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PALYNOLOGY OF FOUR OFFSHORE BRITISH COLUMBIA WELLS

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O.F. 808: PALYNOLOGY OF FOUR OFFSHORE BRITISH COLUMBIA WELLS
by W.S. Hopkins, Jr.

This brief palynological report deals with four wells drilled on the Hecate Depression, a structural low on the continental shelf, in the Queen Charlotte Sound area, between the south end of the Queen Charlotte Islands and the north end of Vancouver Island. The ages of the penetrated sections are defined and a biostratigraphic zonation for the region based on palynological data is discussed.

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Introduction

This brief palynological report deals with four wells drilled on the continental shelf, in the Queen Charlotte Sound area, between the south end of the Queen Charlotte Islands and the north end of Vancouver Island (Fig. 1). The purpose for the study was to define the age of the penetrated sections and to investigate the possibility of establishing a biostratigraphic zonation for the region based on palynological data.

To this end, four wells were selected, the Shell Anglo Murrelet L-15, Shell Anglo Auklet G-41, Shell Anglo Harlequin D-86 and Shell Anglo Osprey D-36. Basic data on each of the four wells is given on Figure 2 and in the section on geology which follows. Figure 2 is a diagramatic representation of the wells in vertical profile, although note that the horizontal distance between wells is not to scale. The irregular line, running vertically beside each well, is the generalized representation of the electric log. The depth to sea floor is indicated as well as the average angle of sea-bottom slope between wells. Also indicated is the top of a volcanic flow which is thought to be essentially a time line. The average slope of the volcanic surface between wells is indicated beneath the line.

Geology

These four wells are located in the Hecate Depression, a structural low on the continental shelf, which lies between the Coast Mountains and the Insular Mountains. Vancouver Island and the Queen Charlotte Islands are exposed portions of the Insular Mountains. The Hecate Depression itself now covered by the sea, and here called Queen Charlotte Sound, separates the north end of Vancouver Island from the south end of the Queen Charlotte Islands. Geologically the Hecate Depression appears to be a northward extension of, and occupies a similar geological position as the Georgia Depression.

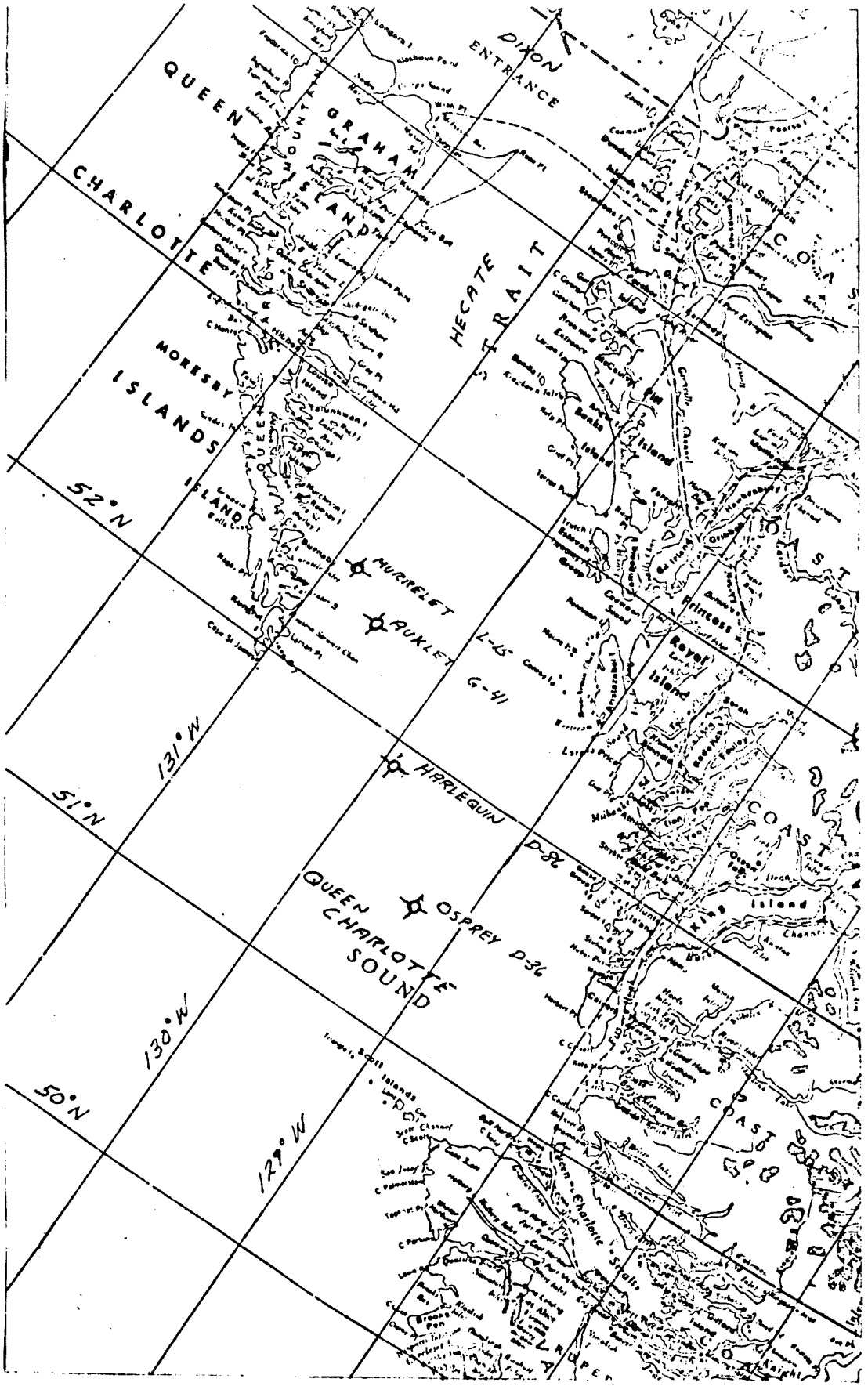

FIG. 1 Location map of wells discussed in this report.

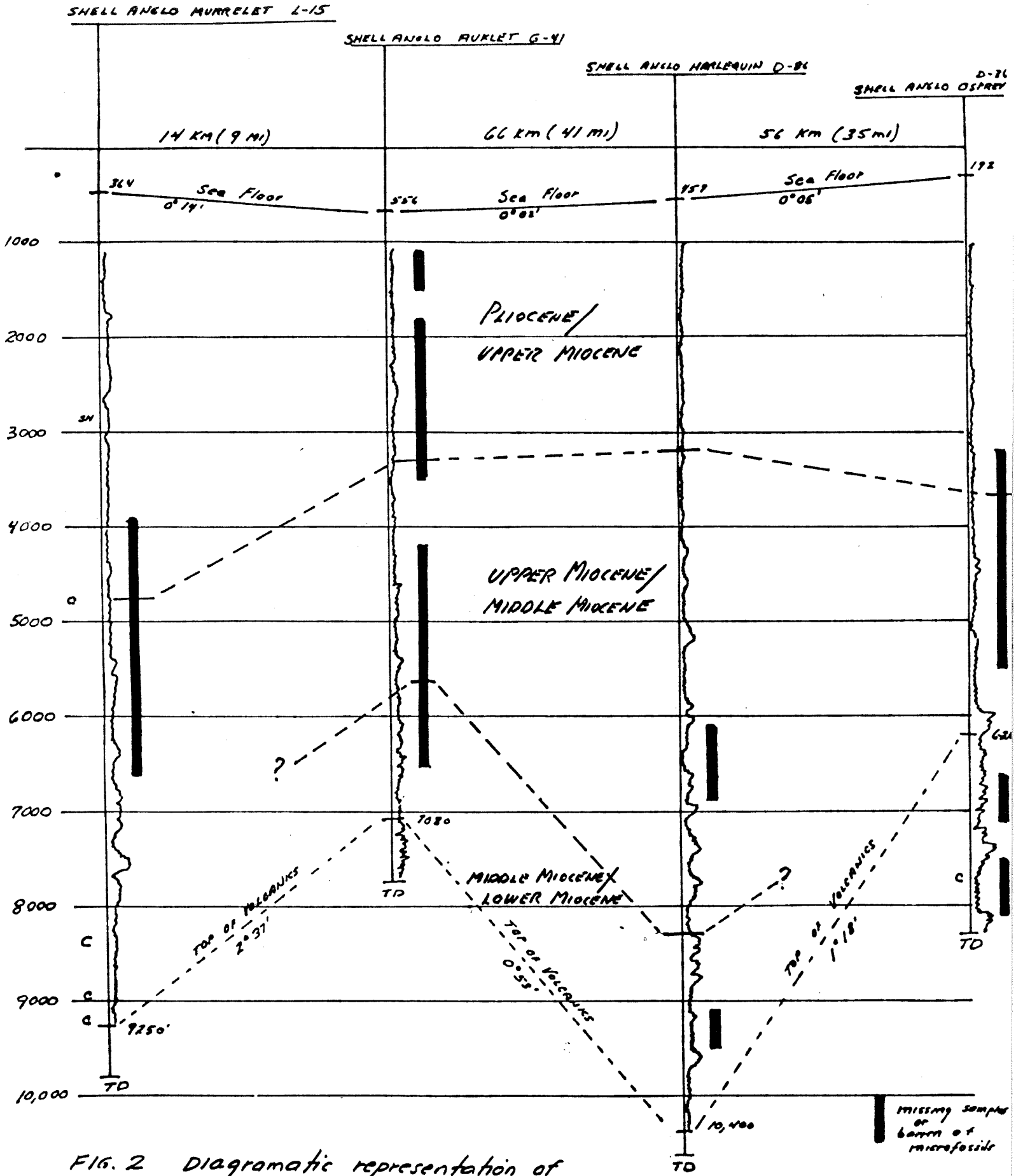

FIG. 2 Diagramatic representation of wells showing location of missing samples and samples barren of microfossils

It is not the purpose of this report to discuss the regional geology or the stratigraphy of the area, but only to briefly present a summary of the palynological conclusions. With this caveat in mind, the four wells are briefly discussed below.

Shell Anglo Harlequin D-86

This well was located about 72 kilometres (45 miles) east of Cape St. James, Queen Charlotte Islands (51°55'3.585"N; 129°58'12.353"W), British Columbia. Spudding took place on 22 September 1968 and the well was plugged and abandoned on 15 October 1968 at a total depth of 3241 metres (10,320 feet). Drilling was from a floating platform in 140 metres (458 feet) of water.

Clastic sedimentary rocks were encountered from the surface to 3146 metres (10,320 feet) and volcanic rocks from there to total depth. A comparatively complete description of the penetrated sediments is given in Shell Canada Limited (1969a) but in general sandstones dominate with lesser amounts of siltstone and still less shale. Overlying the basal volcanics are some 152 metres (500 feet) of shale. Two conventional cores were taken, but as they consisted of sand, were not suitable for palynological analysis. A total of 184 sidewall cores were recovered, but these were tested to destruction by the operator. For additional technical information see Shell Canada Limited (1969a).

Shell Anglo Murrelett L-15

This well, drilled as the final test in Shell's west coast exploratory drilling program, lies about 32 kilometres (20 miles) east of Scudder Point, Queen Charlotte Islands at 52°24'41.3"N; 130°47'38.0"W, British Columbia. Spudding took place on 11 April 1969, the well was plugged and abandoned on 4 May 1969 at a total depth of 2019 metres (9578 feet). Drilling was from a floating platform in 111 metres (364 feet) of water.

Clastic sediments, largely sand, but also interbedded siltstones, shales and lignites were encountered from surface to 2804 metres (9200 feet), and interbedded volcanics and sands from 2804 metres (9200 feet) to total depth. Unfortunately samples are missing from the interval 1190 to 2097 metres (3905-6881 feet), the explanation being that the "fine cuttings went through shaker". No conventional cores were taken but three sidewall core runs were made. However, these latter sidewall cores were tested to desctuction by the operator and were not available to me. For additional technical information see Shell Canada Limited (1969b).

Shell Anglo Osprey D-36

This well was located approximately 97 kilometres (60 miles) northwest of Cape Scott, Vancouver Island, or approximately 56 kilometres (35 miles) southwest of the Shell Anglo Harlequin D-86 well. Depth of water is 59 metres (192 feet). The well was spudded on 1 September 1968 and was plugged and abandoned 16 September 1968 at a depth of 2530 metres (8302 feet).

Clastic sediments were encountered exclusively to a depth of 1871 metres (6140 feet) and interbedded volcanics and sands from there to total depth. Although sandstone is dominent, mudstone, siltstone and shale are abundant. Coal and lignite are absent except for several thin coal seams interbedded with the basalt at around 2347 metres (7700 feet). One conventionel 6 metre (20 feet) core plus three sidewall core runs were made. None of these cores was available to me. For additional technical information see Shell Canada Limited (1968a).

Shell Anglo Auklet G-41

This well was located approximately 132 kilometres (82 miles) south-east of Sandspit, Queen Charlotte Islands and approximately 14 kilometres (9 miles) east south east of the Shell Anglo Murrelet L-15 well. The location is 52°20'16.119"N, 130°36'32.772"W and located in water 170 metres (556 feet) deep. Spudding took place 14 August 1968, the well was plugged and abandoned 28 August 1968 at a total depth of 12,513 metres (7777 feet).

Clastic sediments, almost completely sand, made up the entire penetrated section although a few very minor mudstone, siltstone and shale beds were encountered. Lignite or coal seams appear to be totally absent. Weathered volcanic rocks were encountered at 11,391 metres (7080 feet) and continued to total depth. No conventional cores were taken but three sidewall core runs were made. However, these latter were tested to destruction by the operator and were, like all other cores, not available to me. For additional technical information see Shell Canada Limited (1968b).

PALYNOLOGY

Samples

Because neither conventional nor sidewall cores were used, this entire study is based on cuttings. Unfortunately, because of the unconsolidated nature of the sediments, the rapid rate of bit penetration with subsequent caving, the palynological results from the samples tends to be somewhat muddied.

In the preparation of samples from these wells a laboratory technique was employed which hopefully made the results more meaningful. Samples were dry sieved through 10 and 70 mesh screens. The material retained on

the 10 mesh size was assumed to be mainly cave, that passing through both the 10 and 70 mesh was considered to be largely drilling mud. Rock passing through the 10 mesh screen and retained on the 70 mesh was considered to be a representative sample of the material being drilled by the bit. Consequently, material that remained on the 10 mesh and passed through the 70 mesh was discarded. The material remaining on the 70 mesh screen was saved and macerated in the conventional way. In addition, portions of the residue were sieved through 20, 30 and 45 micron sieves and separate slides made of each fraction. All counting was done, of course, on the unsieved fractions.

Samples were collected down the wells at approximately 30 metre (100 foot) intervals, although in all wells, intervals of varying length were not, for various reasons, represented by samples. These are indicated on Figure 2 by vertical black bars. Included within the intervals represented by the black bars are lengthy intervals of palynologically barren samples.

Shell Anglo Murrelet L-15

60 samples examined, 54 useful

Shell Anglo Auklet G-41

64 samples examined, 15 useful

Shell Anglo Harlequin D-86

93 samples examined, 69 useful

Shell Anglo Osprey D-36

62 samples examined, 30 useful

Total Samples examined 277

Total samples useful 168

Total samples useful 61 per cent.

Those samples defined as useful provided counts of 200 palynomorphs or more, a figure considered minimum for statistical significance.

Results

A summary of results for each well are presented in appendices 1 through 4. The data from these have been combined in Figures 3-14 which follows the bibliography.

The distribution of various taxa and combined groups of taxa were plotted in various formats. However, as most of these plots produced nothing of apparent consequence, only a few are reproduced here. They represent only simple percentage frequency of selected taxa, as well as that of larger taxonomic groups. Figures 3 to 7 illustrate, for each well, the relative abundance of major taxonomic groups. Figures 8 and 9 illustrate the ratio of 4 and 5 pored Alnus, Figure 10, the frequency of phytoplankton, while figures 11 to 14 are the relative frequency of selected genera. The latter figures are not provided for the Auklet G-41 which had too few samples of a quality sufficient to be useful. Because all the taxa are common Neogene forms, and have been illustrated in numerous publications, I have decided against further illustrations here.

Age

There is no doubt this is a Neogene sequence, a conclusion based mainly on the modern appearance of the taxa, the presence of such families as compositae, Chenopodiaceae and Gramineae, and the total absence of characteristic Paleogene forms. Palynological subdivision of the Tertiary is always difficult, and perhaps is more so in this area where well-dated marine sequences are absent and which could be used for correlation. It was hoped the merger of

foraminiferal and palynological data in this paper would enhance our understanding, but the limited foraminiferal studies made on these wells are not available at this time. In an attempt to establish a probable age for this sequence of rocks I have compared floras from Alaska (Wolfe and others, 1966; Wolfe, 1966); from the Queen Charlotte Islands (Martin and Rouse, 1966): from interior British Columbia (Piel, 1971) and from the northwestern United States (leopold, 1969). However, our knowledge of Miocene-Pliocene microfloras from the margin of the North Pacific Basin is woefully inadequate and many suppositions are necessary.

As discussed earlier, this is undoubtedly a Neogene sequence, i.e. Miocene and Pliocene, possibly including some Lower Pleistocene. There is no evidence that Oligocene is present as largely indicated by the absence of such characteristic forms as the ferm family Schizaceae and the near absence of Tiliaceae. Furthermore, the sporadic appearance of the family Compositae indicates a Neogene age as this is a family which does not make its appearance until the latest Oligocene or earliest Miocene.

Unfortunately we do not have any clear idea as to what defines a Miocene-Pliocene boundary, at least in palynological terms. However, Wolfe and others (1966) subdivided the south central Alaska Tertiary into three broad floral groups, the Seldovian, the Homerian, and the Clamgulchian. Although the ages assigned by Wolfe and others are highly uncertain the Seldovian would appear to be Early to Middle Miocene with the possibility of some Oligocene at the base. The Homerian is thought to be mostly or entirely Late Miocene, while the Clamgulchian is at least partly Pliocene. As a result, on the basis of palynology, I would suggest that the sections represented in these wells includes upper Seldovian, Homerian and Clamgulchian. Boundaries, in general terms, are approximated by dashed lines on Fig. 2, p. 3.

However, even though examination of the distribution of frequency curves shows exact age dating is not possible, another method of suggesting age might be the use of Miocene-Pliocene mean temperature curves. These curves were developed by a number of workers on a number of floras [mainly using various megafossil groups, i.e. Brooks (1951); Darf (1955); Wolfe and Hopkins (1967): Tanai and Huzioka (1967)]. Although analyses differ in detail, the general picture indicated by most investigators is a warm peak in late early or middle Miocene, followed by a general cooling into the Pleistocene. The Early Miocene is considered to have been somewhat cooler than the Middle Miocene.

If we look at the vegetative proportions with this concept in mind we find, generally, the lowest proportion of Pinaceae and highest proportion of Taxodiaceae about two-thirds of the way down the respective wells. This conceivably could represent the thermal maximum of the Middle Miocene. Although this is a very tenuous observation, based on inadequate data, it is possible the general increase of the Pinaceae and decrease of the Taxodiaceae below this zone, could indicate the slightly cooler Early Miocene. The gradual cooling from the Middle Miocene through the Pliocene to the Pleistocene would then explain the steady uphole increase in the Pinaceae (mostly pine, spruce and hemlock) and the ferns. During this same interval the Taxadiaceae and the angiosperms show a decrease in abundance. For reasons which I can not yet explain, the Murrelet L-15 well does not show these trends. Interestingly enough the percentage of five-pored pollen is high compared to four-pored in samples above 4000 feet (figs. 8, 9,). The significance of this is not clear.

Therefore, in broadly general trends, the relative proportions of the gymnosperm families Taxodiaceae-Pinaceae, complement the interpretation made by floral comparisons with Alaska, British Columbia and the northwest United States. Unfortunately other taxa neither support nor refute this interpretation; they tend to remain neutral. Hence I hasten to emphasize this is all very tenuous at the present time. At best, microfloral comparisons can only be suggestive because the floras to which comparisons are made, are themselves only tenuously dated. Furthermore, the interpreted climatic changes are suspect, largely because the apparent change in floras as revealed by percentages may be an artifact of method rather than indicative of significant floral change.

All things considered, we can say only that the section penetrated by these wells represents Miocene, Pliocene and possibly Pleistocene rocks.

Environment

Deposition would appear to have been on a continuously subsiding coastal plain, apparently subsiding rapidly enough to prevent accumulation of significant quantities of organic deposits, such as peat. The intermittent and always low frequency of phytoplankton (fig. 10) suggest deposition of, or occasionally below, sea level. Subsidence was rapid, permitting the accumulation of 3050 metres (10,000 feet) of clastic sediment during a period no longer, or only slightly longer, than the Miocene-Pliocene. Assuming a 20 million year length for the Miocene-Pliocene, this is an accumulation of about 0.3 metres (1 foot) every 2000 years.

The plants indicate a warm temperate climate for the Middle Miocene ranging to perhaps temperate at the end of the Epoch. The presence of Nyssa, Taxodium, Metosequoia, Alnus, Betula and other genera would indicate a comparatively damp climate with abundant rainfall. Temperatures below freezing must have been absent or very rare.

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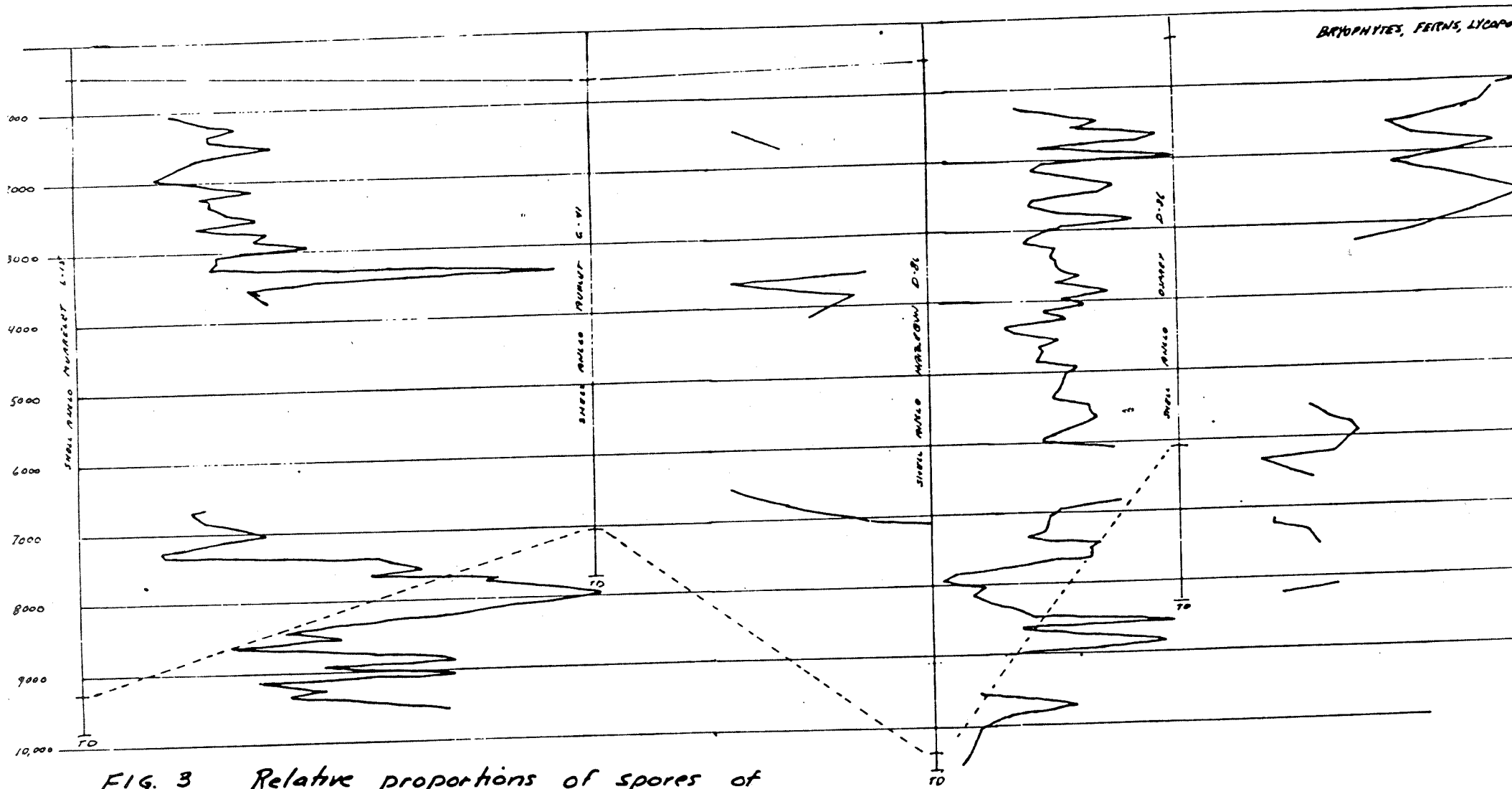

FIG. 3 Relative proportions of spores of bryophytes, ferns, and lycopods.

