strike readings and aneroid barometer.

Sections e-f, g-h and i-j were prepared in Canberra from field data and using the stereocomparagraph to prepare the profile sections.

Excessive tilt on the available photographs introduced difficulties in the preparation of these latter sections, but their final accuracy is considered to be comparable with that of Section a-b.

III GEOMORPHOLOGY

The geomorphology of the Apinaipi structure, in common with other structures in the area, is controlled by the structural characteristics of the anticline. This is readily apparent from map PAP-1-3, which shows drainage and structure.

The drainage pattern is simple. In the central part of the structure the creeks drain east and west from the central ridge into the surrounding swamp. As the pitching ends of the structure are approached, the direction of drainage gradually swings around to the north-south direction - again draining into the swamp, which in turn is drained by the Biaru River to the south and the Kapuri River and other smaller streams to the north.

The creeks draining the Apinaipi structure in general have a medium gradient and steep sides, particularly in the central part of the structure, where the creeks lie parallel to one another, separated by well defined ridges falling gradually from the central ridge to the swamp.

As a result of this structural control i.e. the steeply dipping beds on the western limb, the gently dipping beds on the eastern flank and the pitch of the structure to the north and south, the west limb is comparatively rugged in the central portion of the structure with occasional steep dip slopes and falling rapidly to the swamp from the most westerly spurs (Photo No. 3). On the other hand, the eastern limb falls gradually to the swamp, broken by occasional humps of more resistant rock (Photo No. 5). The surface slope is controlled for the most part by the dip of the underlying beds and dip slopes are better defined than on the western limb.

The hills die away to the north and south comensurate with the pitch of the structure in these directions (Photo No. 4) disappearing beneath the swamp to the north, and giving way through a zone of irregular dips, to the northern pitching end of the Iokea structure to the south in the vicinity of the Biaru River.

The stream courses, dry during the S.E. Monsoon, are entirely consequent and well defined.

As can be seen from map PAP-1-3, the streams closely follow the structure and almost without exception the primary stream courses are at right-angles to the strike and the down-stream direction is down dip.

The axial region between location 116 (locations are plotted on key map PAP-1-2) and Apinaipi Hill is reasonably flat (Photo No. 2) with high points at Haynes Hill and Apinaipi Hill (up to this date no points on the structure have been distinguished and these relatively conspicuous hill-tops have been named to provide permanent fixed reference points). North of Haynes Hill and south of Apinaipi Hill the central ridge gradually falls away at a slope closely approaching the angle of pitch.

IV STRUCTURE.

The Iokea and Apinaipi structure are closely related and have been formed along the same line of folding and, disregarding the possibility of dislocation in the vicinity of the Biaru River, are joined by a saddle in the area immediately north of the River.

Outcrops are common in the area, except low on the limbs. However, only a fraction of the outcrops give reliable structural information. During the progress of the work sufficient reasonably good readings were obtained in the critical areas to confirm the structure suggested by the topography.

The structural picture is set out on pPlans PAP-1-3 and PAP-1-4 and sections a-b, c-d, e-f, g-h, and i-j, which show clearly

that the structure is closed at the northern end and commences (near Haynes Hill) pitching to the north at an angle of between 15 and 20 degrees, becoming gentler towards the edge of the map where it is 10 to 15 degrees.

To the south the closure is less obvious, but the readings obtained and the geomorphology, leave no doubt that closure exists, but owing to the flatter angle of pitch between 5 and 10 degrees, it is less apparent than at the north end.

Irregular dips and strikes are found in the saddle area, between the Iokea and Apinaipi structures near the Biaru River.

The crestal area is broad and flat particularly on the gently dipping east limb of the structure. The dips on this limb increase gradually to 20 degrees, midway between the crest and the swamp, and then gradually diminish to approximately 5 degrees, far out on the limb in the vicinity of locations 89 and 90, the farthest easterly dip readings. This flattening indicates the proximity of a synclinal area some distance out in the swamp, and passing north through the low area between the Apinaipi and Akina groups of hills.

To the west of the crest of the anticline the dip of the strata is at first gentle gradually increasing from 5 to 10 degrees. About half-way down the limb, there is a rapid increase in dip from 10 to as much as 80 degrees at localities 64 and 65. Readings west of these points are not available and it is possible that the beds may dip even more steeply before they flatten to form the synclinal area between the Apinaipi and Lesi hills.