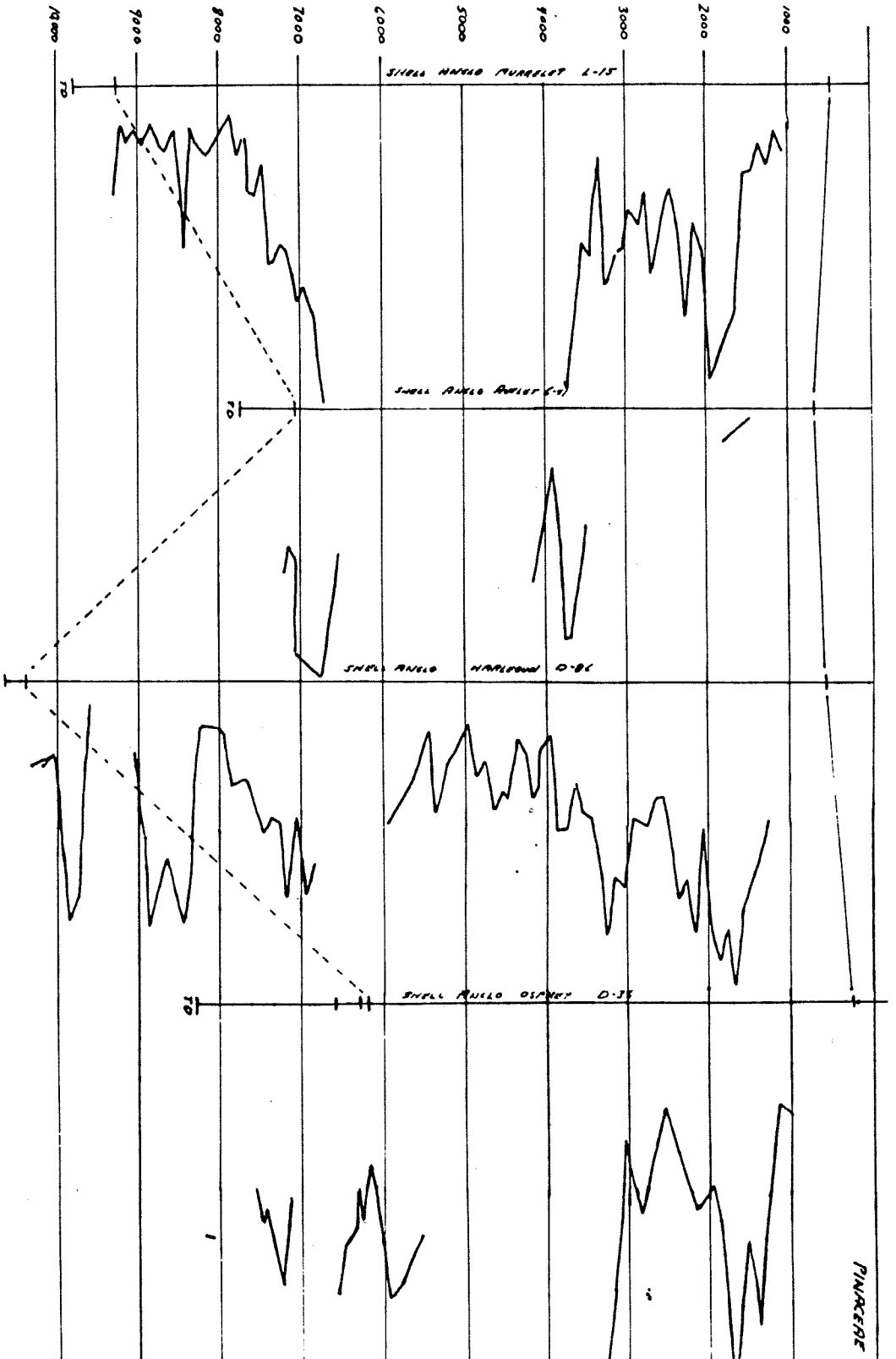

FIG. 4 Relative proportions of pollen of Pinaceae

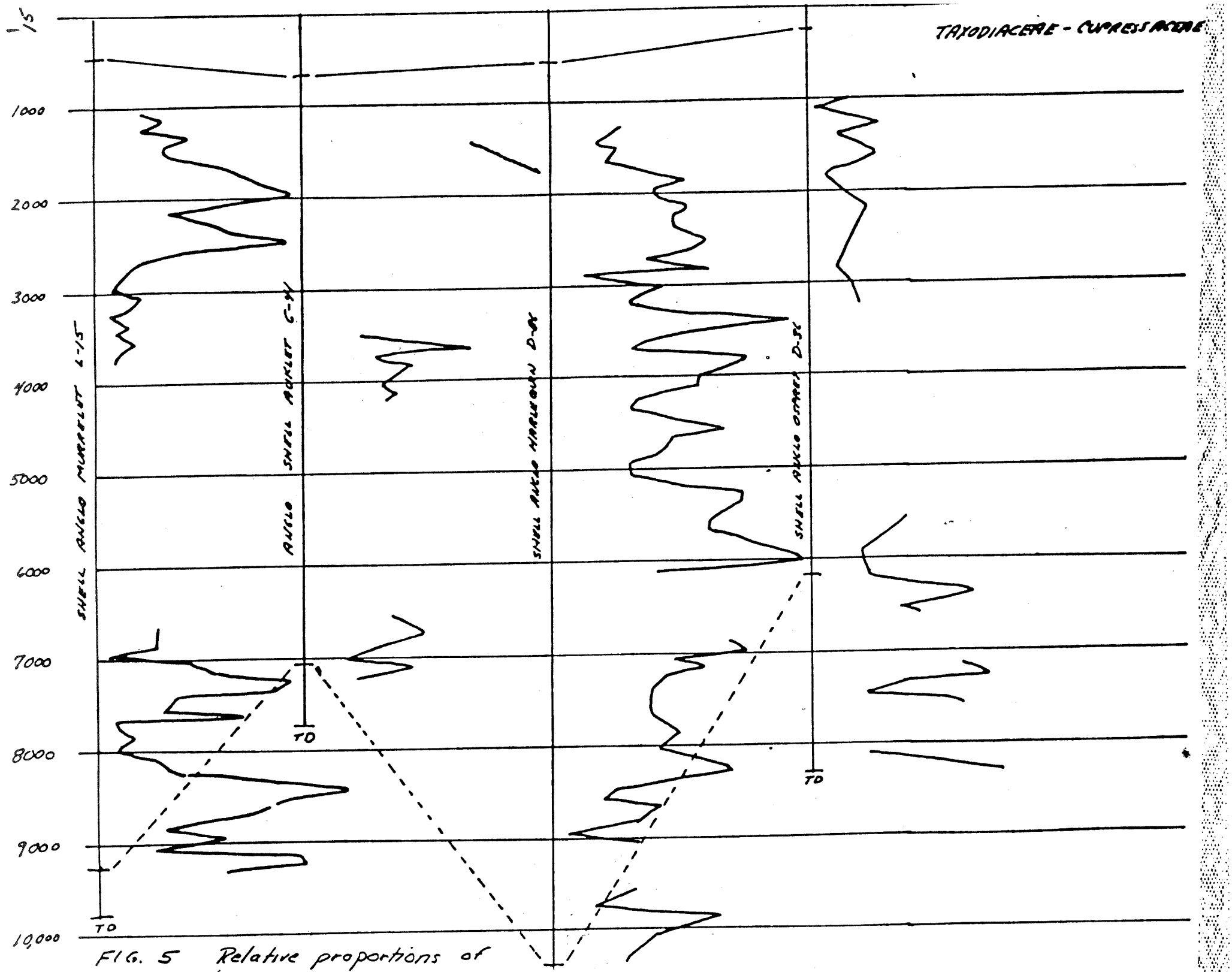

FIG. 5 Relative proportions of

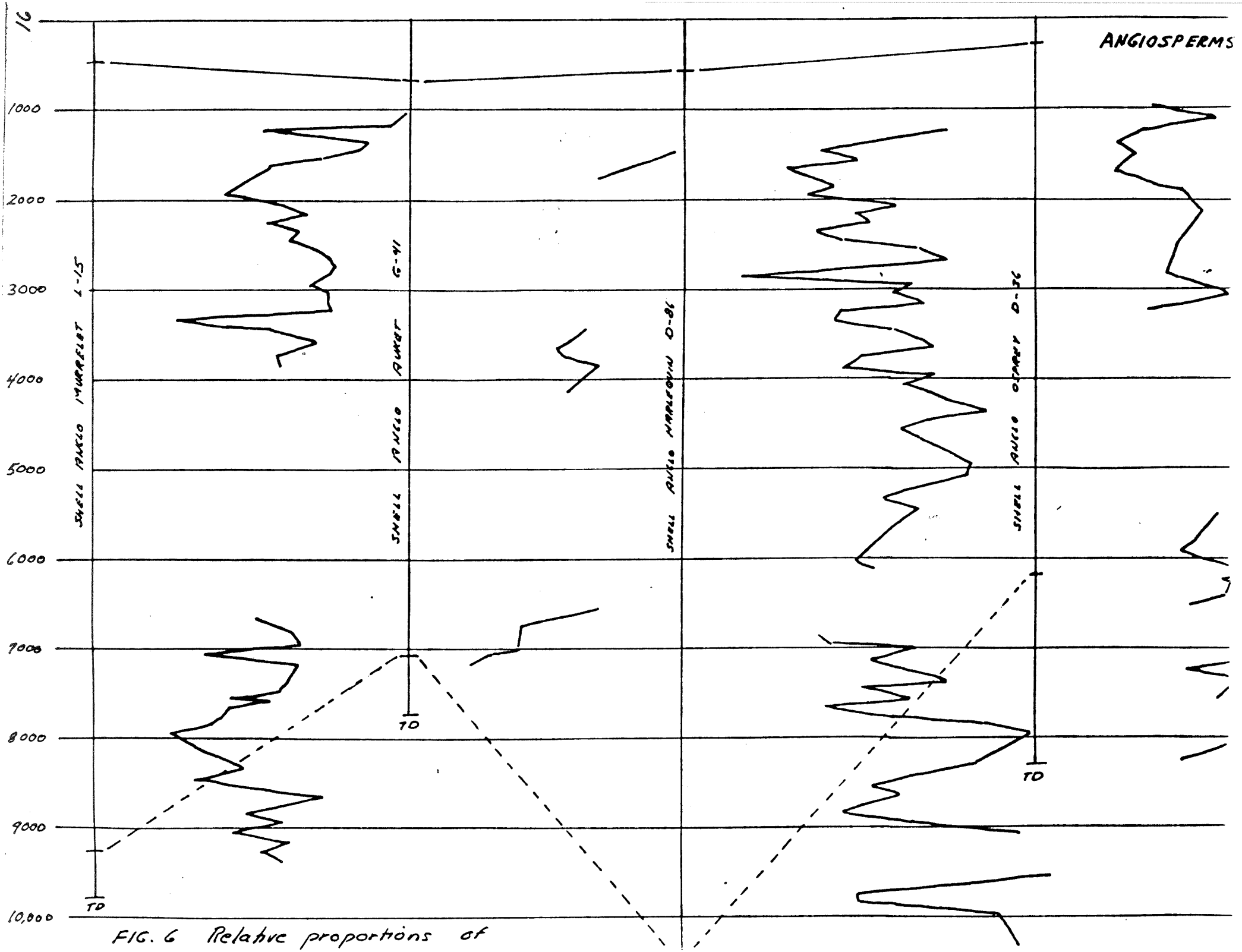

FIG. 6 Relative proportions of

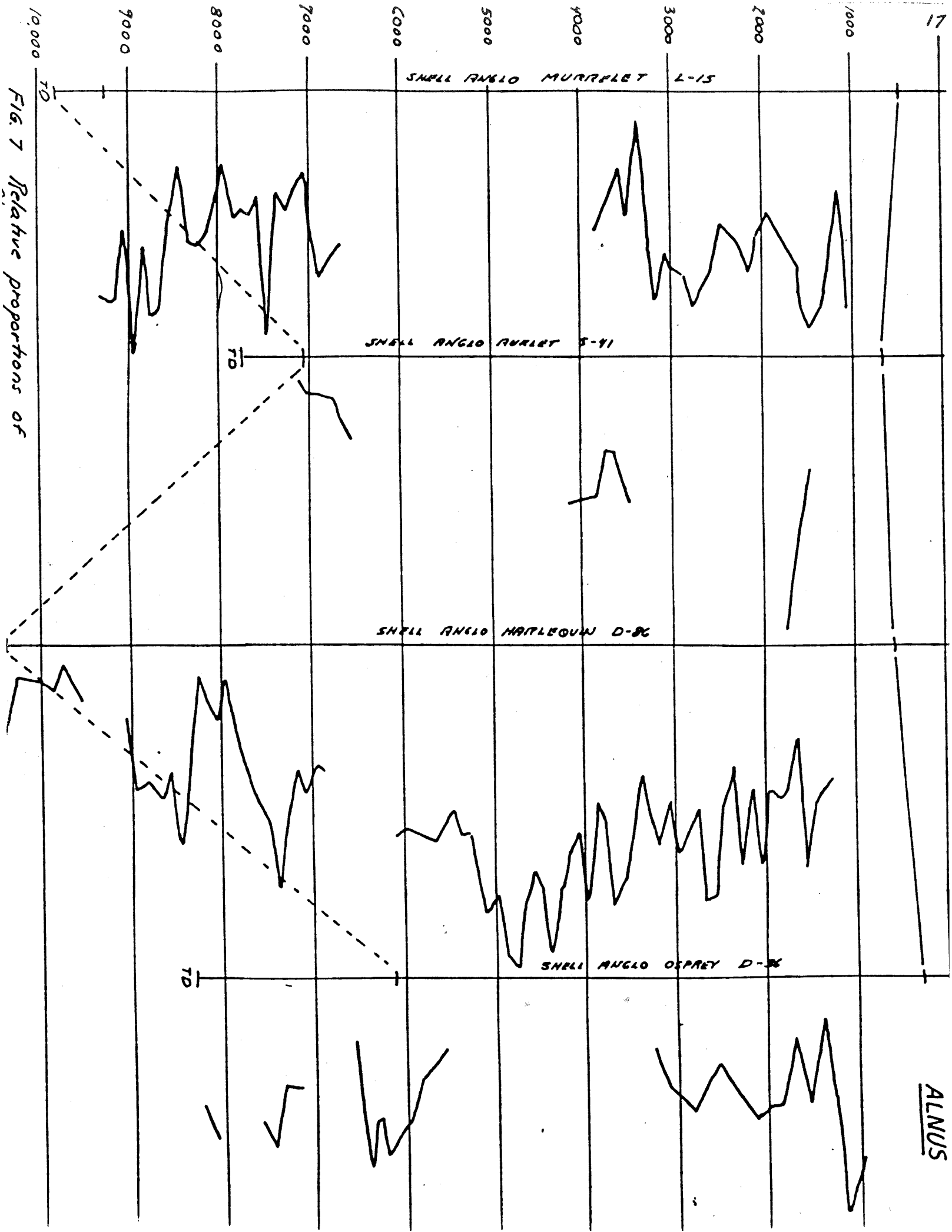

FIG. 7 Relative proportions of

ALNUS

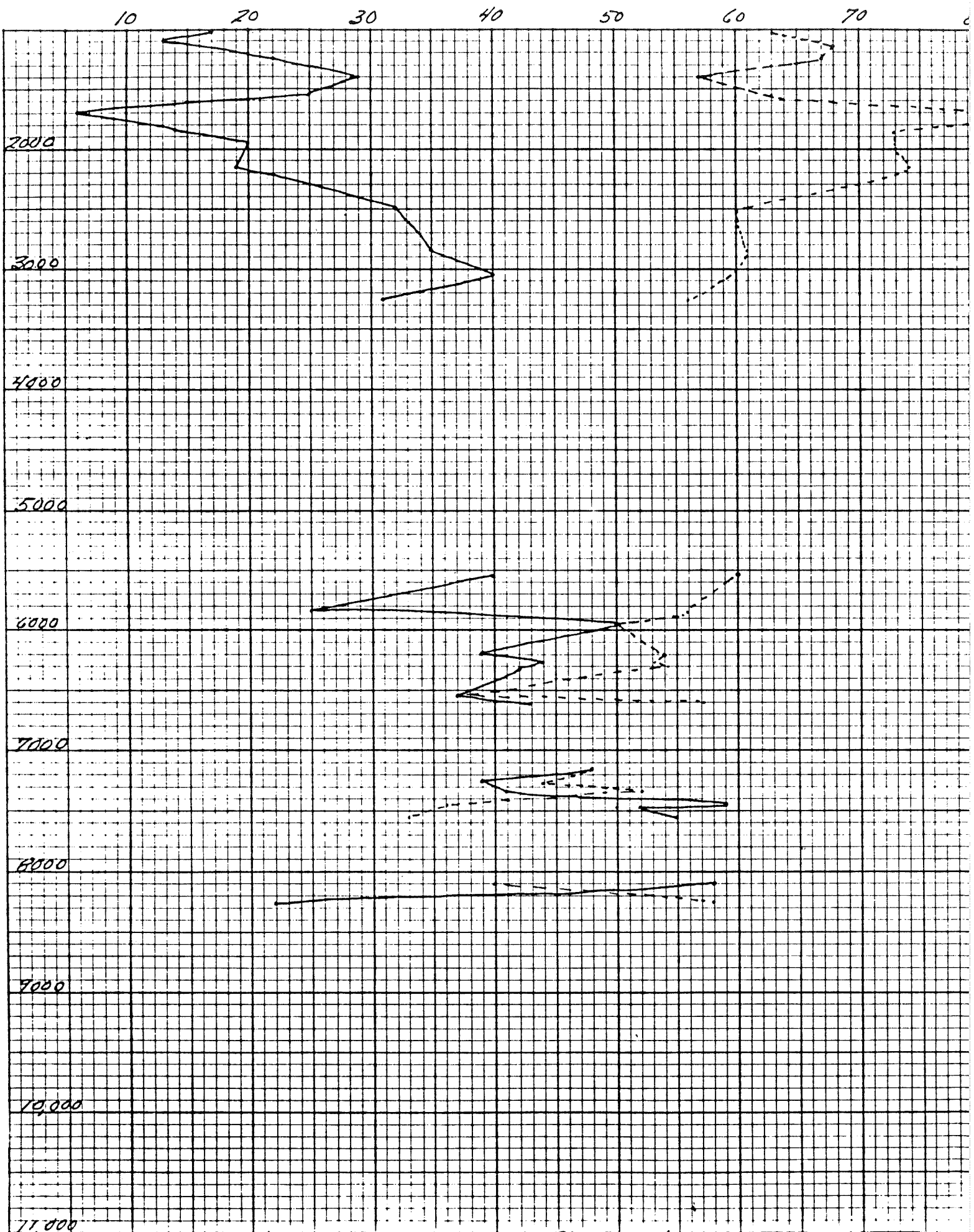

FIG. 8 Proportions of 4 and 5 pored Alnus pollen in Osprey well.

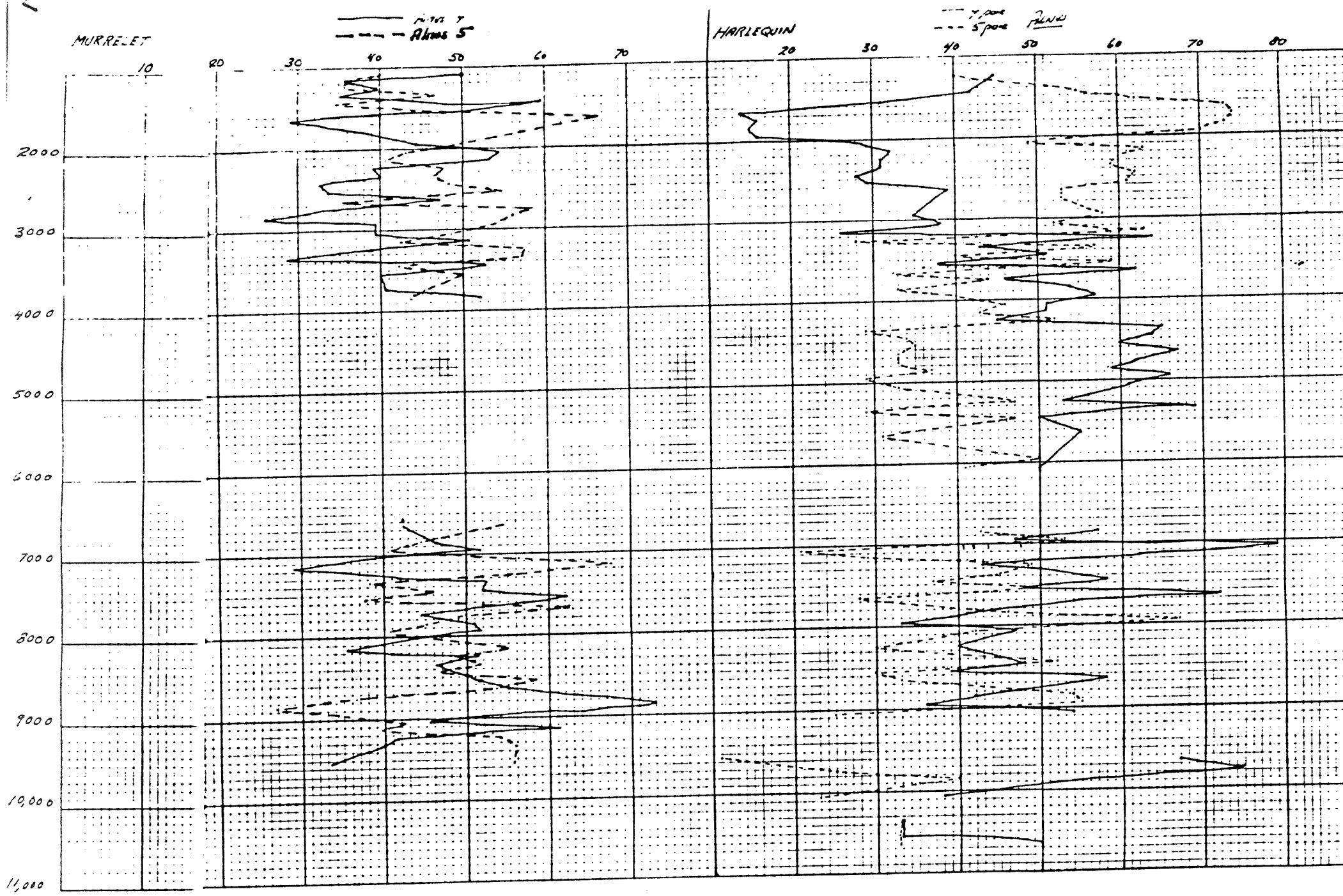

FIG. 9 Proportions of 4 and 5 pored *Alnus* pollen in the Murrelet and Harlequin wells.

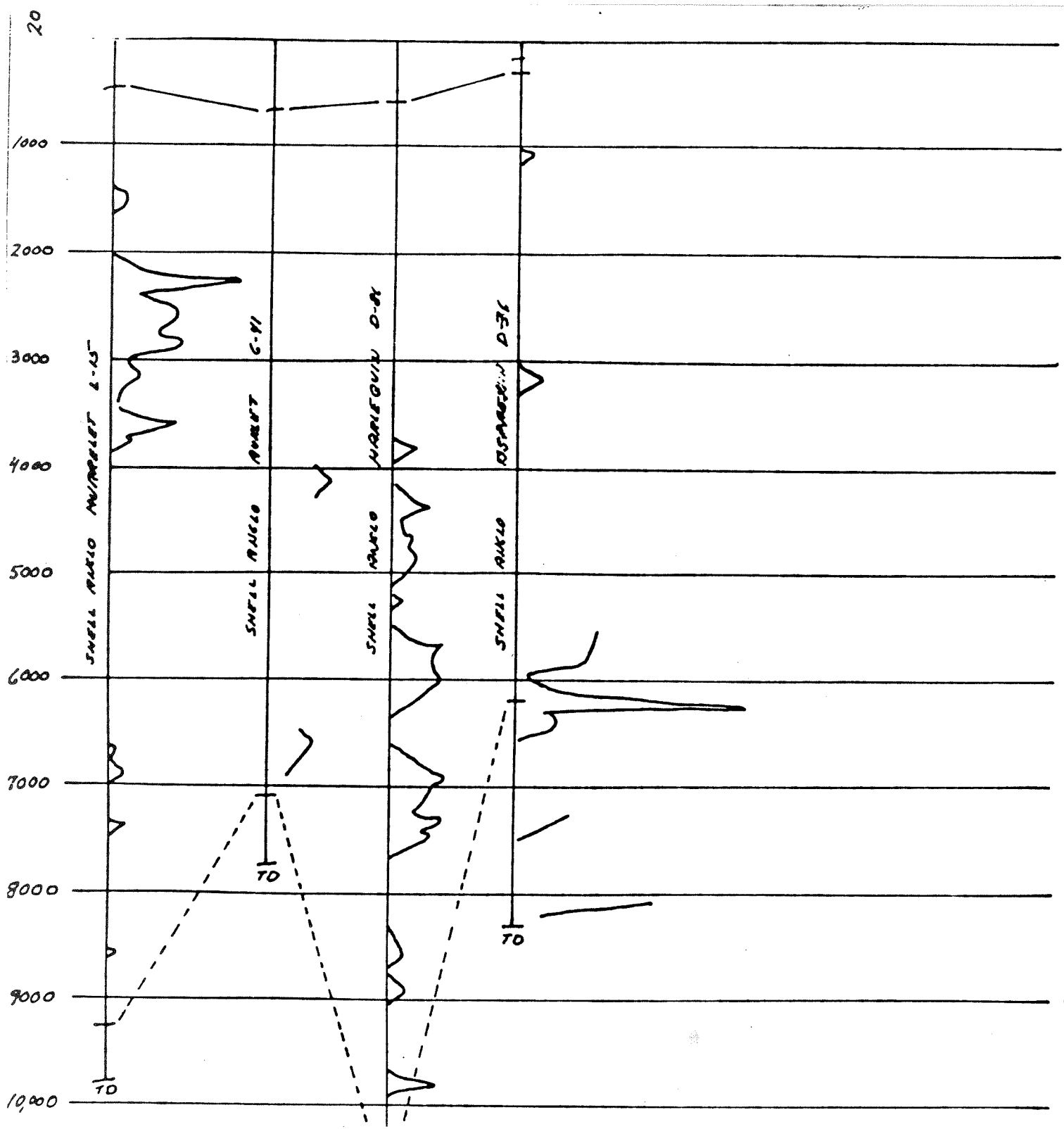

FIG. 10 Relative proportion of phytoplankton in the four wells.

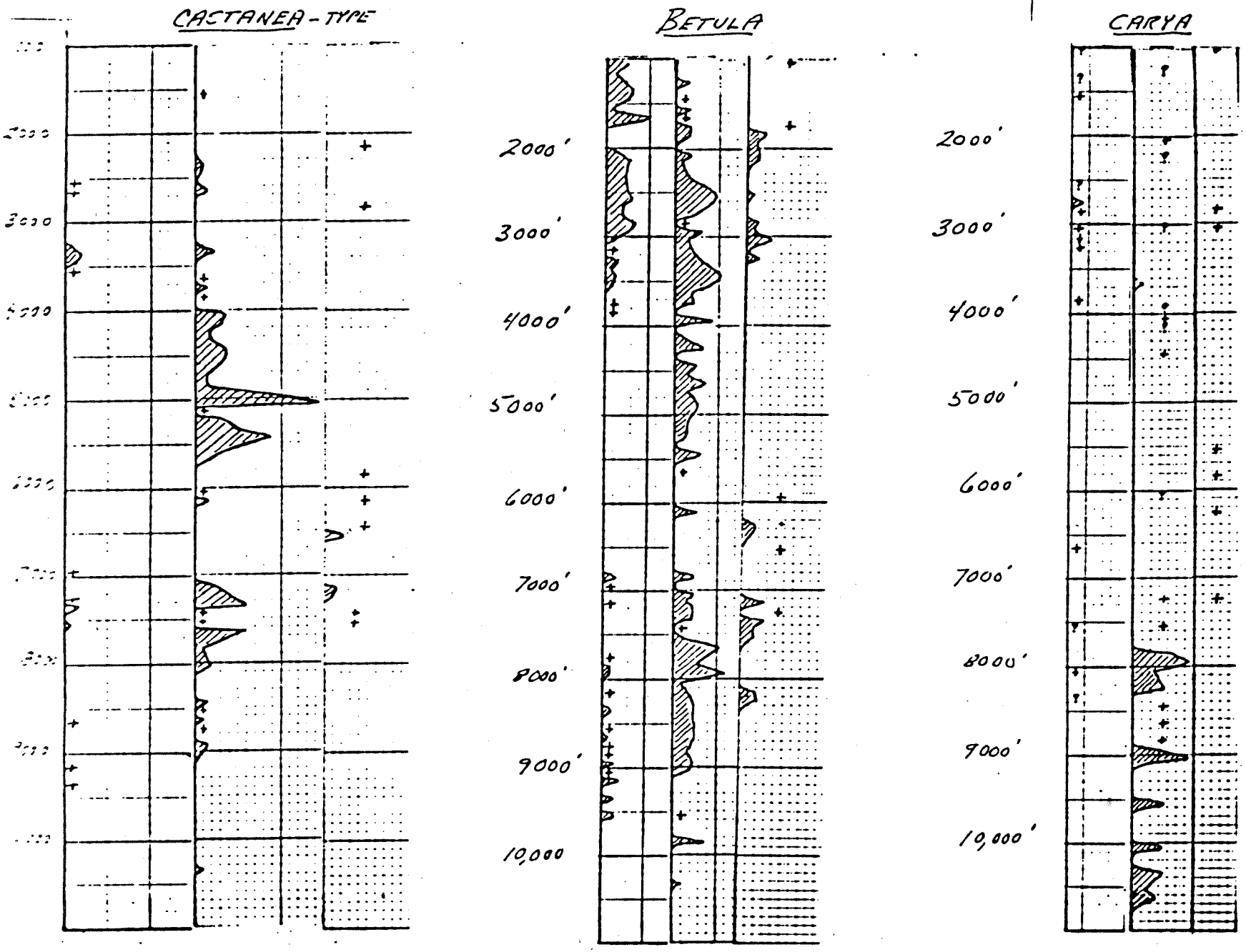

FIG. 11 RELATIVE FREQUENCY OF CASTANEA, BETULA AND CARYA POLLEN

MURRELET I-15 — HARLEQUIN D-86 + OSPREY D-36

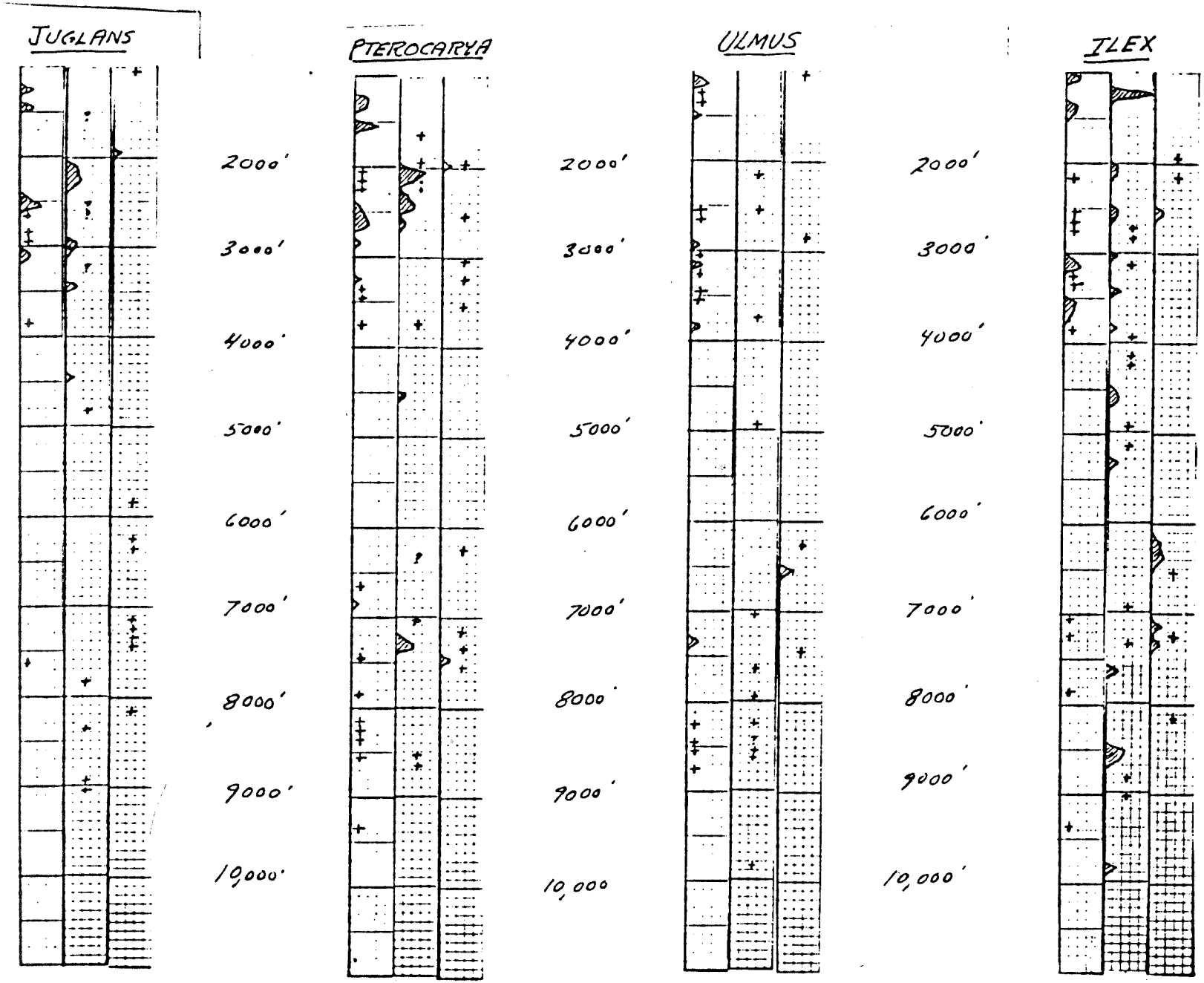

FIG. 12 RELATIVE FREQUENCY OF JUGLANS, PTEROCARYA, ULMUS AND ILEX POLLEN

MIRRELET L-15 | HARLEQUIN D-8L — OSPRY D-3L

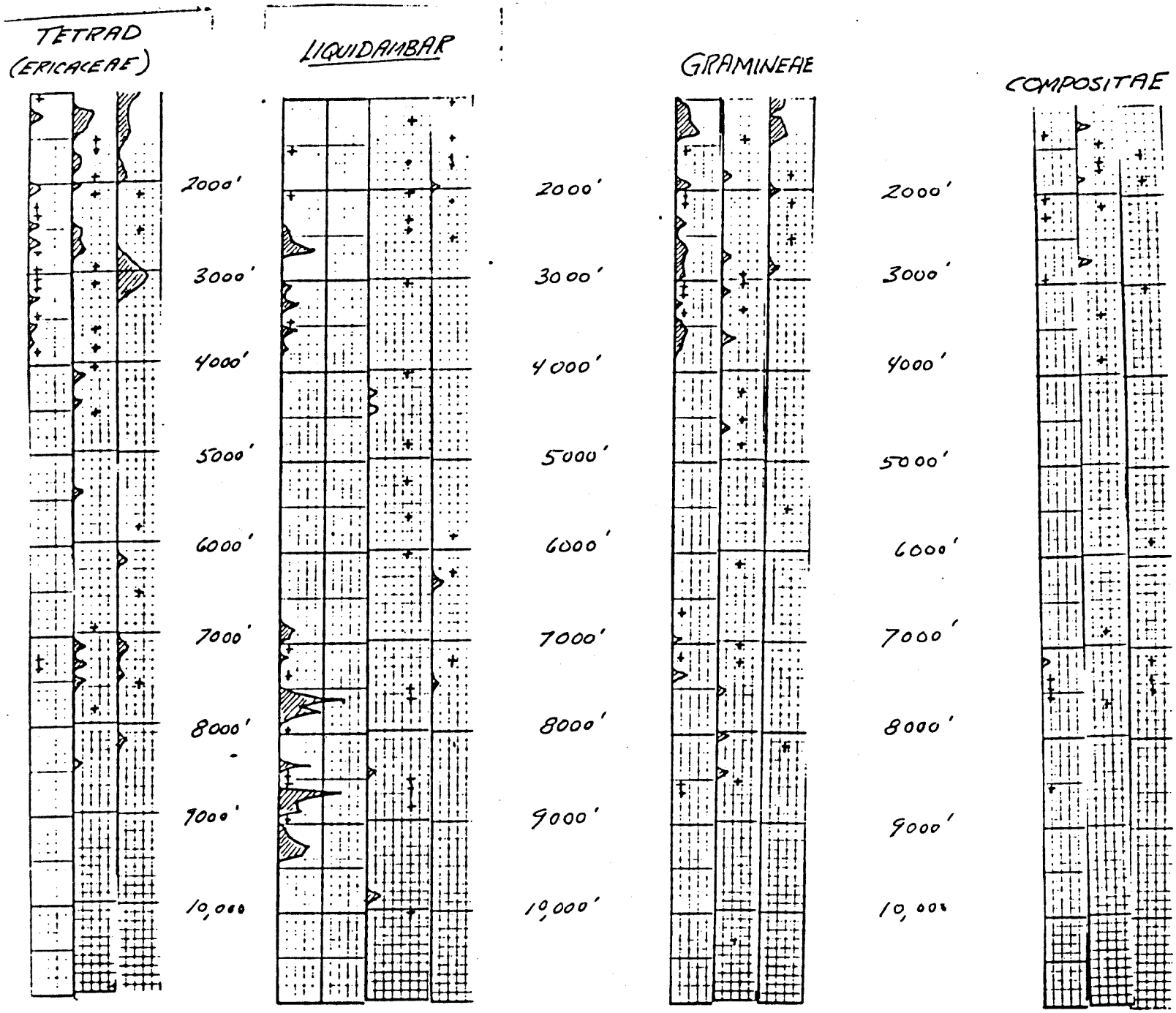

FIG 13 Palynomorph frequency [illegible]

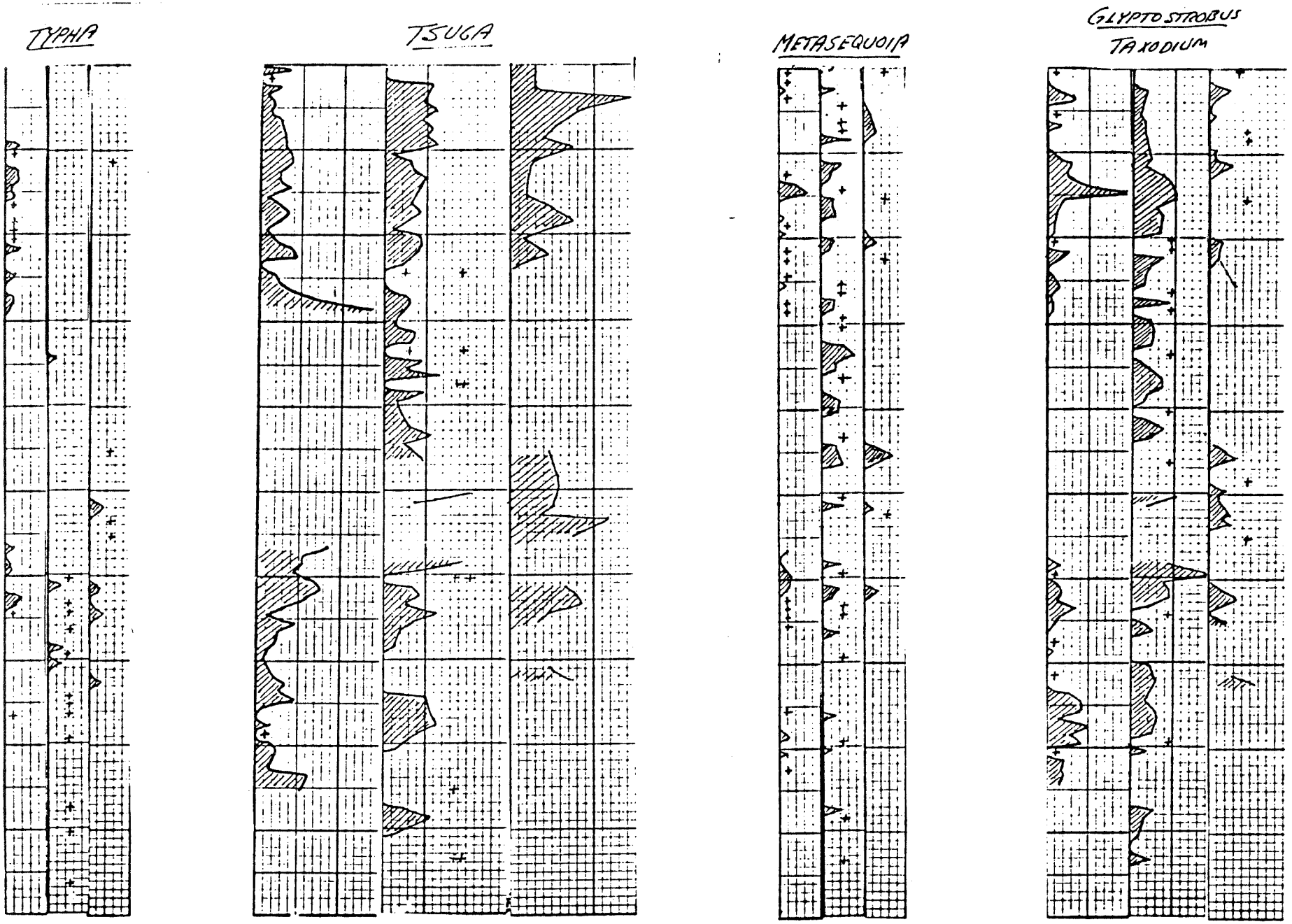

FIG. 14 RELATIVE FREQUENCY OF TYPHA TSUGA METASEQUOIA AND GLYPTOSTROBUS/TAXODIUM POLLEN

PRELIMINARY REPORT

PALYNOLOGICAL STUDY OF SHELL ANGLO HARLEQUIN D-86 WELL

W.S. Hopkins, Jr.

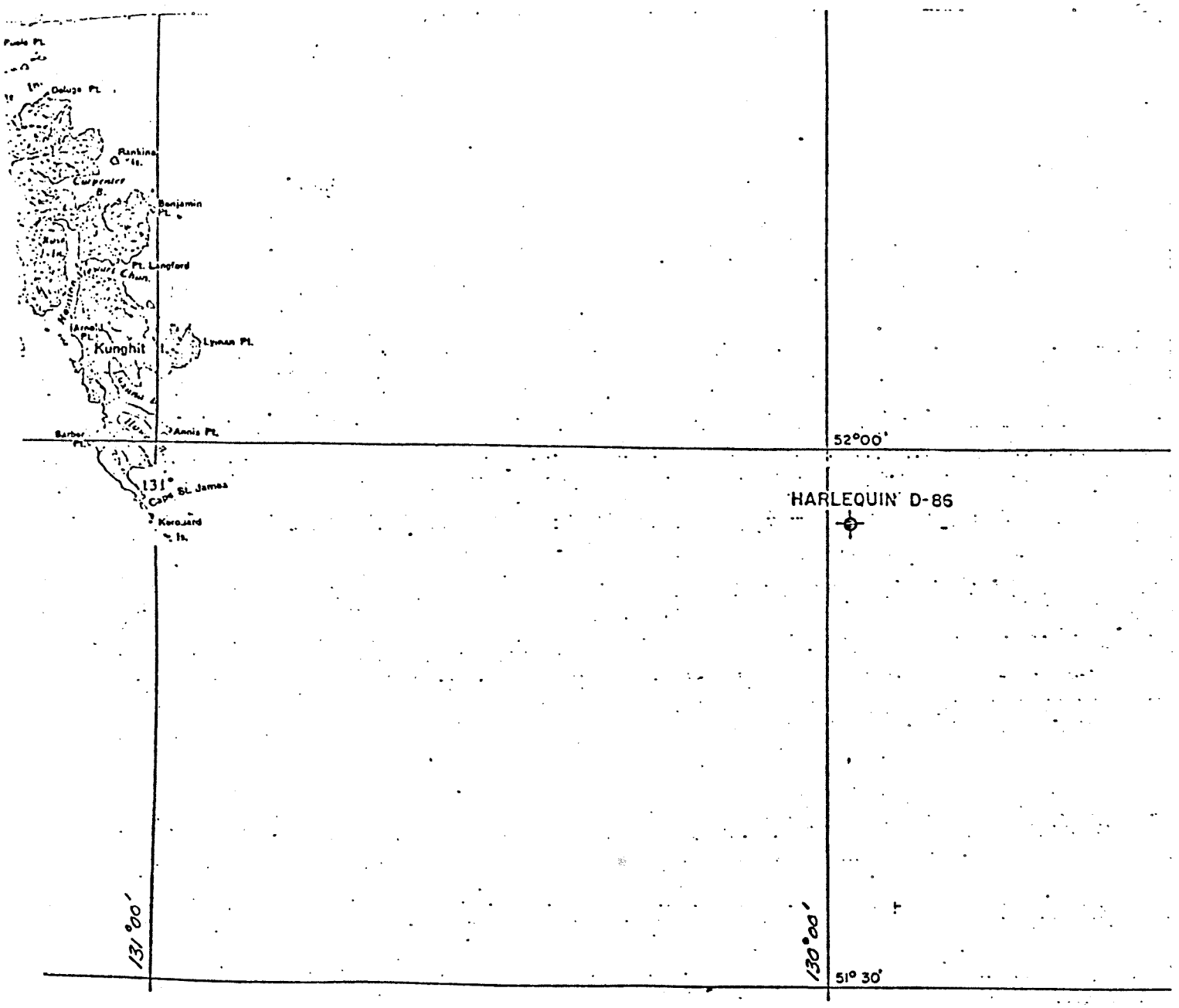

Fig. 1. Index Map Showing Location of Shell Anglo Harlequin D-86 taken from Shell History Report (1969).