Southward of location 64, the beds are flatter, where they come under the influence of the south-pitching end of the structure, The steepest dip recorded is 35 degrees at location 36.

Northwards where the farthest west outcrops are at a somewhat lower horizon, the steepest recorded dip is 60 degrees at location 106.

It is evident from the sections, particularly a-b, c-d, and e-f, that the anticline is highly asymmetrical, and in fact, may be slightly over-turned. Insufficient data are available on the western limb to project the structure to any depth.

The crestal line is close to vertical, whereas the axis line is at a considerable angle with the vertical, and from the construction employed in the sections a-b, c-d, (Busk - 1929) it appears warped, gradually approaching the vertical with depth.

As mentioned before, the lack of a continuous well-defined marker horizon, renders geological mapping in the area difficult and tedious. However, subsequent to the field work, an attempt has been made, using photographs and field data, to indicate the approximate position of the outcrop of a coarse band (conglomerate and coarse grit) which was observed at locations 64 and 65. This bed may be followed between these locations, but apart from this the trace as plotted on the map (PAP-1-4) has been interpolated from available information and should be considered as approximate only. As a result, an estimation of the surface area over which the structure is closed may be made, and is of the order of 6 square miles.

V LITHOLOGY.

The sediments outcropping on the Apinaipi structure may be divided into four lithological groups. These groups are conglomerate, medium to fine-grained, grits of variable grain sizes, sandstones with variable grain sizes and lime content and mudstones and clays. Of these, conglomerates are comparatively rare, and the remainder, particularly the sandstones and mudstones, are found throughout the section.

The above terms are defined in accordance with the limiting dimensions given by Twenhofel (1932) as follows:-

Conglomerate	-	Limiting dimension	64 mm. (Includes Twenhofels cobble and boulder conglomerate).
Grit	-	" "	- 2 - 64mm. (Includes Twenhofels granule and pebble conglomerate).
Sandstone	-	" "	2mm. (Includes Twenhofels. Very coarse, coarse, medium and fine sandstones).

The conglomerates, grits and sandstones contain numerous volcanic pebbles and in places the conglomerates are comparatively rich in quartz fragments. Of particular interest, are the small depressed areas which are found along the crest zone viz. at locations 114, 53, and 70. At these points, the sediments consist of interbedded brown-stained and grey sandstone and grey mudstone. The depression usually supports a characteristic type of swamp grass. For some reason (as yet undetermined) the wallabies have a particular liking for the grey mudstone and at locations 53 and 70, they are continually excavating the material. These particular mudstones are available elsewhere, but are not touched, which suggest that the grey mudstones in these localities have some particular characteristic (possibly higher salinity) associated with the crest of the structure.

Many of the mudstones are light in colour, and where exposed readily exfoliate, possibly due to the presence of bentonitic material.

Small scale structures are common (Photo Nos. 8 and 9) and where rock faces are exposed reveal cross-bedding, lensing, penecontemporaneous folding or slumping and small scale structures, in which fissures in one material have been filled by another material, e.g. fissures in sandstone filled with mudstone.

Floaters, or surface indications of the underlying sediments consist of fragments of all sizes in a number of localities. At first, they suggest conglomerate or coarse grit, but on further examination it was decided generally, that they represented the larger residual fragments from grits and occasionally sandstones, as both sediments may contain a variety of fragments of variable grain-size in a grit or sandstone base.

A table of sedimentary types and the locations at which they were examined follows:-

Mudstones and clays	Sandstones		Calcareous Sandstones		Grit		Conglomerates.
7	1	75	139	13	151	3	125	6
11	2	76	141	16	155	4	126	8
12	3	77	143	18	157	5	129	17
27	4	80	147	20	160	14	130	18
28	7	82	148	31	161	15	131	19
30	9	83	149	45	162	17	134	22
33	10	84	151	47	163	21	147	23
51	12	85	152	48	165	22	148	27
53	14	86	153	50	167	23	153	28
56	15	87	154	64	168	27	155	29
58	17	91	170	65	170	28	156	37
70	22	92	175	66	171	34	157	38
72	23	94	176	72	172	40	158	41
76	27	95	177	73	174	42	159	42
85	28	96	181	78	176	43	163	43
94	30	99	182	79	180	44	164	44
95	32	100	184	84		46	166	46