INTRODUCTION AND GEOLOGY

This well, drilled by Shell Canada, was located about 72 kms (45 miles) east of Cape St. James, Queen Charlotte Islands (51°55'3.585"N; 129°58'12.353"W), British Columbia. Spudding took place on 22 September 1968 and the well was plugged and abandoned on 15 October 1968 at a total depth of 3241 meters (10,320 feet). Drilling was from a floating platform in 140 meters (458 feet) of water.

Clastic sedimentary rocks were encountered from surface to 3146 meters (10,320 feet); volcanic rocks from there to total depth. A comparatively complete description of the penetrated sediments is given in Shell Canada Limited (1968) but in general sandstones dominate with lesser amounts of siltstone, and still less shale. Overlying the basal volcanics are some 152 meters (500 feet) of shale. Two conventional cores were taken, bust as they consisted of sand, were not suitable for palynological analysis. A total of 184 sidewall cores were recovered, but these were tested to destruction by the operator.

SAMPLES

As neither suitable conventional or sidewall cores were available to me, this (entire) study is based entirely on cuttings. Because of the unconsolidated nature of the sediments, the rapid rate of bit penetration, and subsequent caving, the palynological results from the samples tends to be somewhat muddied. Future wells studied in this program will be processed utilizing dry sieving techniques which tends to remove cave material and dried drilling mud; therefore, results should be somewhat more meaningful. A total of 93 samples were examined from 384 meters (1260 feet) to total depth, spaced at approximately 30 meter (100 feet) intervals. Although the bottom 91 meters (300 feet) of hole was in

volcanic rocks, the shale recovery was good, probably representing shale caving from immediately above the volcanics.

PALYNOLOGY

Generally speaking the quality of palynomorph preservation was good in the upper part of the well, but quality gradually decreased down hole, mainly resulting from increased carbonization. In addition, many forms, especially the saccate grains were crushed or folded. Therefore, identification in many cases was questionable. Nevertheless, where possible, identifiable taxa were recorded when possible. However, compilation for range charts involved much lumping, the only method whidh appeared to give meaningful results.

With few exceptions the taxa were the same from top to bottom of the hole, consequently relative proportions had to be employed. Considering the nature of the samples and the considerable reworking or recirculating that must have occurred, results from individual samples are questionable. However, examination of the stratigraphic distribution charts, show that several broad trends are apparent, and these would appear to have both age and environmental signifcance. For example, there is a gradual decrease in proportions (Fig. 3) of ferns, lycopods and bryophytes; a decrease in the Pinaceae was matched by an increase in the Taxodiaceae, (Fig. 4), then a reversal in the bottom half of the hole. The angiosperms (Fig. 7) showed a steady increase, a pronounced decrease, then again an increase. Although the depositional environment may be partially responsible for this variation, I think it more probable that most of these changes are climatic. Consequently they may have value in age dating, a discussion of which follows.

AGE

There seems to be no doubt this is a Neogene sequence, a conclusion based mainly on the modern appearance of the taxa and the presence of such families as Compositae, Chenopodiaceae and Gramineae. Palynological subdivision of the Tertiary is always difficult, and perhaps is more so in this area where well dated marine sequences are absent, which could be used for correlation. In an attempt to establish a probable age for this sequence of rocks, I have compared floras from Alaska (Wolfe, and others, 1966; Wolf, 1966); from the Queen Charlotte Islands (martin and Rouse, 1966); from interior British Columbia (Piel, 1971) and from the northwestern United States (Leopold, 1969). Unpublished data of my own has also been considered. However, our knowledge of Miocene-Pliocene floras from the margin of the North Pacific Basin is woefully inadequate and many suppositions are necessary.

A through discussion of this will be deferred until examination of several more wells is completed, and foraminiferal data from marine zones can be considered. It is necessary to see if the floral patterns indicated here are consistent in other wells and not just a local aberation. Furthermore, some of the data are somewhat contradictory. However, at this preliminary stage I would suggest that the upper 457 meters (1500 feet) or so of the examined section is essentially equivalent in age and environment to that of the Sknonun Formation of British Columbia, as described by Martin and Rouse (1966). Although their conclusions are admittedly tenuous, they feel the age of this unit is most probably Late Miocene or Early Pliocene. Wolfe and others (1966) subdivided the southcentral Alaska Tertiary into three broad floral groups, the Seldovian, the Homerian and the Clamgulchian. Although the ages assigned here are highly uncertain the Seldovian would appear

to be aarly to middle Miocene with the possibility of some Oligocene at the base. The Homerian is thought to be mostly or entirely late Miocene, while the Clamgulchian is at least partly Pliocene.

I would suggest that the upper part of the section examined in this well is equivalent to the Homerian while the lower part is Seldovian (Figure 2). The Clamgulchian in Alaska is a very impoverished flora, and it would appear that the comparatively abundant microflora recovered from this well generally represents temperate to warm temperate plants, is older than this. It is possible that Pliocene is present in the upper cemented and unsampled part of the well.

Consequently, I suggest that the sediments in this well are entirely Miocene, although possibly a bit of Oligocene is present at the bottom. My own observations indicate that coastal Oligocene, at least in Oregon, contain schizaeaceous spores which are not present in any of the assemblages here. Therefore, I would suggest if Oligocene is present, it would be only a small amount from the upper part of the Oligocene.

Another method of suggesting age might be the use of Miocene-Pliocene mean temperature curves, established by a number of workers on a number of floras (mainly utilizing various megafossil groups), i.e. Brooks, (1951); Dorf, (1955); Wolf and Hopkins, (1967); Tanai and Huzioka, (1967). Although the analyses differ in detail, the general picture indicated by most investigators is a warm peak in late early or middle Miocene, followed by a general cooing into the Pleistocene. The early Miocene is considered to be somewhat cooler than the middle Miocene. If we look at the vegetative proportions with this concept in mind we find the lowest proportion of Pinaceae and Maximum Taxodiaceae at about 1707 meters (5600 feet). A marked reduction in the total

percentage of angiosperms also takes place in this zone. This then could prepresent the thermal maximum of the middle Miocene. The general increase of the Pinaceae and decrease of the Taxodiaceae below this zone, could indicate the slightly cooler early Miocene. The gradual cooling from middle to Late Miocene would explain thessteady increase in the Pinaceae (mostly pine, spruce and hemlock) and the ferns. During this same interval the Taxodiaceae and the angiosperms show a decrease in abundance.

Therefore, in broadly general terms, interpreted climatic trends compliment the interpretations made by floral comparisons with Alaska, British Columbia and the northwest United States. I must hasten to reemphacize this is all very tenuous at the present time. Floral comparisons can only be suggestive because the floras to which comparisons are made are themselves only tenuously dated. Furthermore, the interpreted climatic changes are suspect, largely because the apparent change in floras as revealed by percentages may be an artifcat of method rather than indicative of significant floral changes.

However, the suggestion is there of a Miocene age, and until further studies on wells and outcrop data are completed, further discussion must be suspended.

ENVIRONMENT

Deposition would appear to have been on a continuously subsiding coastal plain, apparently subsiding rapidly enough to prevent accumulation of organic deposits such as peat. The intermittent and always low frequency of phytoplankton (Fig. 7) suggests deposition at, or occasionally slightly below, sea level. Subsidence was remarkably rapid, permitting the accumulation of 3050 meters (10,000 feet) of clastic sediment during a period no longer, or only slightly longer than the Miocene. Assuming

a 20 million year length for the Miocene this is an accumulation of about .3 meters (1 Foot) every 2000 years.

The plants indicate a warm temperate climate for the middle Miocene ranging to perhaps temperate at the end of the epoch. The presence of Nyssa, Taxodium, Metasequoia, Alnus, Betula and other genera would indicate a comparatively damp climate with abundant rainfall. Temperatures below freezing must have been absent or very rare.

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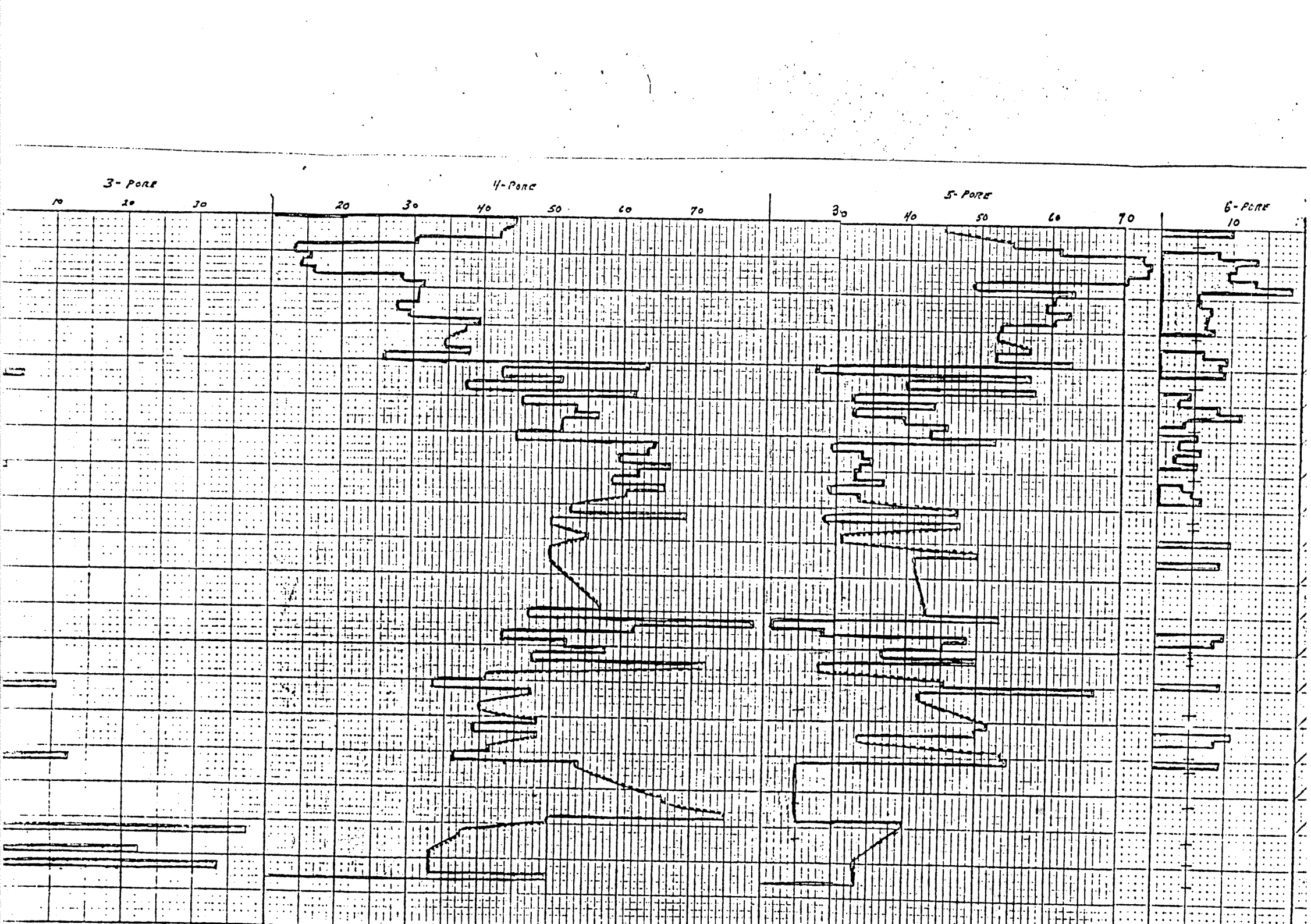
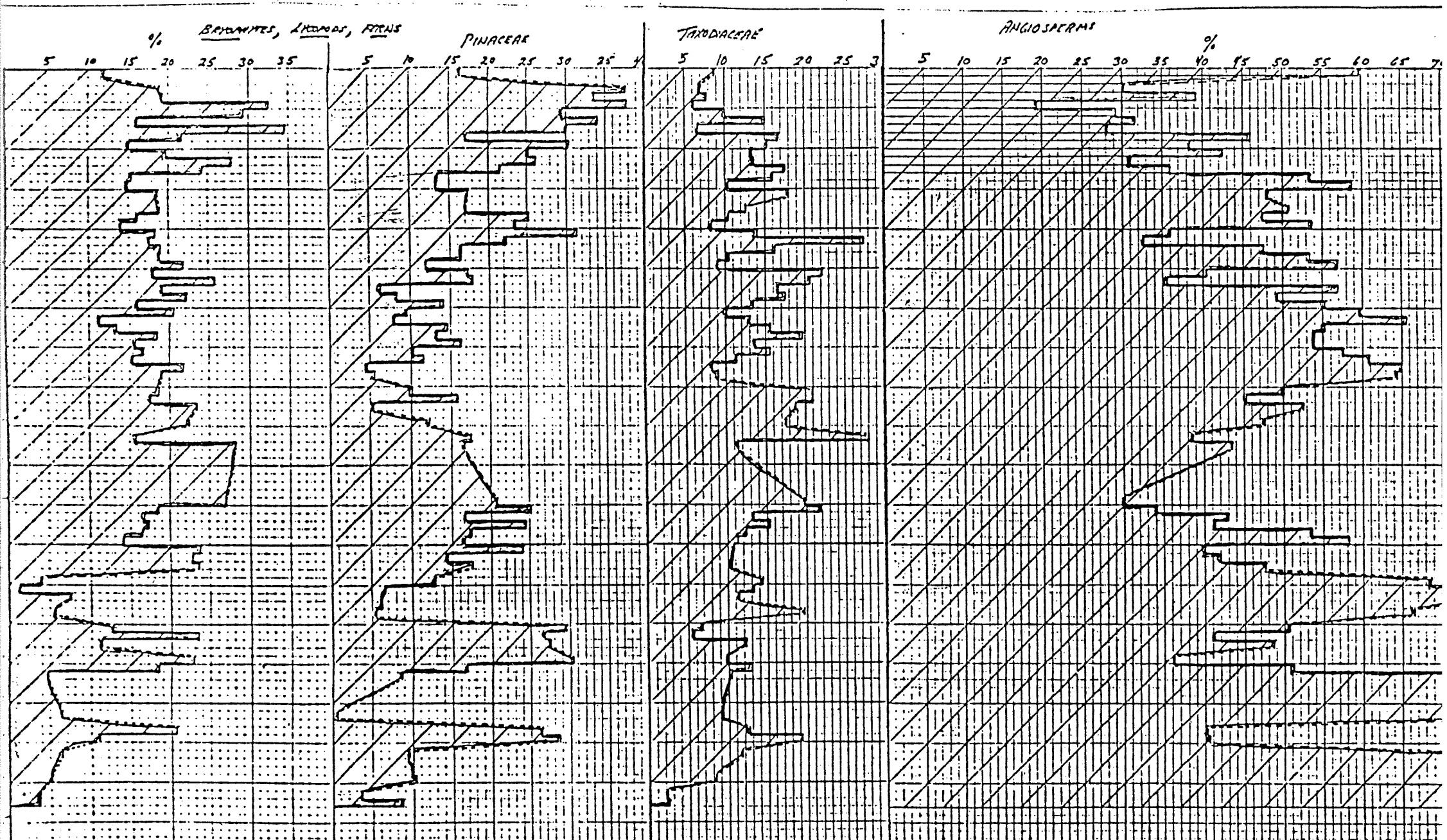
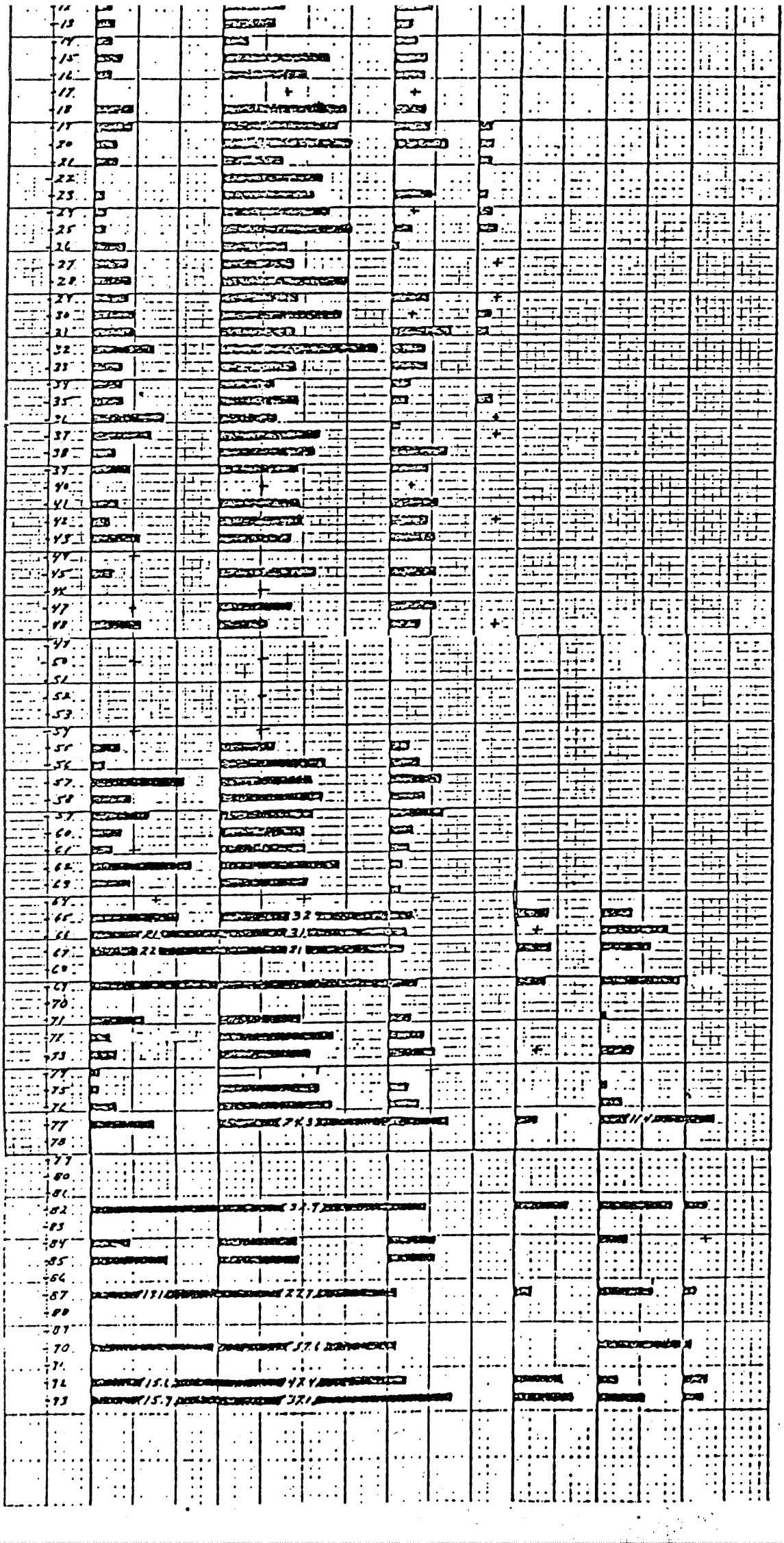
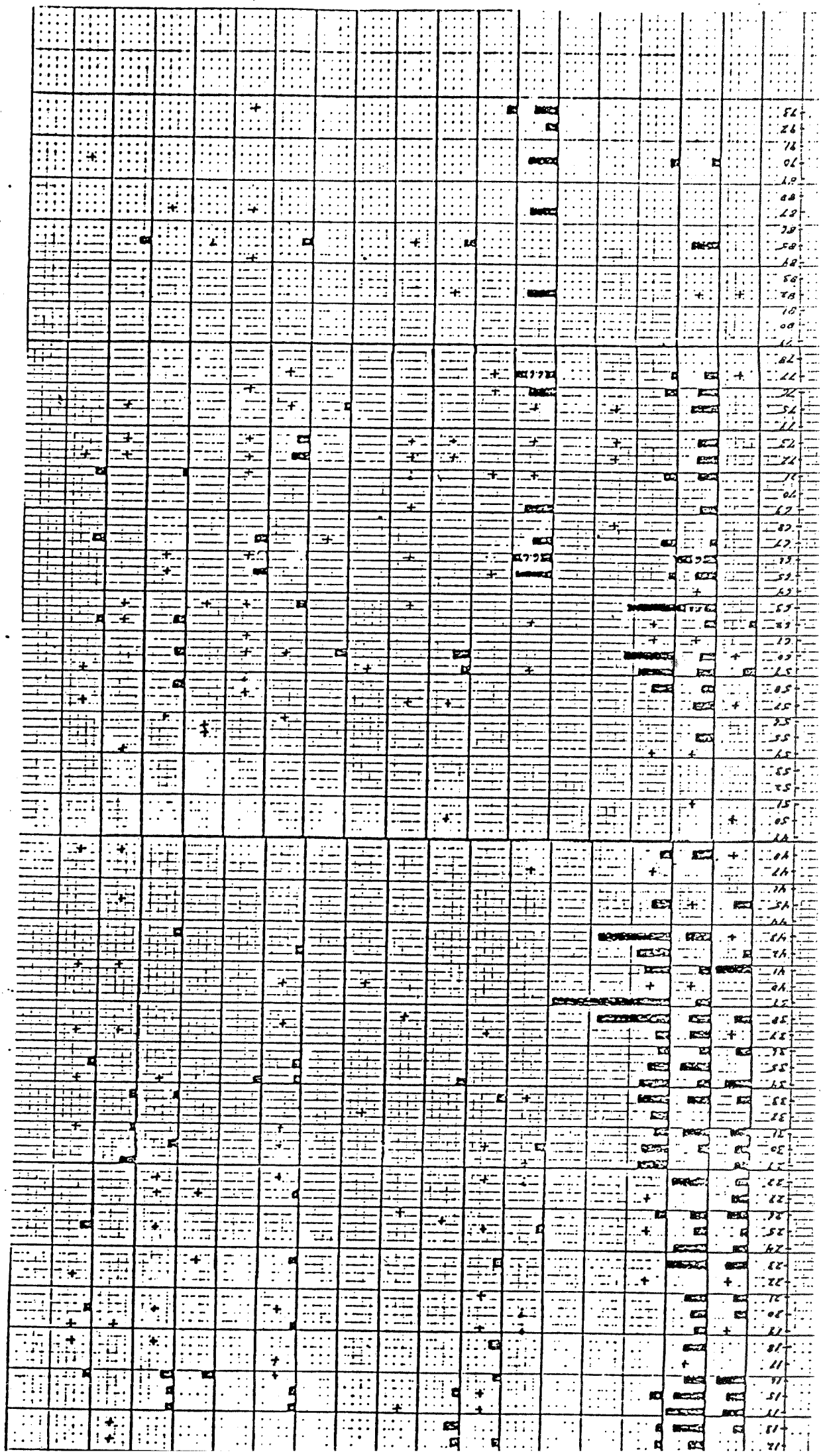
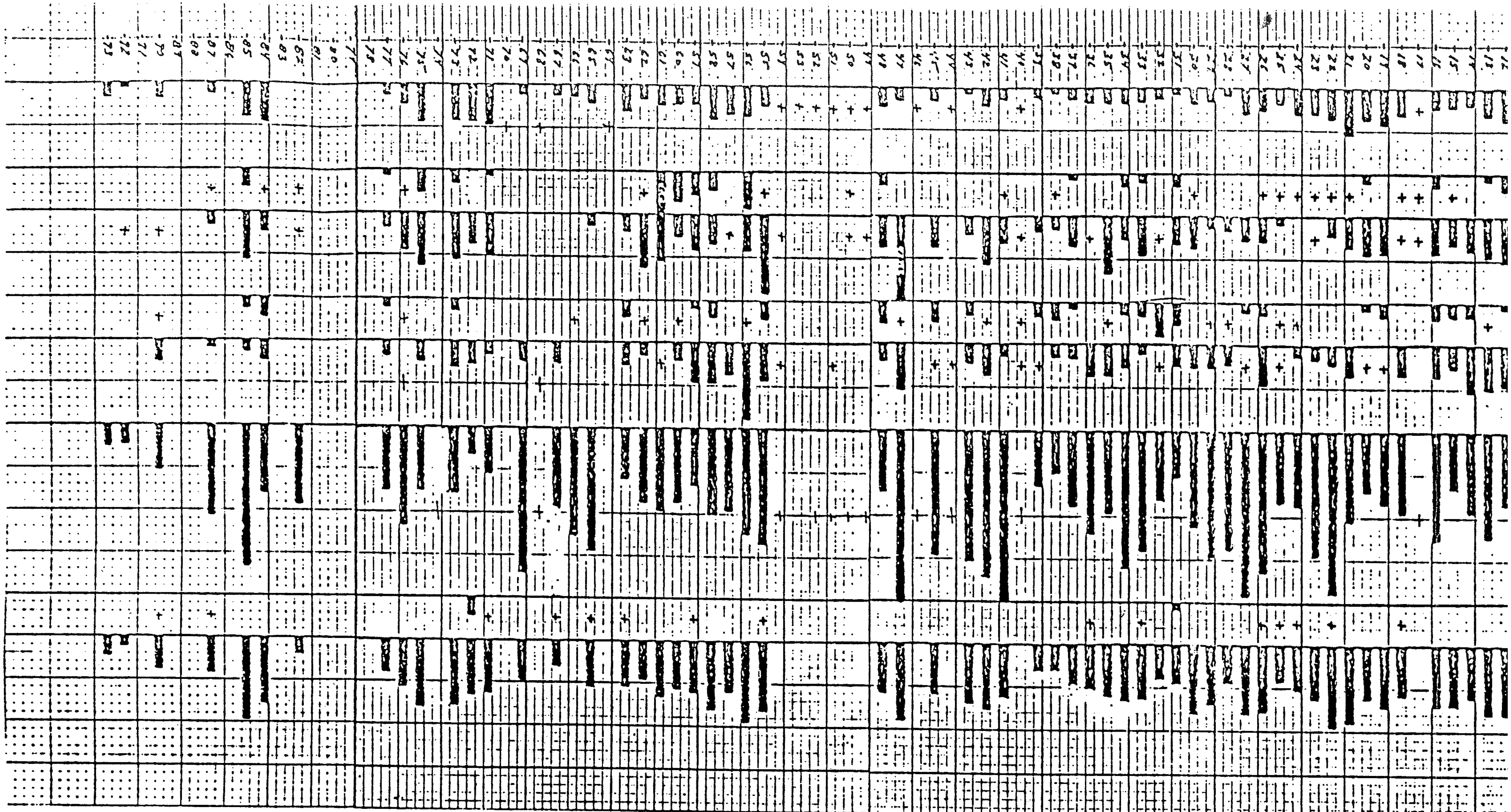
LIST OF FIGURES

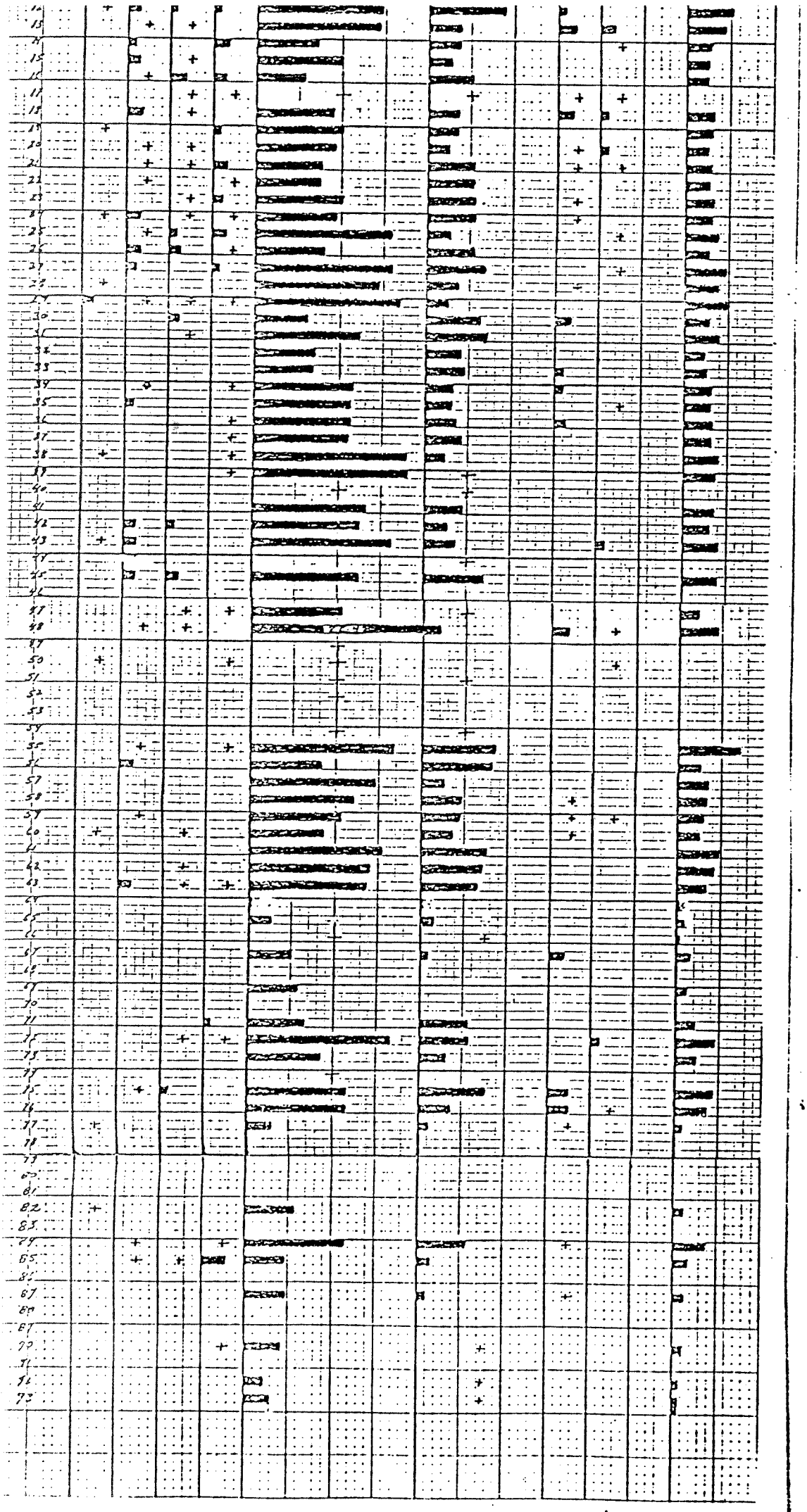

3- PORE
10
20
30
4- PORE
20
30
40
50
60
70
5- PORE
30
40
50
60
70
6- PORE
10


%
BRYOPHYTES, LYCOPODS, FERNS
5 10 15 20 25 30 35
PINACEAE
5 10 15 20 25 30 35
TAXODIACEAE
5 10 15 20 25
ANGIOSPERMS
%
5 10 15 20 25 30 35 40 45 50 55 60 65









2650	2700	733-15	
2750	2800	733-16	
2850	2900	733-17	
2950	3000	733-18	
3050	3100	733-19	
3150	3200	733-20	
3250	3300	733-21	991 - 1006
3350	3400	733-22	
3450	3500	733-23	
3550	3600	733-24	
3650	3700	733-25	
3750	3800	733-26	
3850	3900	733-27	
3950	4000	733-28	
4050	4100	733-29	
4150	4195	733-30	
4213	4263	733-31	1293 - 1302
4346	4367	733-32	
4470	4525	733-33	
4557	4582	733-34	
4641	4671	733-35	
4733	4784	733-36	
4816	4878	733-37	
4963	4990	733-38	
5014	5111	733-39	
5150	5190	733-40	
5245	5275	733-41	1599 - 1608
5363	5376	733-42	
5457	5475	733-43	
5563	5573	733-44	
5658	5708	733-45	
5820	5910	733-46	
6000	6040	733-47	
6100	6120	733-48	
6250	6317	733-49	
6348	6378	733-50	
6459	6512	733-51	1962 - 1972
6554	6621	733-52	
6684	6714	733-53	
6745	6779	733-54	
6833	6902	733-55	
6958	6988	733-56	
7051	7082	733-57	
7144	7175	733-58	
7237	7270	733-59	
7335	7367	733-60	
7456	7467	733-61	2266 - 2276
7534	7550	733-62	
7640	7660	733-63	
7750	7760	733-64	
7871	7920	733-65	
7960	7990	733-66	
8050	8070	733-67	
8160	8170	733-68	
8260	8270	733-69	
8360	8370	733-70	
8460	8470	733-71	2579 - 2582
8560	8570	733-72	
8660	8670	733-73	
8760	8780	733-74	
8860	8880	733-75	
8950	8960	733-76	
9050	9060	733-77	
9160	9170	733-78	
9260	9270	733-79	
9360	9370	733-80	
9460	9470	733-81	
9560	9574	733-82	2883 - 2917
9660	9670	733-83	
9760	9770	733-84	
9860	9870	733-85	
9960	9970	733-86	
10,060	10,070	733-87	
10,160	10,170	733-88	
10,260	10,275	733-89	
10,360	10,370	733-90	
10,460	10,470	733-91	3188 - 3191
10,560	10,570	733-92	
10,620	10,630	733-93	

ESTIMATED

UPPER MIOCENE/
MIDDLE MIOCENE

ESTIMATED

MIDDLE MIOCENE/
LOWER MIOCENE

P R E L I M I N A R Y _ R E P O R T

PALYNOLOGICAL STUDY OF SHELL ANGLO AUKLET G-41

W.S. Hopkins, Jr.

Introduction and Geology

Information in this section was largely derived from Shell Canada (1968). The well was located approximately 132 kms (82 miles) southeast of Sandspit Queen Charlotte Island and approximately 14 kms (9 miles) east-southeast of the Shell Anglo Murrelet L-15 well. The location is 52°20'16.119"N; 130°36'32.772"W and located in water 556 feet deep. Spudding took place 14 August 1968; the well was plugged and abandoned 28 August 1968 at a totoal depth of 12,513 m (7777 feet).

Clastic sediments, almost completely sand made up the penetrated section although a few very minor mudstone, siltstone and shale beds were encountered. Lignite or coal seems to be totally absent. Weathered volcanic rocks were encountered at 11,391 m (7080 feet) and continued to total depth. No conventional cores were taken but threesidewall core runs were made. However, these latter were tested to destruction by the operator and were not available to me.

Palynology

Although 64 samples were processed and examined only 15 yielded sufficeint palynomorphs to be used. The cuttings were largely sandbut were carefully prepared using the same methods described in the Murrelet L-15 well palynology report.

Because recovery was so poor and little statistical data was possible stratigraphic or environmental conclusions are not possible.

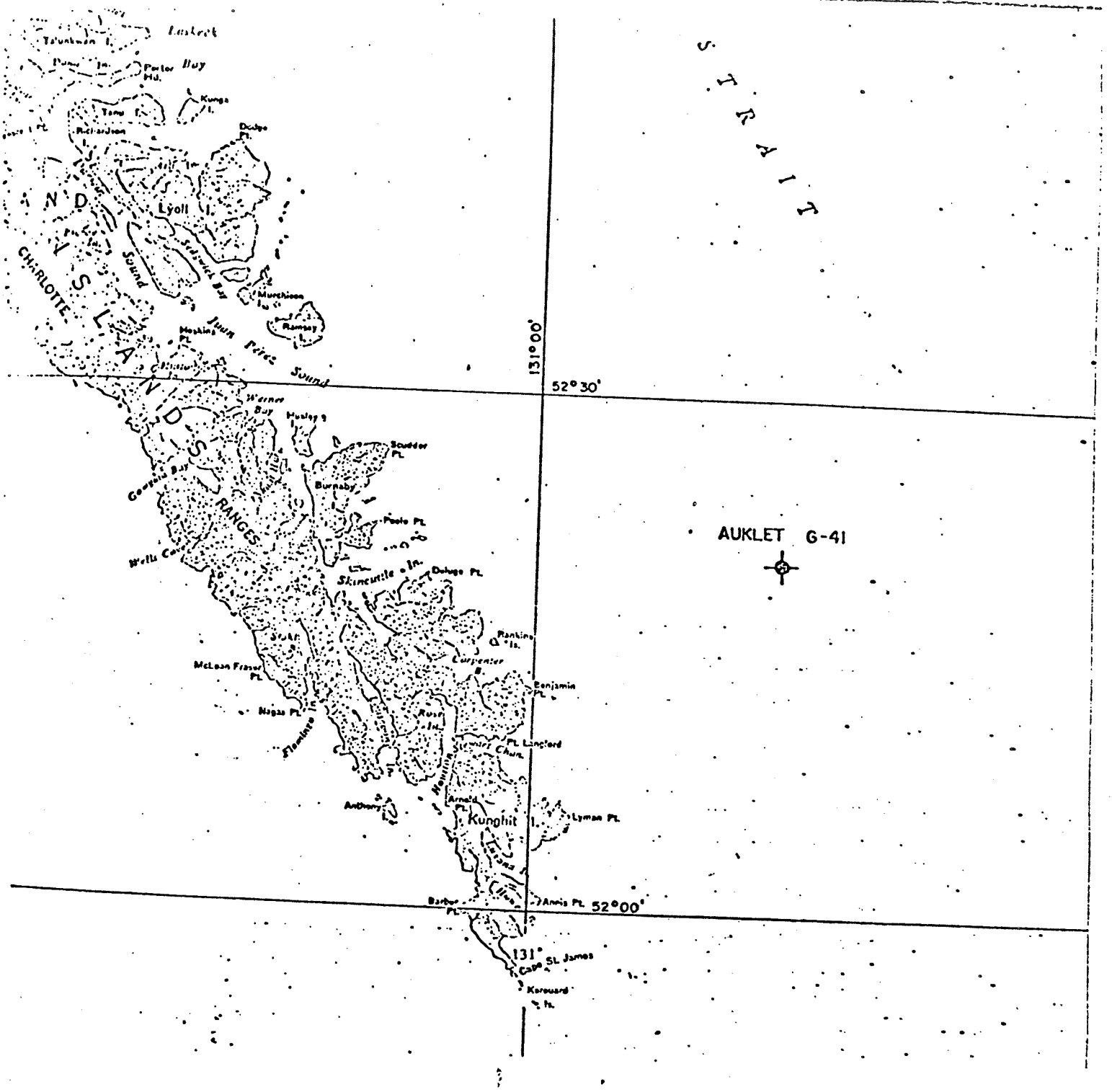


Figure 1. Index map Showing Location of Shell Anglo Auklet G-41. Taken from Well History Report (Shell Canada Limited, 1968)

SAMPLE No.	DEPTH FEET	DEPTH METERS
1	1330-50	
2	1408-37	
3	1493-1520	
4	1727-50	
5	1874-1901	
6	2057-89	
7	2089-2120	
8	2150-82	
9	2276-2307	
10	2397-2429	
11	2460-2493	
12	2586-2617	
13	2617-2650	
14	2775-2808	
15	2899-2929	
16	2992-3021	
17	3021-3053	
18	3082-3114	
19	3177-3210	
20	3210-40	
21	3340-72	
22	3362-93	
23	3393-3429	
24	3455-90	
25	3470-3527	
26	3588-3641	
27	3694-3715	
28	3777-3808	
29	3870-3901	
30	3965-4007	
31	4007 [illegible]	
32	4008-4120	
33	4150-80	
34	4180-4213	
35	4245-75	
36	5000-31	
37	missing	
38	5277-5862	
39	6135-64	
40	6225-6330	
41	6371-6421	
42	6483-6571	
43	6571-6632	
44	6693-6789	
45	6789-6882	
46	6977-7009	
47	7059-97	
48	7060-70	
49	7090-7100	
50	7140-50	
51	7190-7200	
52	7240-50	
53	7290-7300	
54	7340-50	
55	7390-7400	
56	7440-50	
57	7480-7500	
58	7540-50	
59	7590-7600	
60	7640-50	
61	7690-7700	
62	7720-30	
63	7730-40	
64	7740-50	

PLIOCENE/
UPPER MIOCENE

UPPER MIOCENE/
MIDDLE MIOCENE

MIDDLE MIOCENE/
LOWER MIOCENE

AUKLET G-41

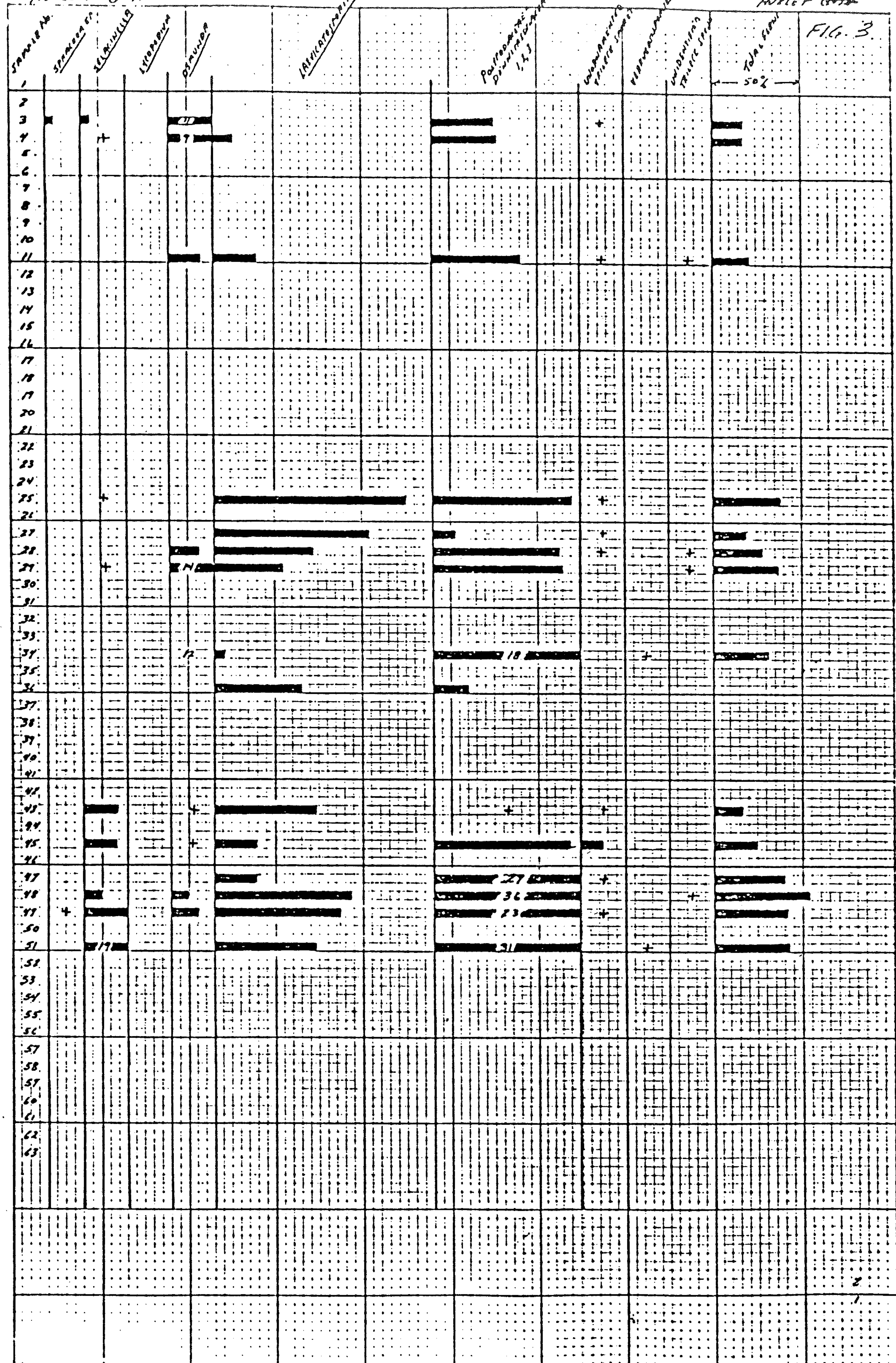
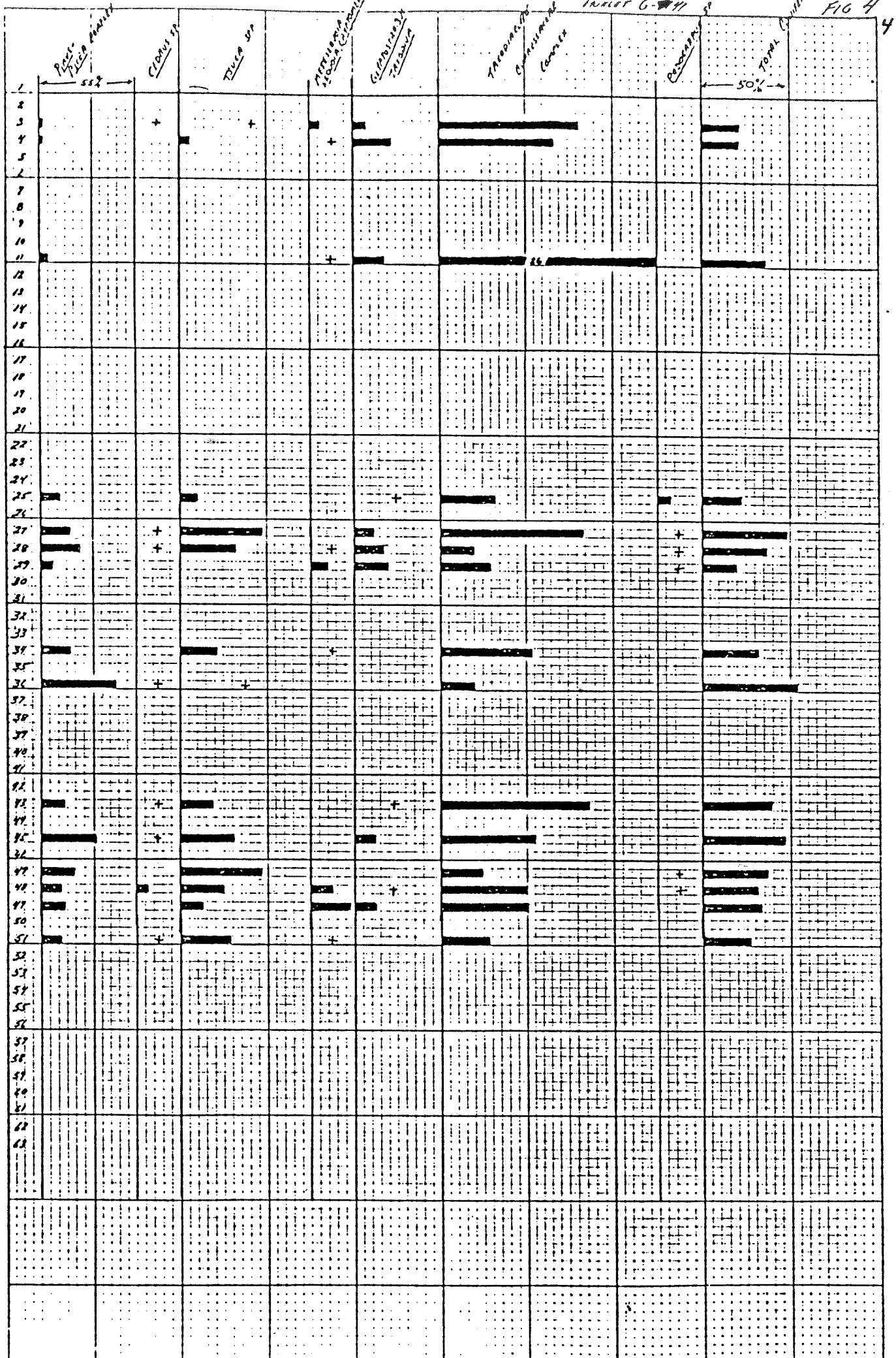