Mudstones and clays	Sandstones			Calcareous Sandstones	Grits		Conglomerates
101	33	101	185	90	49	169	64
104	35	103	186	93	50	173	65
112	36	104	187	94	52	179	88
114	39	106	192	96	59	181	89
115	43	107	193	98	60	183	90
116	46	111	194	102	61	184	91
121	47	113	195	105	62	186	109
129	48	114		108	63		110
178	51	117		122	78		129
188	52	118		124	80		137
193	53	119		127	83		154
194	54	120		132	91		157
	55	121		133	92		173
	56	124		136	96		
	57	125		137	97		
	58	126		138	103		
	60	128		141	105		
	61	129		145	107		
	62	134		146	109		
	63	135		147	110		
	70			148	113		
	71			150	117		
	74				119		
					123		
					124		

The table shows very clearly that the bulk of the outcrops examined are sandstones, varying from almost lime-free to lime-rich. This, however, does not necessarily mean that the sequence is composed mainly of sandstones, as the mudstones and allied types naturally do not outcrop, and are found only in washouts in creeks, and valley sides. They probably constitute a larger proportion of the sediments deposited in the area than indicated by the table.

VI COMPARISON WITH OTHER STRUCTURES IN THE PERMIT AREA.

At this date only one area in the Papuan Apinaipi Petroleum Co. Ltd., permit area has not yet been examined in detail. This is the Lesi structure situated north of the Biaru River and immediately west of the Apinaipi structure.

Information available from previous field work (Mayo and de Verteuil - 1921) and photo-geological evidence suggests that the Lesi Anticline may be the most promising structure in the area, but confirmation of this awaits further detailed field work.

Apart from the Lesi Anticline, the more promising of the structures is the Iokea Anticline for the following reasons:-

(a) Its asymmetrical characteristics are moderate;

(b) The spudding-in horizon is the lowest, with the exception of the Oiapu structure, which, however, is complicated by the presence of volcanics.

(c) Access to the area presents no serious difficulties. As mentioned before, the Apinaipi and Iokea structures are closely related, but differ in the following respects:-

(i) The Apinaipi structure is highly asymmetrical, a condition which may give some initial difficulties in the drilling location and

(ii) The spudding-in horizon is higher e.g. the approximate depth to the top of the Lower Argillaceous Group (Series A) is about 1,400 ft. at point c on Section c-d, whereas, as much as 400 ft. of Series A is exposed on the Iokea Anticline.

However, if the Iokea structure should prove to be productive, there is every reason that the Apinaipi structure should prove likewise.

Drilling in this area at Popo (1922-1929), (Wyllie, 1930), met many difficulties owing to various factors, but with modern rotary drilling technique and equipment, no unsurmountable difficulties should be encountered, and as is the case in all new areas, only the drill (possibly assisted by geophysical traverses) can give the information required of the subsurface structure and lithology.

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Millward : Geology of the Popo-Maiva Area Permit 5, Papua 1941. Unpublished report of Australasian Petroleum Company Pty. Ltd.

Twenhofel : Treatise on Sedimentation, Baltimore, 1926.

Wyllie : The Oil Exploration Work in Papua and New Guinea conducted by the Anglo-Persian Oil Company, on behalf of the Government of the Commonwealth of Australia. Parts V and VI - 1921. Drilling operations at Popo, 1922 - 1929.

PHOTOGRAPHS.

No 1.

No. 2.

No. 3.

No 4.

No 5.

No 6.

No. 7.

No 8.

No 9.

Kapuri R.

Popo

Lési

Akina

Biaru

R.

Apinapi

Iokea

Akaifu

R.

MT YULE

8°30'

Angabunga R.

Kubuna R.

Dilava R.

Yule Island

KAIRUKU

DELENA

R.

Aroa

9°00'

Vanapa R.

R.

Brown R.

Laloki R.