FIG. 3

FIG 4


Pinus ponderosa
55%
Cedrus sp.
Tsuga sp.
Abies concolor & grandis
Calocedrus decurrens
Taxodiaceae/Cupressaceae/Cornaceae
Pseudotsuga
50% TOTAL
Quercus
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
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59
60
61
62
63

AUKLET G-41

AUKLET G-14

FIG 5

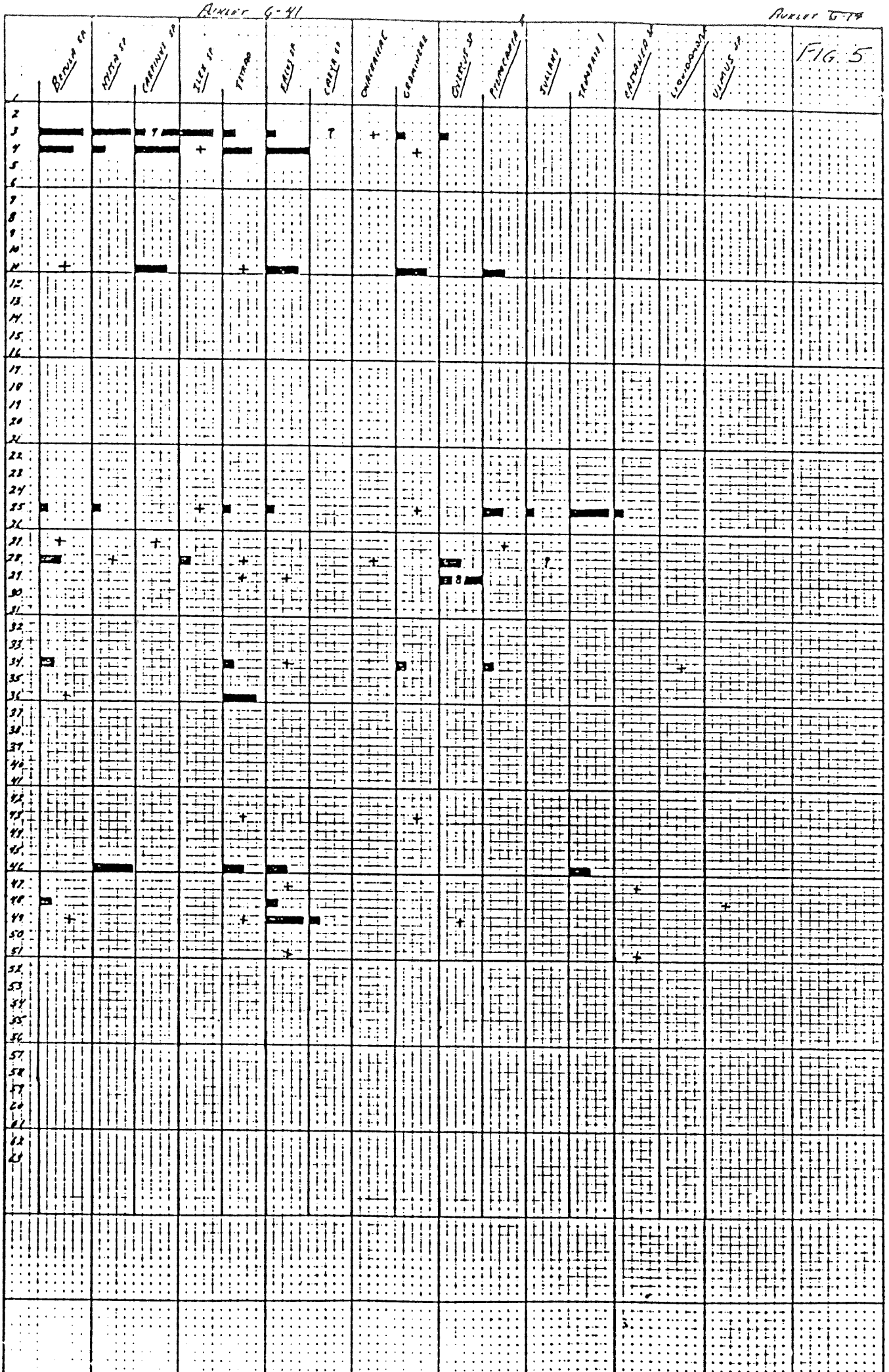
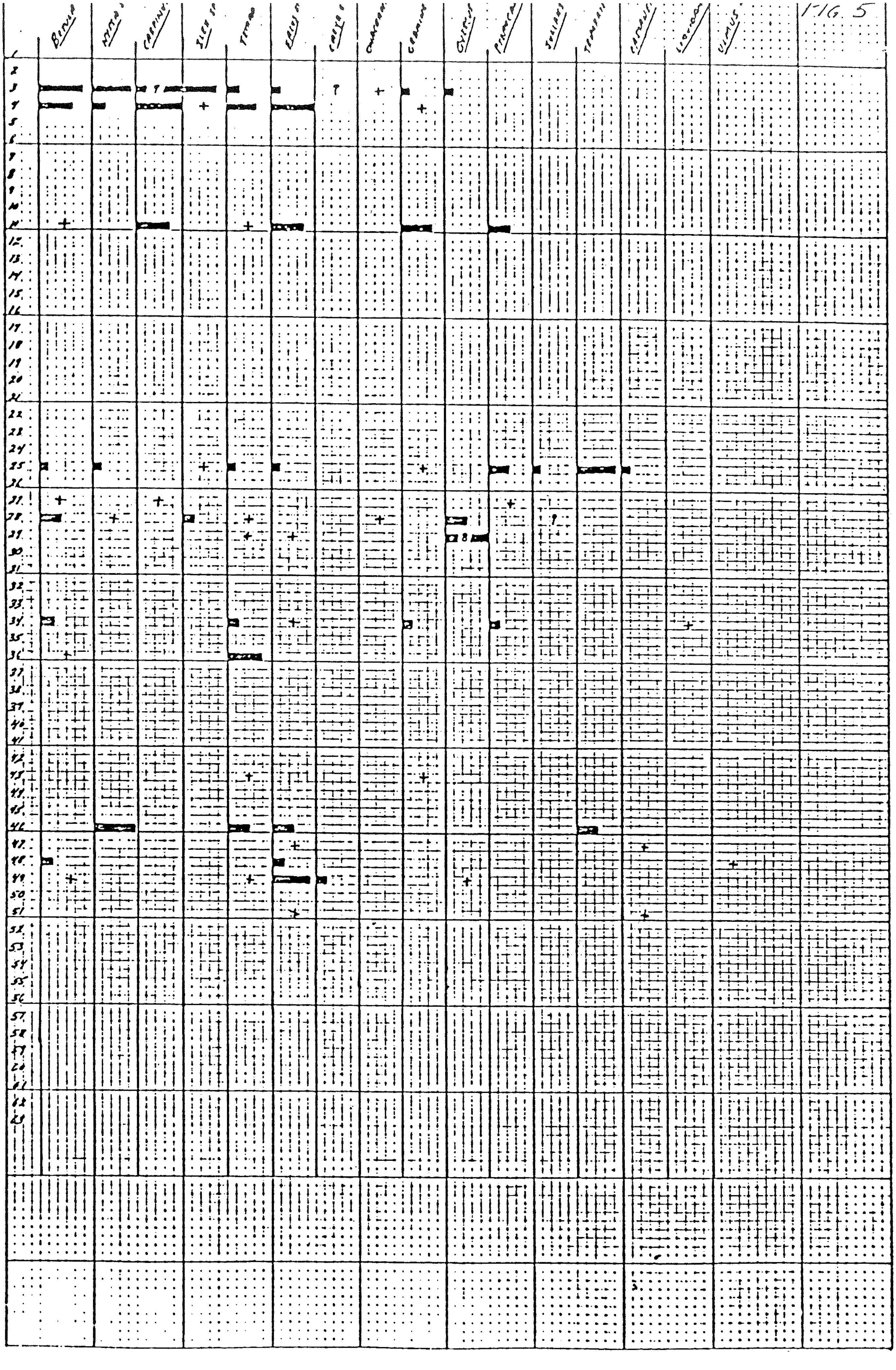


FIG. 5



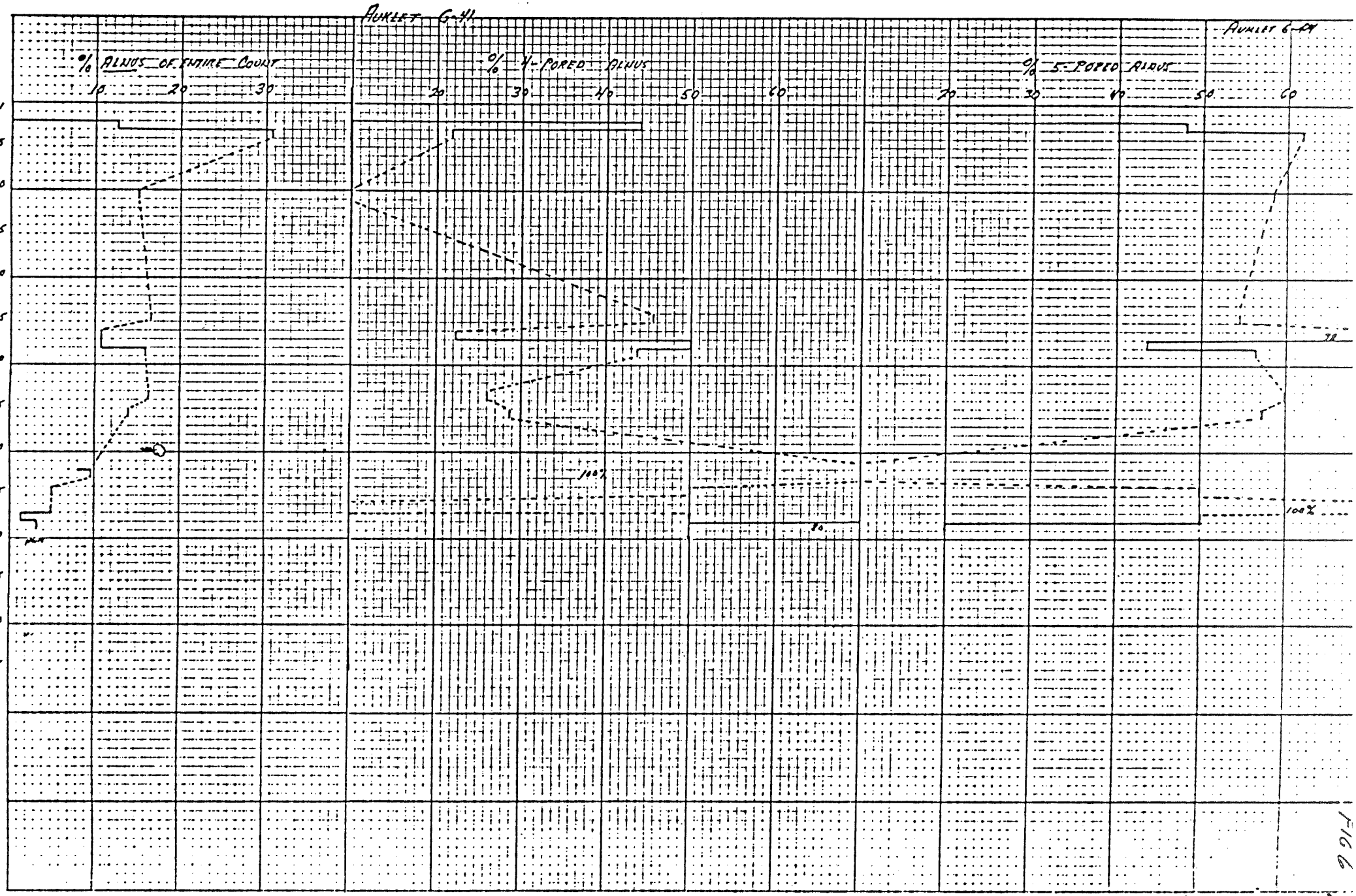

AUKLET 6-41
% ALNUS OF ENTIRE COUNT
10
20
30
% 4-PORED ALNUS
20
30
40
50
60
% 5-PORED ALNUS
70
30
40
50
AUKLET 6-84
60
1
5
10
15
20
25
30
35
40
45
50
55
60
65
100%
100%

FIG 6

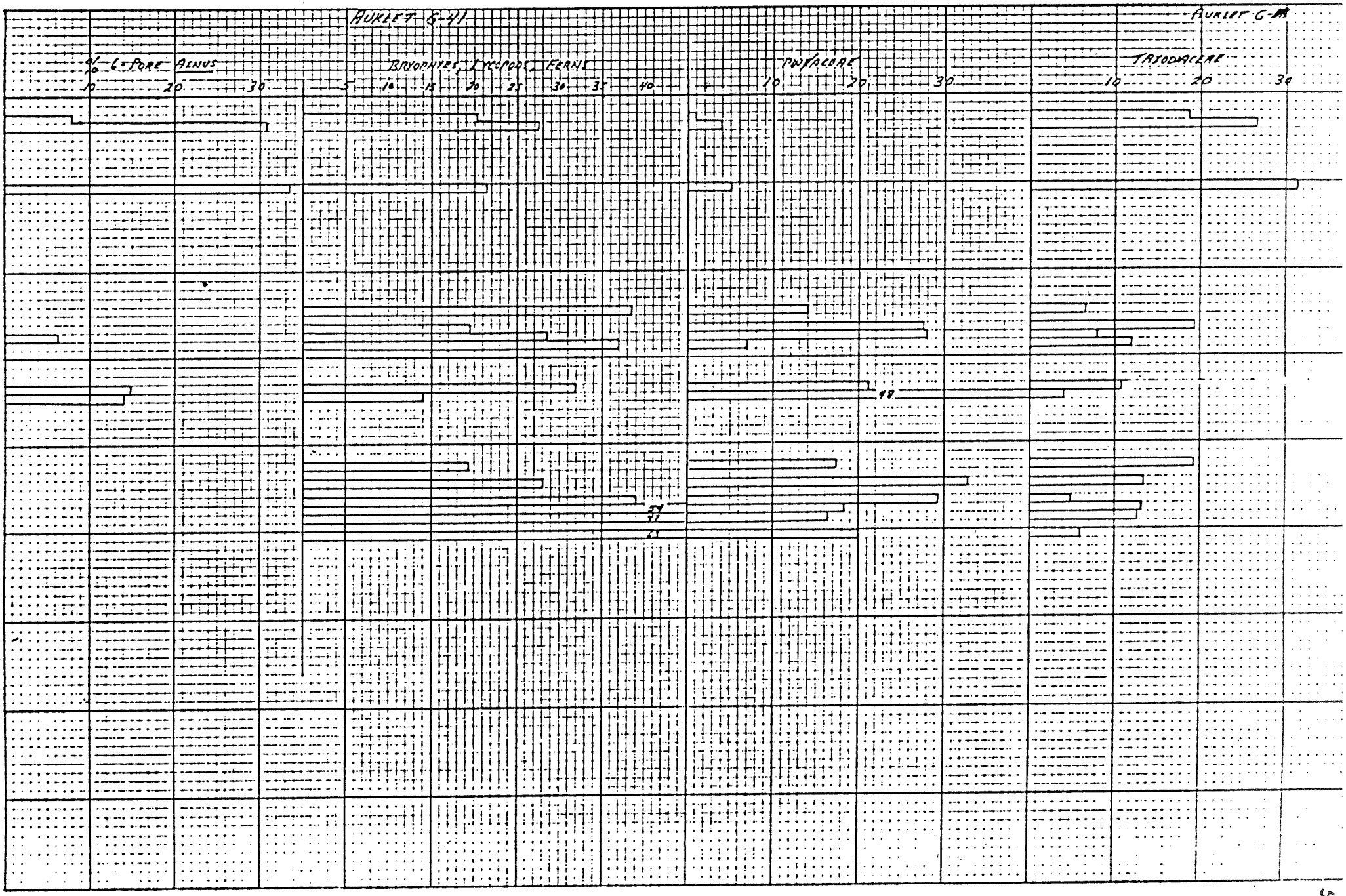

AUKLET 8-41
% L. PORE ALNUS
10
20
30
BRYOPHYTES, LYCOPODS, FERNS
5
10
15
20
25
30
35
40
PINACEAE
10
20
30
AUKLET G-
TAXODIACEAE
10
20
30
1
5
10
15
20
25
30
35
40
45
50
55
60
65
18
57
31
23