PORT MORESBY

MAP No. PAP-1-1

SCALE

MILES 0 10 20 MILES

Anticlines

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146° 30'

PNG I G-4

147° 00'

TRUE NORTH Var° 5½° E

Approximate Permit Boundary

HAYNES HILL

APINAIPI HILL

APINAIPI VILLAGE

RIVER

RIVER

RIVER

KEY MAP

N° PAP-I-2

SCALE

Yds. 0 500 1000 Yds

LEGEND

- Numbered Outcrops
- Outcrop Boundary
- Vegetation Boundary
- Dense Trees
- a" Scattered Trees & Grass
- Swamp
- Coconut
- Sago

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PNG I G-5

1/20,000

TRUE NORTH Var^n 5½° E

MAP Nº PAP-1-3

SCALE

Yds 0 Yds

LEGEND

- Strike & Dip
- Geological Boundary
- Horizontal Strata
- Section Lines
- Crest of Structure, and Pitch

Approximate Permit Boundary

a b c d e f g h i j

ARAFO R.

BIAPU R.

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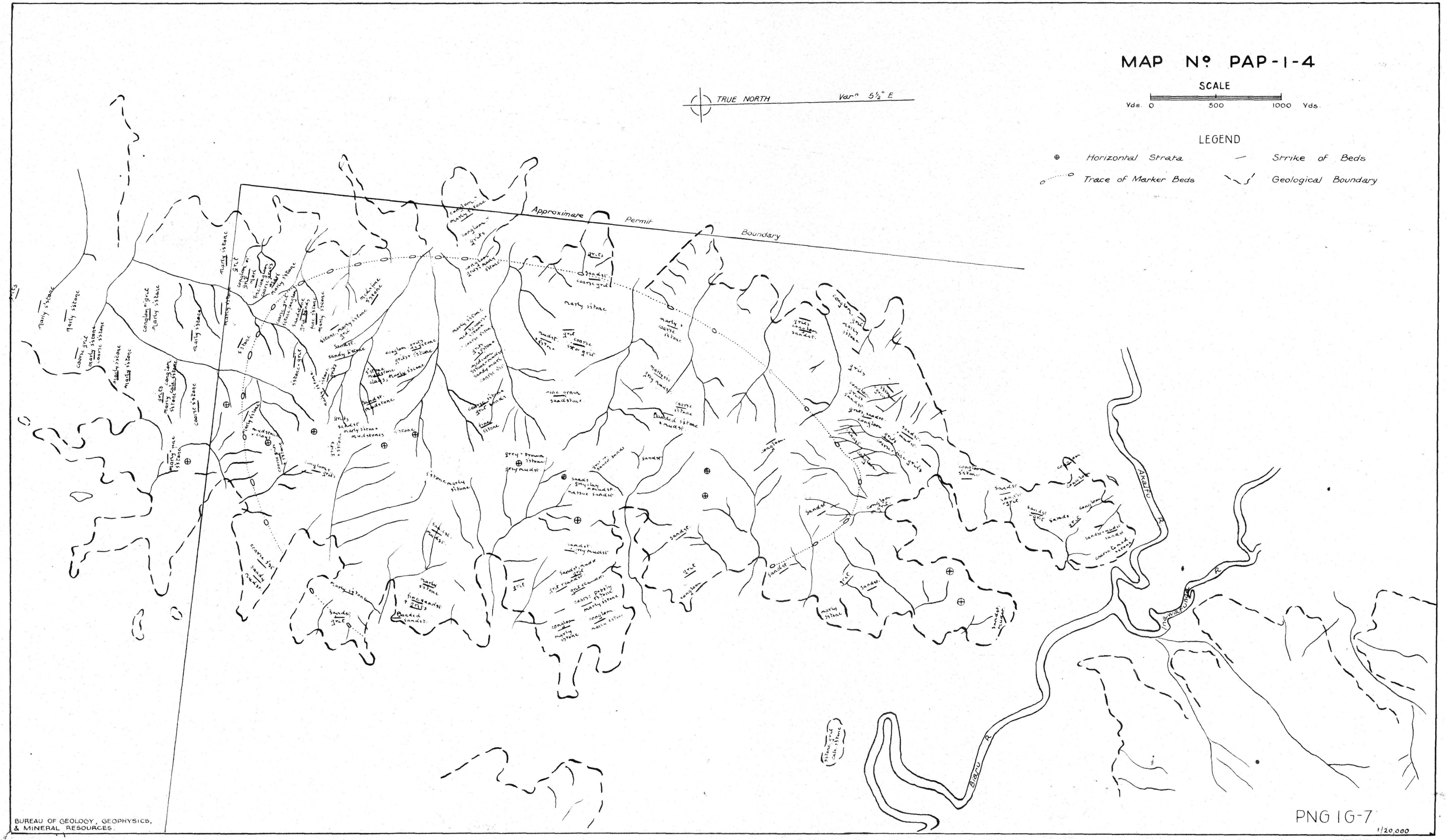
PNG 16-6

1/20,000


MAP Nº PAP-1-4
SCALE
Yds. 0 500 1000 Yds.
TRUE NORTH Varⁿ 5½° E
LEGEND
Horizontal Strata
Strike of Beds
Trace of Marker Beds
Geological Boundary
Approximate Permit Boundary
Akafu R.
Biaru R.
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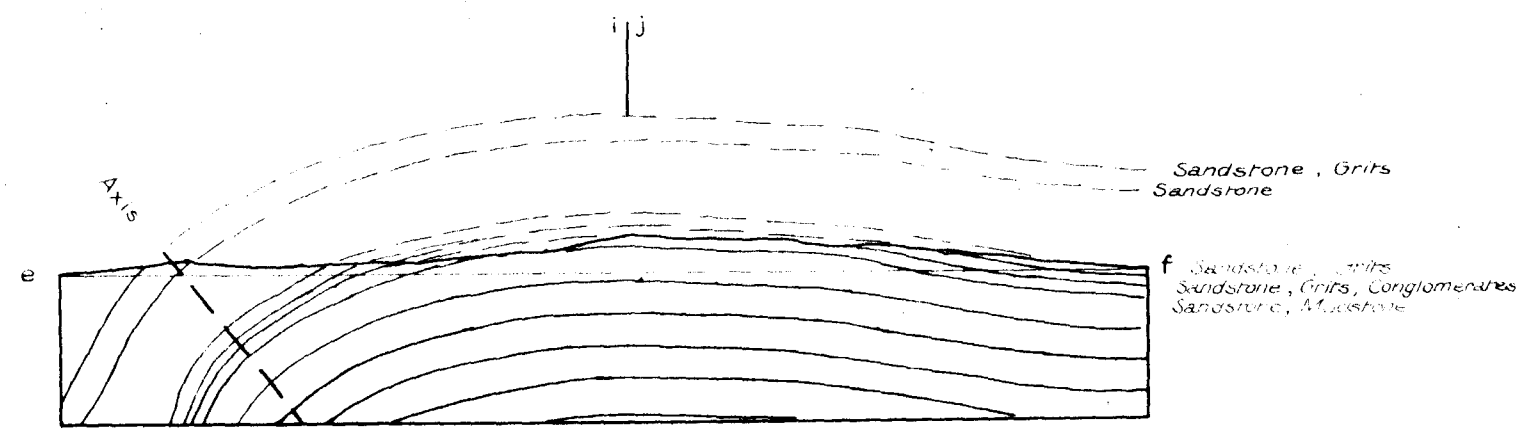
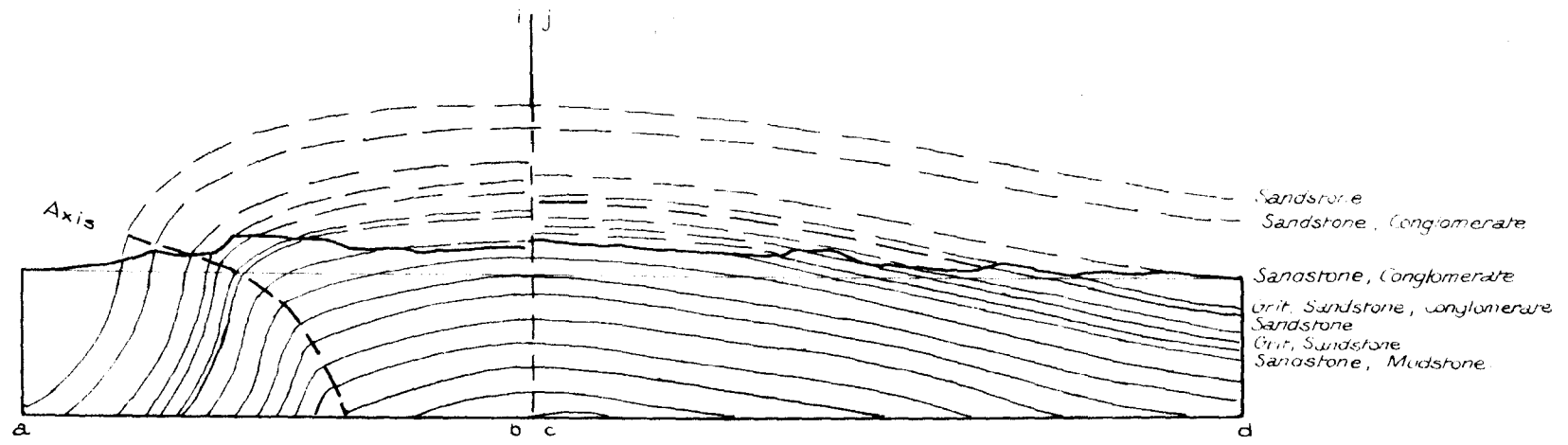
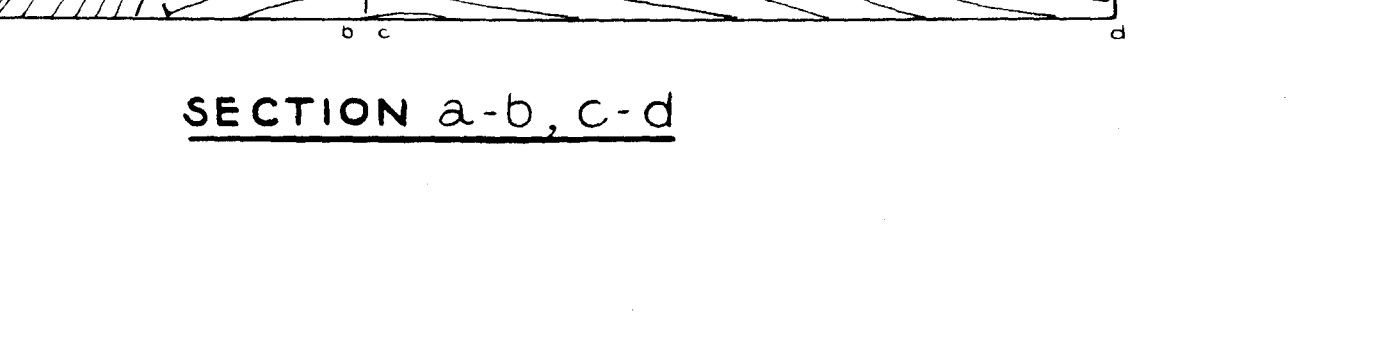
PNG 1G-7
1/20,000