FIG. 8

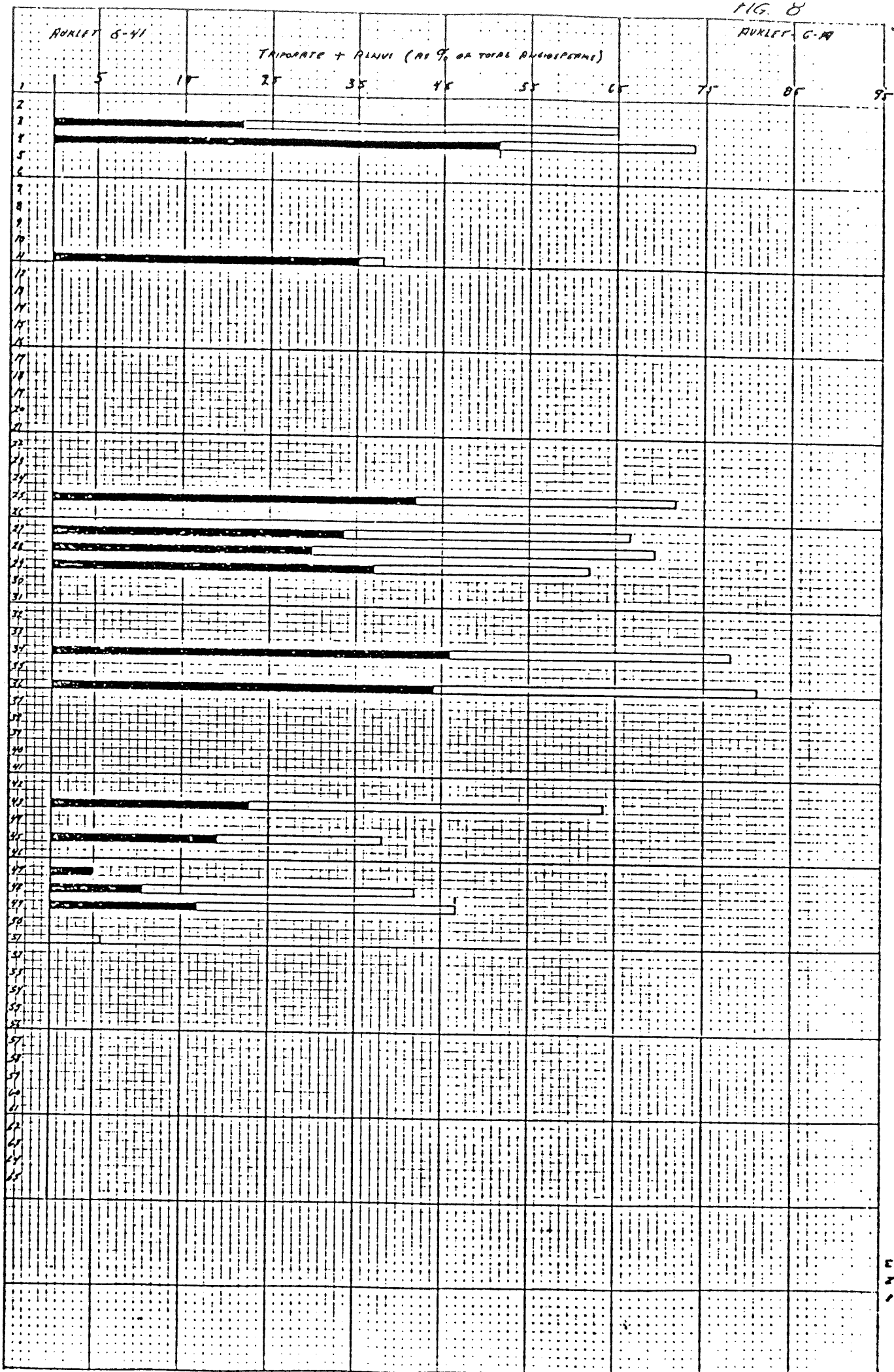
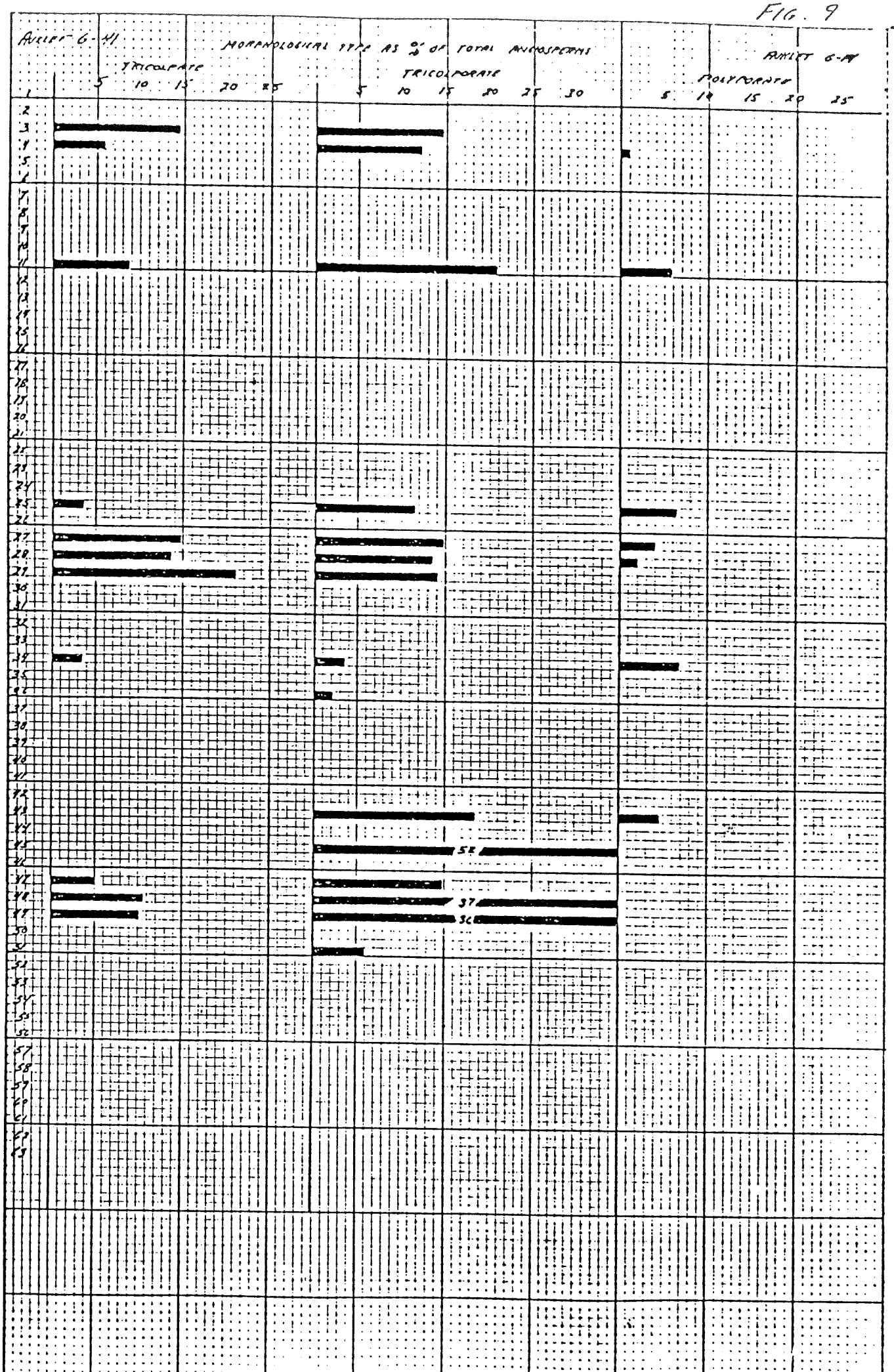
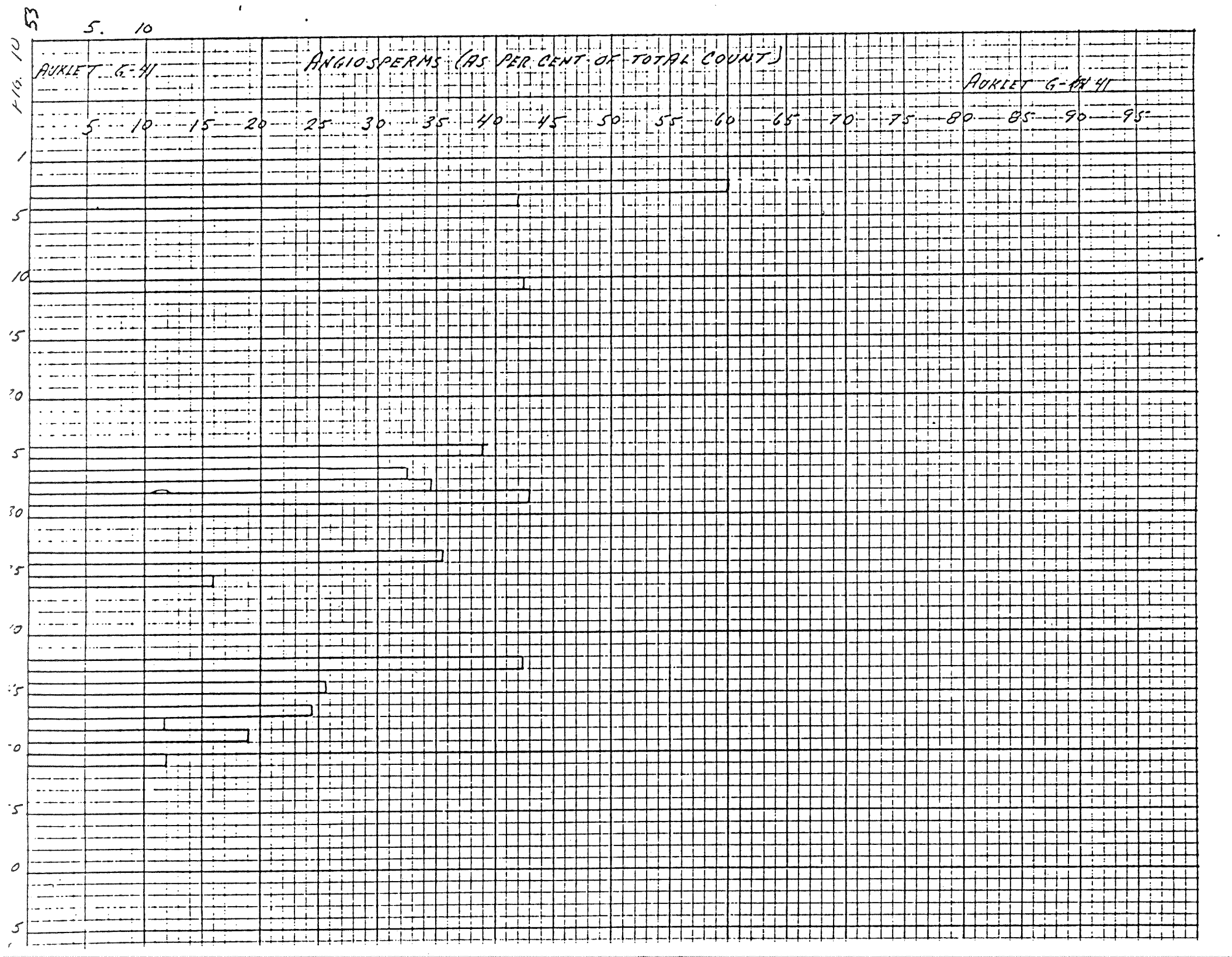

AUKLET 6-41
AUKLET C-M
TRIPORATE + ALNUI (AS % OF TOTAL ALKOXYPYRANS)
1
5
15
25
35
45
55
65
75
85
95

FIG. 9


AUSLEY 6-41
MORPHOLOGICAL TYPE AS % OF TOTAL ANGIOSPERMS
TRICOLPATE
TRICOLPORATE
POLYPORATE
RAMLEY 6-A
5
10
15
20
25
30
58
37
36


AUKLET G-41
ANGIOSPERMS (AS PER CENT OF TOTAL COUNT)
AUKLET G-41
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95

PRELIMINARY REPORT

PALYNOLOGICAL STUDY OF SHELL ANGLO MURRELET L-15

W. S. Hopkins, Jr.

Introduction and Geology

Information in this section was largely derived from Shell Canada (1969).

This well, drilled as the final test in Shells west coast exploratory drilling program, lies about 32 km (20 miles) east of Scudder Point, Queen Charlotte Islands at 52°24'41.3"N, 130°47'38.0"W, British Columbia. Spudding took place on 11 April 1969; the well was plugged and abandoned on 4 May 1969 at a total depth of 2019 m (9578 feet). Drilling was from a floating platform in 111 m (364 feet) of water.

Clastic sediments, largely sand, but also interbedded siltstones, shales and lignites were encountered from surface to 2804 m (9200 feet), and interbedded volcanics and sands from 2804 m (9200 feet) to total depth. Unfortunately samples are missing from the interval 1190 to 2097 m (3905-6881 feet), the explanation being that the "fine cuttings went through shaker." No conventional cores were taken but three sidewall core runs were made. However, these latter sidewall cores were tested to destruction by the operator and were not available to me.

Palynology

At the beginning of this study I had hoped to be able to correlate this well with the Shell Anglo Harlequin D-86 which was reported on earlier (Hopkins, 1975). Although they are only 80 km (50 miles) apart and although they generally appear to consist of the same age rocks, there are no zones which are correlatable at this time. Whether this is the result of environmental differences, the somewhat different treatment the rock samples received in the laboratory, or the comparatively short period of time represented in a thick sequence of sediments I can

not say. Probably a combination of factors is responsible.

Palynomorph preservation, on the whole, was fair, but the quality of preservation tended to decrease down-hole. Many of the grains tended to be abraided or crushed, but identification was usually possible. As in the Anglo Harlequin, the variety of taxa was limited. Regardless of whether compilation involved plotting of more specific taxa, or groups of taxa, the results were inconclusive. The accompanying charts are mainly the result of considerable lumping.

Because of the unconsolidated nature of the sediments, the rapid rate of bit penetration and the lack of cores, the results are inconclusive for correlation, and to a lesser extent for age and environment. However, there are several broad trends, apparent on the range charts, which may have significance.

1) There is a pronounced increase in the polypodiaceous and osmundaceous ferns, along with Selaginella, down-hole.
2) There is a marked decrease in the Pinaceae and an increase in the Taxodiaceae with depth.
3) A general decrease in angiosperm pollen occurs down-hole.

Because these are simple frequency percentages, the actual changes are probably more complicated than indicated. Other changes observed on the charts would appear to be without significance. It may be that the depositional environment may be responsible for these changes, but it may also reflect climatic variation, and this will be discussed in a later section.

Samples

As neither conventional nor sidewall cores were available to me, this study is based entirely on cuttings. Because of the unconsolidated nature of the sediments, the rapid rate of bit penetration and caving, the

palynological results from sample to sample tend to be unclear. In the preparation of these samples a laboratory technique was employed which we hape made the results more meaningful. Samples were dry sieved through 10 and 70 mesh schreens. The material retained on the 10 mesh size was assumed to be mainly cave, that passing through both the 10 and 70 mesh was considered to be largely drilling mud. Rock passing through the 10 mesh screen and retained on the 70 mesh was thought to be a representative sample of the material being drilled by the bit. Consequently, material that remained on the 10 mesh and passed through the 70 mesh was discarded. The material remaining on the 70 mesh screen was saved and macerated in the conventional way.

Correlation

At this time no direct correlations are possible with one other well which was reported on by Hopkins (1975). Samples from this well were macerated in the normal manner, but the dry sieving technique described previously, was not used, and this may have affected results. Furthermore, this well seems to have been drilled in essentially continental sediments, while the Anglo Harlequin penetrated sediments which appear to be brackish, or even marine. Consequently, the environment of deposition may have markedly affected pollen and spore distribution. What ever the reasons, zonal correlation between these two wells is not possible.

Age

As in the well discussed in my previous report, and for the same reasons, there seems to be no doubt this is a Neogene sequence, i.e. Miocene and/or Pliocene. Without detailed discussion I would suggest that

the upper portion of this well represents the Skonun Formation, which has surface exposures on the northern Queen Charlotte Islands, and which is considered to be either upper Miocene or lower Pliocene.

Furthermore, I would suggest that the sediments below 2097 m (6881 feet) are Miocene. If so, a Pliocene-Miocene contact exists in the large misssing interval, but this would be difficult to acertain on the evidence available. It is possible, as implied above, that the entire sequence of rocks is Miocene. There is no evidence that the bottom of the well has yet reached rocks of Oligocene age.

Environment

Deposition of these Neogene sediments preseumably was on some coastal plain, probably back some distance from the coast itself. The presence of such coniferous genera as Tsuga, Picea and Abies (although the latter two genera are not common) which now have a southern limit, corresponding approximately to the July isother of 21°C(70°F), indicating a summer average that didn't rise much above this figure. Additionally, the rather commong occurrence of Liquidambar, and the rare Juglans and Carya, all of which require summer temperatures of 18-21°C (64°70°F) support interpretations of mean summer temperatures near this level.

Additionally, the presence of Ilex, Taxodium and Glyptostrobus would indicate that winter temperatures seldom if ever fell below freezing. These and other genera, such as Alnus, indicate that precipitation was quite high. The mean July high temperature for the Queen Charlotte Island lowland is currently about 15°C (60°F) while the mean January temperature is perhaps 3°C (37°F). As a consequence it would seem the Miocene-Pliocene temperatures of this area were somewhat higher than now. It would probably have been considered a damp temperate to possibly

warm temperate climate.

The lower 800 m (2625 feet) of the well contains a microfloral assemblage which would appear to represent somewhat warmer conditions than that reflected higher up the hole. Possibly these may represent mid-Miocene rocks.

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Shell Canada Limited

1969: Well history report, Shell Anglo Murrelet L-15. Unpublished manuscript

LIST OF FIGURES

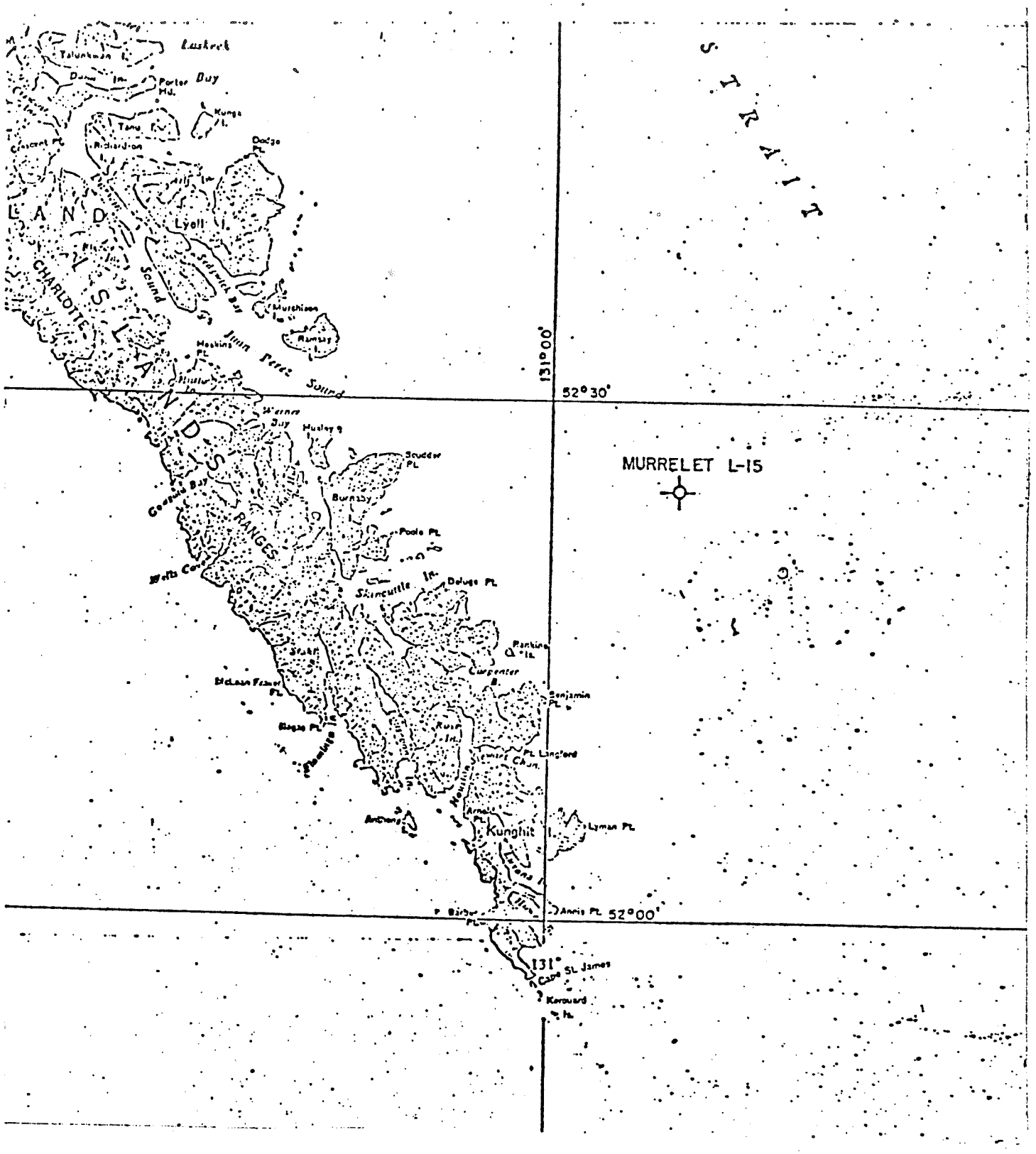


Figure 1. Index Map Showing Location of Shell Anglo Murrelet L-15. Taken from Well History Report (Shell Canada Limited, 1969)

GSC Locality No. C-3011 Z

SAMPLE NUMBER	DEPTH FEET	DEPTH METRES	
1	1105 - 1139	337 - 347	
2	1164 - 1200	355 - 366	
3	1258 - 1287	383 - 392	
4	1379 - 1380	411 - 421	
5	1472 - 1503	449 - 458	
6	1564	477	
7	1657 - 1681	505 - 512	
8	1760 - 1784	536 - 545	
9	1851 - 1902	564 - 579	
10	1943 - 1972	592 - 601	
11	2063 - 2093	629 - 638	
12	2157 - 2190	658 - 668	
13	2254 - 2283	687 - 696	
14	2376 - 2404	724 - 733	
15	2465 - 2497	751 - 761	
16	2558 - 2589	780 - 789	
17	2652 - 2684	808 - 818	
18	2748 - 2780	838 - 847	PLIOCENE —
19	2841 - 2872	866 - 875	
20	2965 - 2994	904 - 913	
21	3051 - 3084	931 - 940	? LATE MIOCENE
22	3145 - 3174	959 - 967	
23	3235 - 3265	986 - 995	
24	3338 - 3389	1029 - 1033	
25	3451 - 3493	1052 - 1062	
26	3545 - 3572	1081 - 1089	
27	3663 - 3693	1116 - 1126	
28	3754 - 3785	1144 - 1154	
29	3845 - 3875	1172 - 1181	
	SAMPLES	MISSING	
	IN THIS	INTERVAL	
30	6665 - 6759	2031 - 2060	
31	6881 - 6913	2097 - 2107	
32	6944 - 6974	2117 - 2126	
33	7067 - 7095	2154 - 2163	
34	7156 - 7187	2181 - 2191	
35	7250 - 7281	2210 - 2219	
36			
37	7341 - 7371	2238 - 2247	
38	7407 - 7437	2258 - 2267	LATE TO MIDDLE
39	7586 - 7570	2313 - 2313	
40	7610	2320	
41	7650 - 7660	2332 - 2335	MIOCENE
42	7750 - 7760	2362 - 2365	
43	7850 - 7860	2373 - 2394	
44	7950 - 7960	2425 - 2426	
45	8060 - 8070	2457 - 2460	
46	8170 - 8180	2490 - 2493	
47	8250 - 8260	2515 - 2518	
48	8350 - 8360	2545 - 2548	
49	8460 - 8470	2579 - 2582	
50	8560 - 8570	2609 - 2612	
51	8650 - 8660	2637 - 2640	
52	8760 - 8770	2670 - 2673	
53	8860 - 8870	2701 - 2704	
54	8960 - 8970	2731 - 2734	
55	9060 - 9070	2761 - 2765	
56	9160 - 9170	2792 - 2795	MIDDLE /
57	9260 - 9270	2822 - 2825	EARLY MIOCENE
58	9360 - 9370	2853 - 2856	
59	9460 - 9470	2883 - 2886	
60	9560 - 9570	2914 - 2917	