SECTION e-f



SECTION a-b, c-d



SECTION g-h

SCALE

Yds 0 500 1000 Yds

No Vertical Exaggeration

PNG 1 G-8

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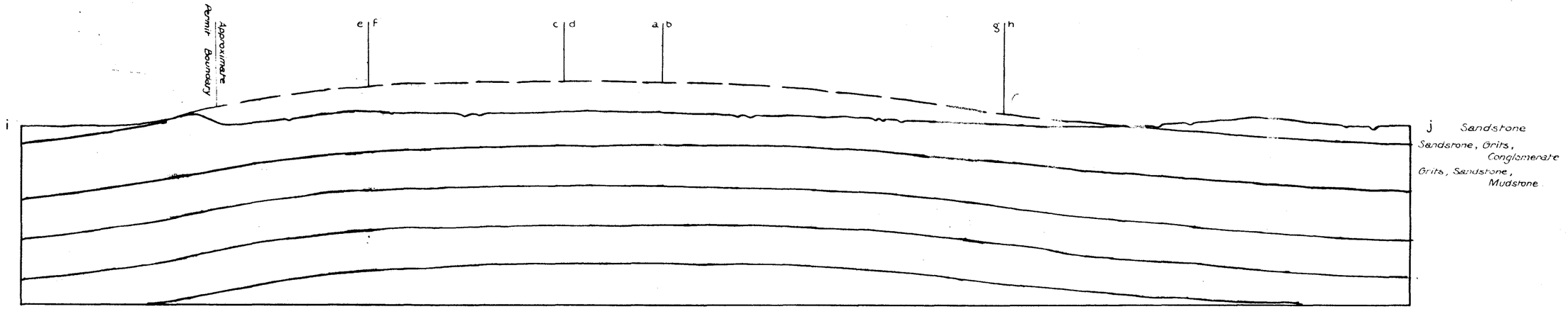

SECTION i - j

SCALE

Yds 0 500 1000 Yds

No Vertical Exaggeration

PNG 16-9

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