Figure 3

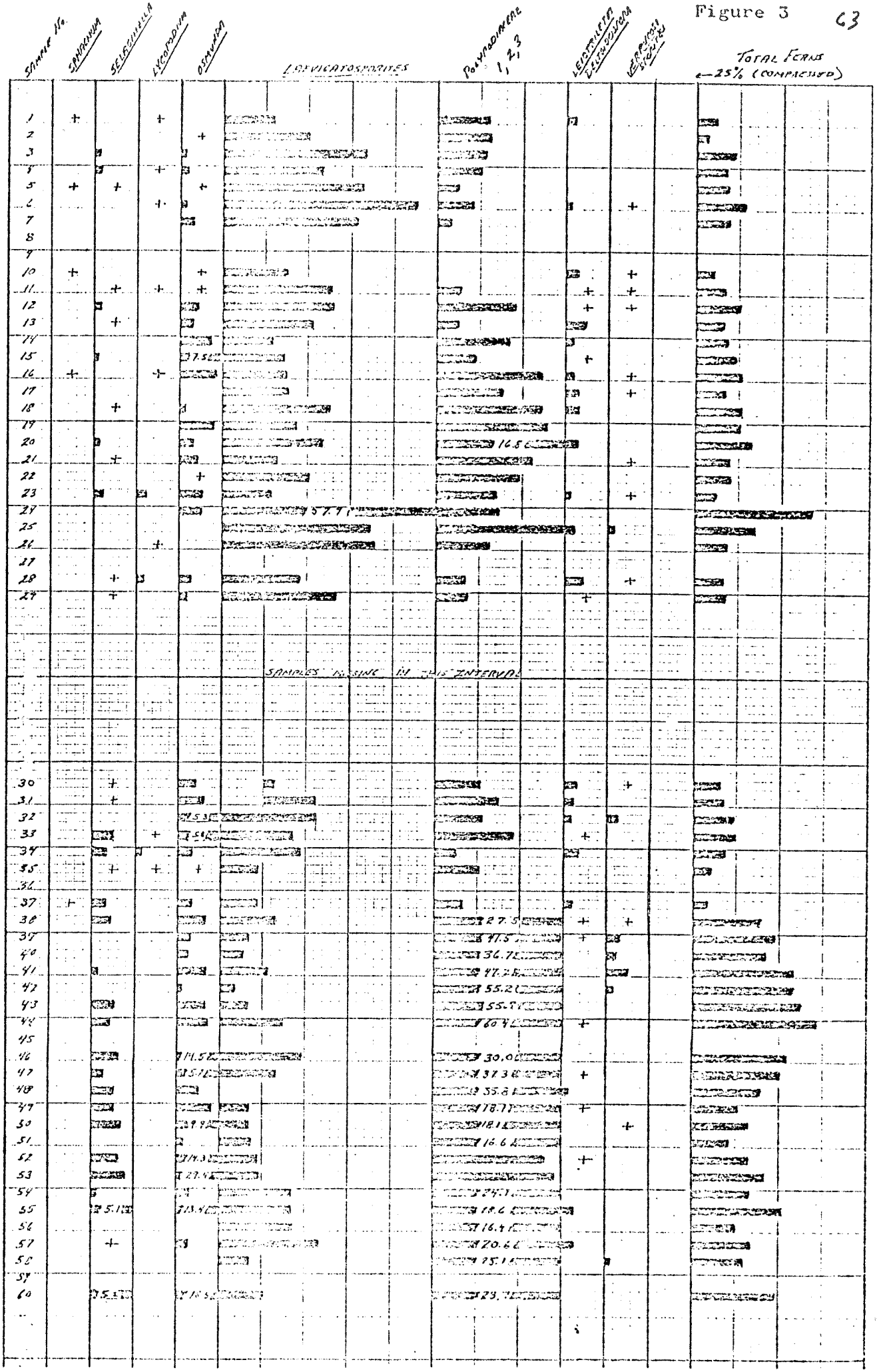
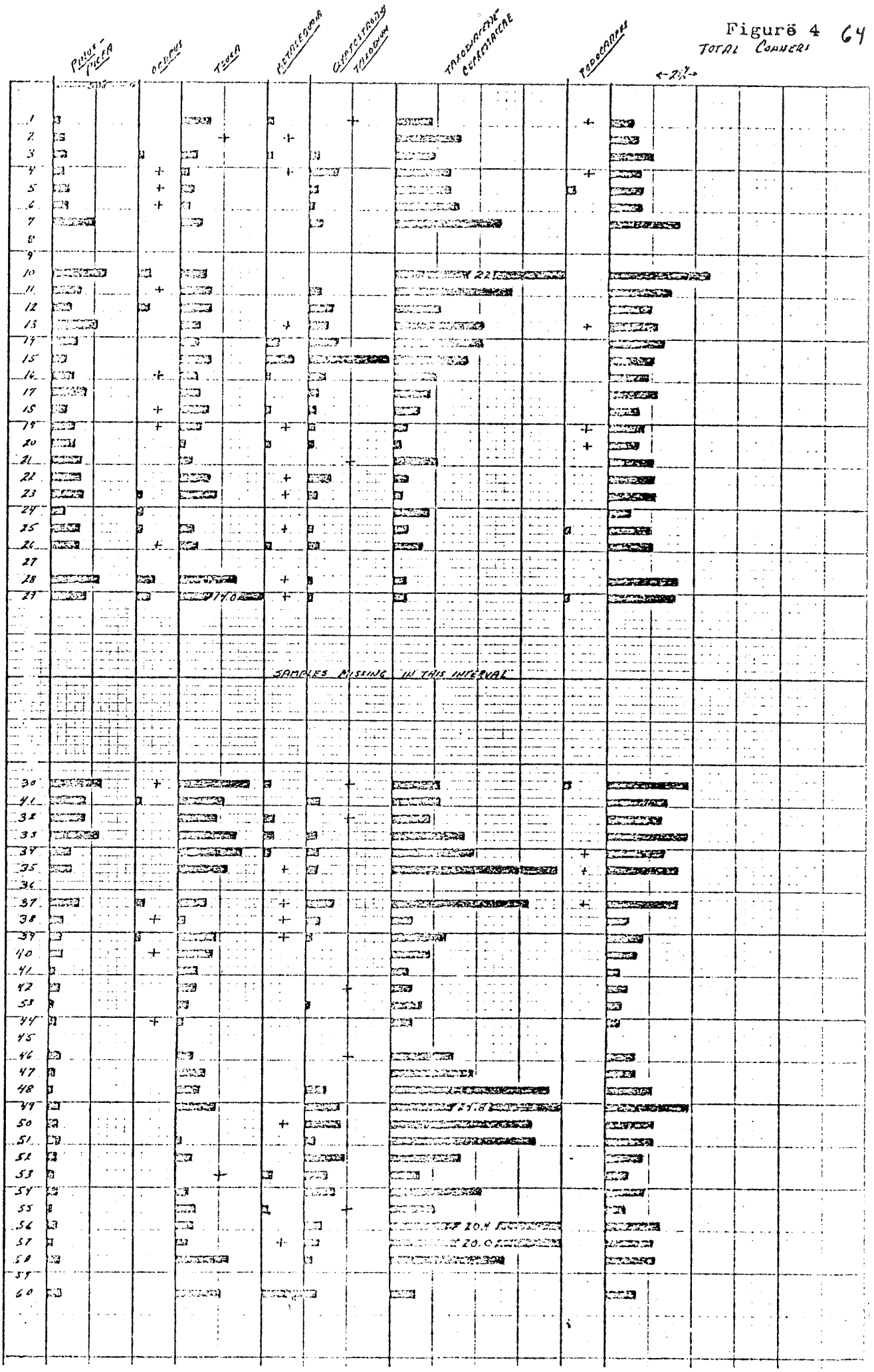
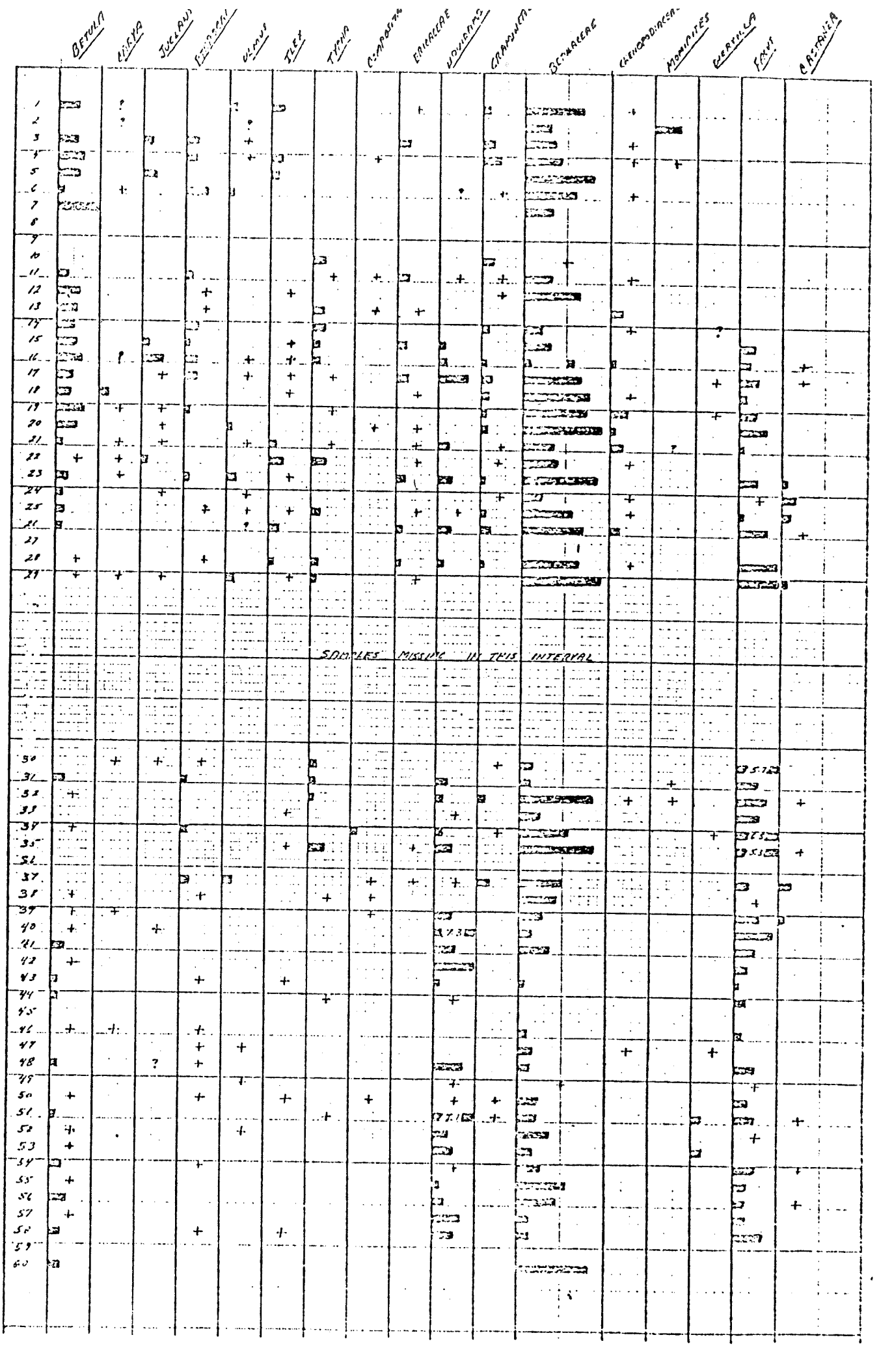
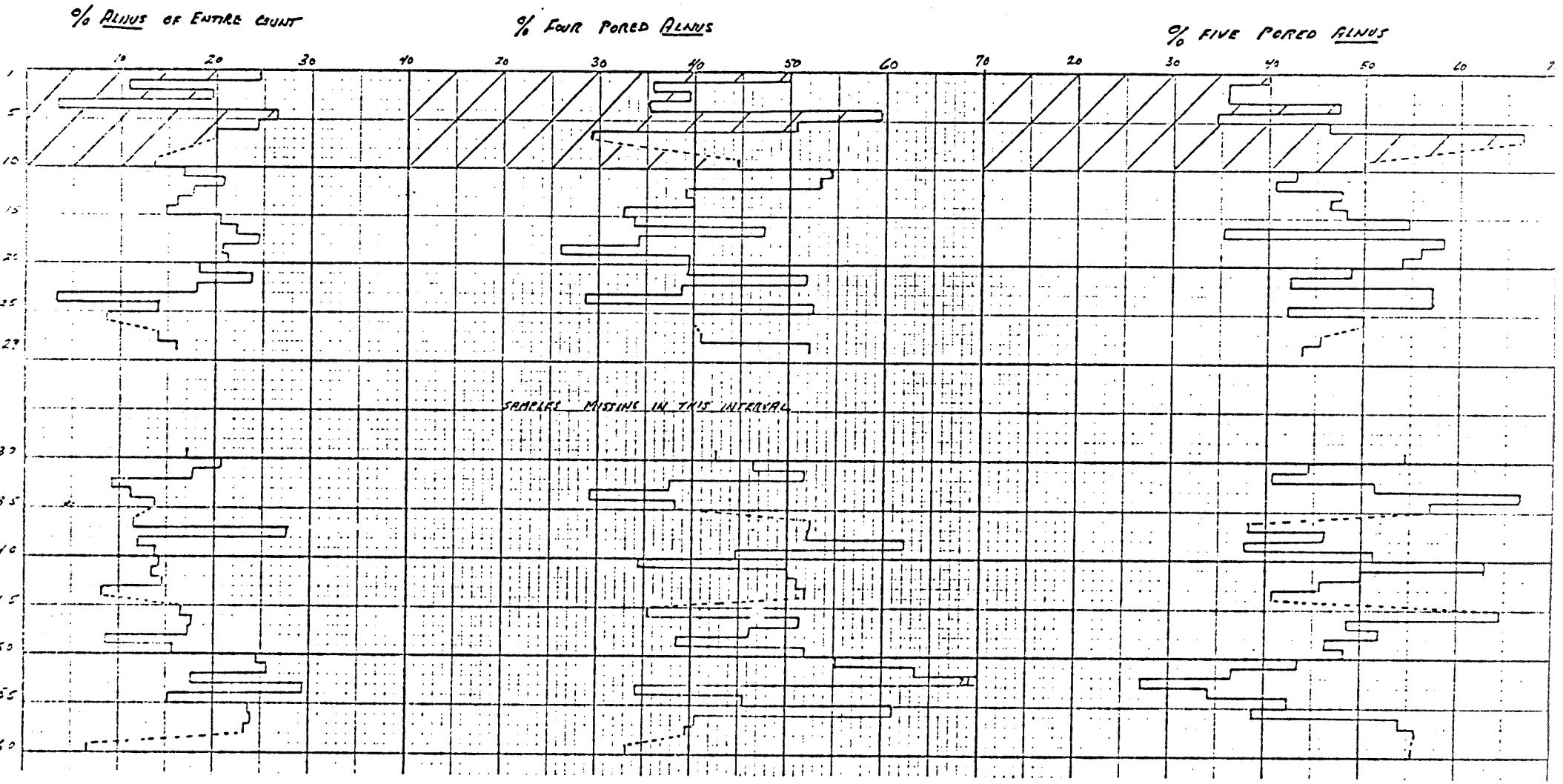

SAMPLE No.
SPATHUM
SELENOSPHAERA
LYCOPODIUM
OSMUNDA
LAEVIGATOSPORITES
POLYPODIACEAE I, 2, 3
LEIOTRILETES LEIOTRILETES
LEIOTRILETES SCABRATUS
TOTAL FERNS ~25% (COMPLICATED)
SAMPLES MISSING IN THIS INTERVAL

Figure 4
TOTAL CONNERI




BETULA
ALNUS
JUGLANS
PTEROCARYA
ULMUS
TILIA
TYPHA
COMPOSITAE
ERICALES
UMBELLIFERS
GRAMINEAE
CHENOPODIACEAE
MONOLITES
CYPERACEAE
POACEAE
CARYOPHYLLACEAE
SAMPLES MISSING IN THIS INTERVAL


% ALNUS OF ENTIRE COUNT
% FOUR PORED ALNUS
% FIVE PORED ALNUS
SAMPLES MISSING IN THIS INTERVAL

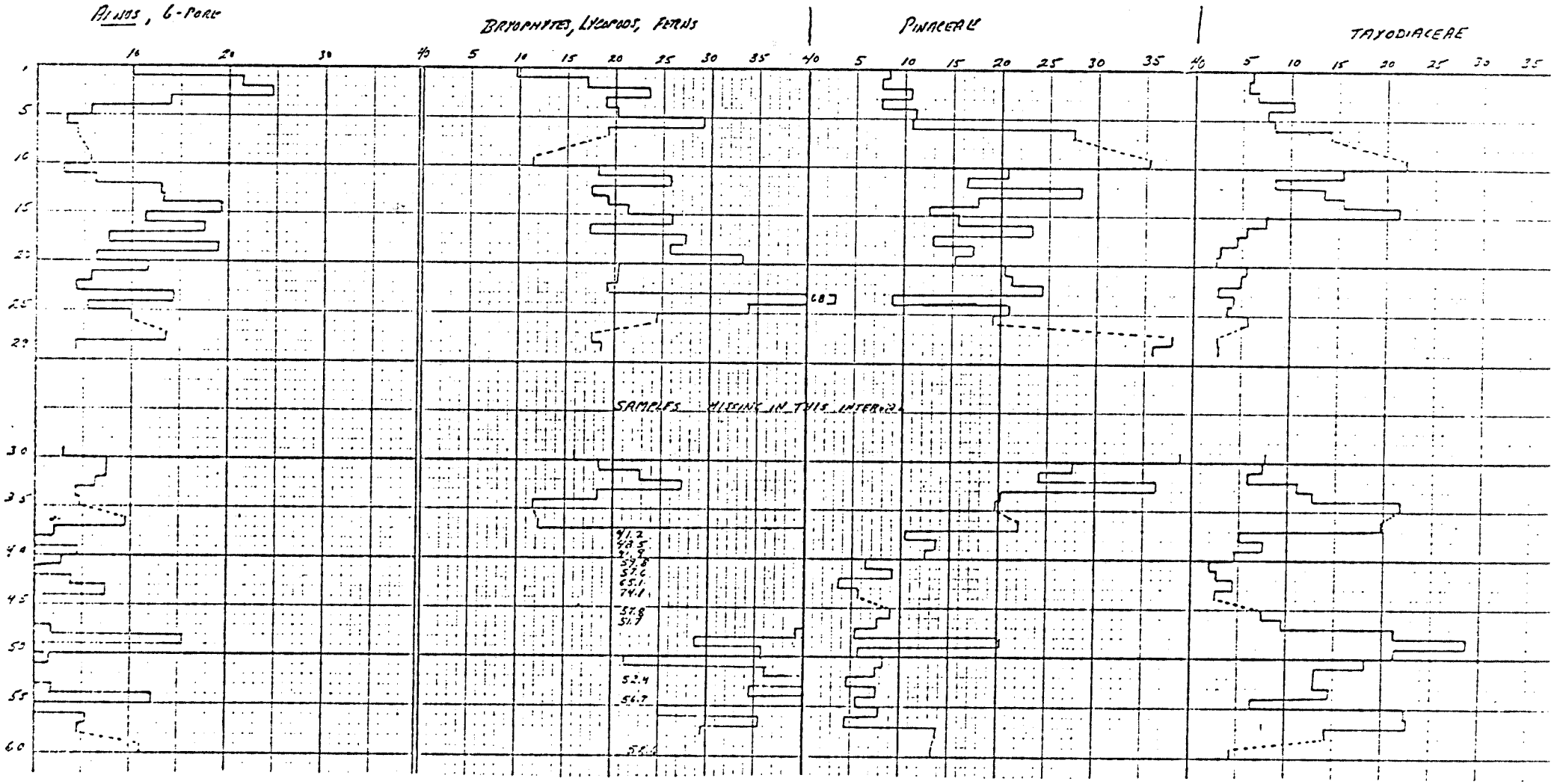
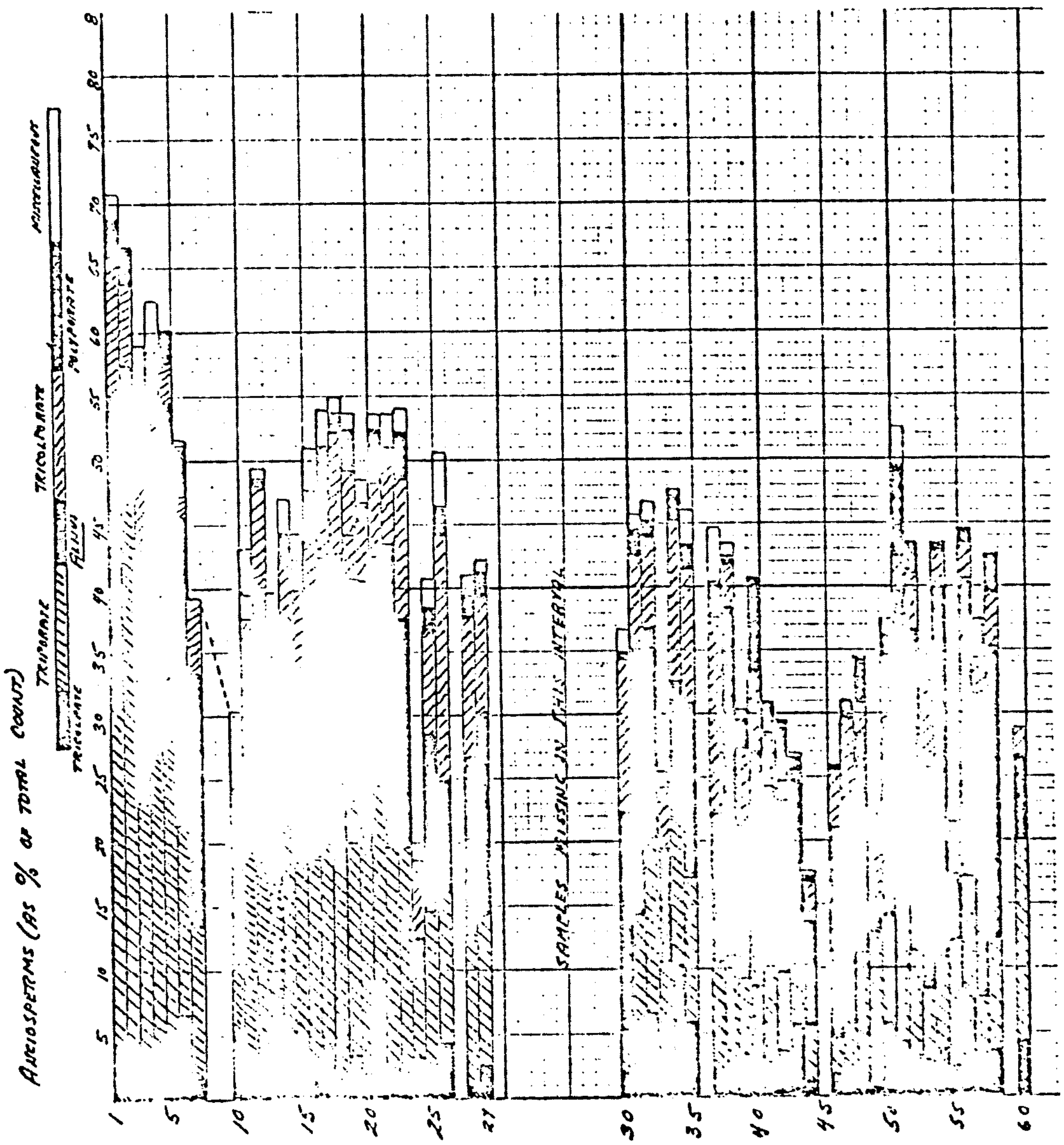
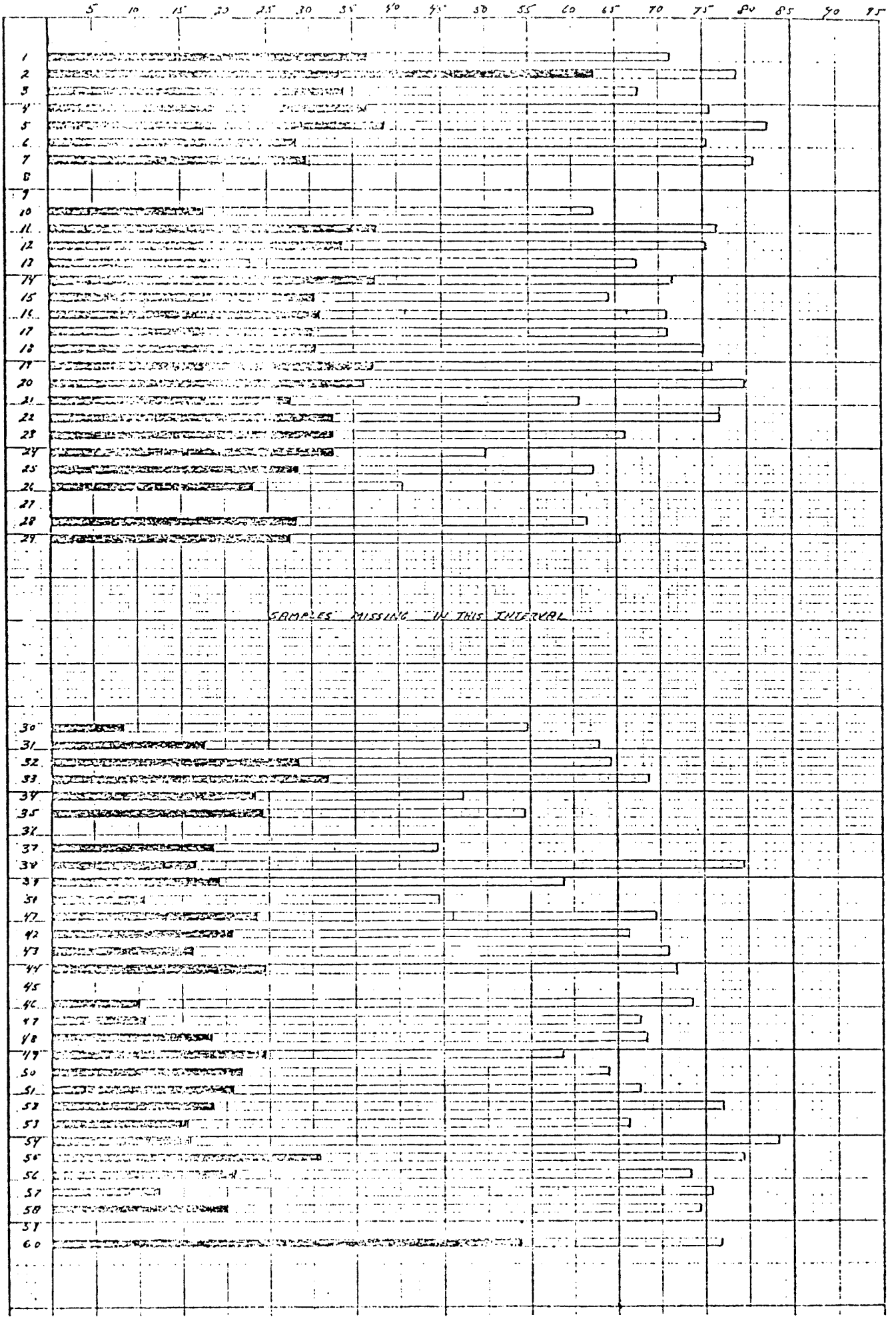
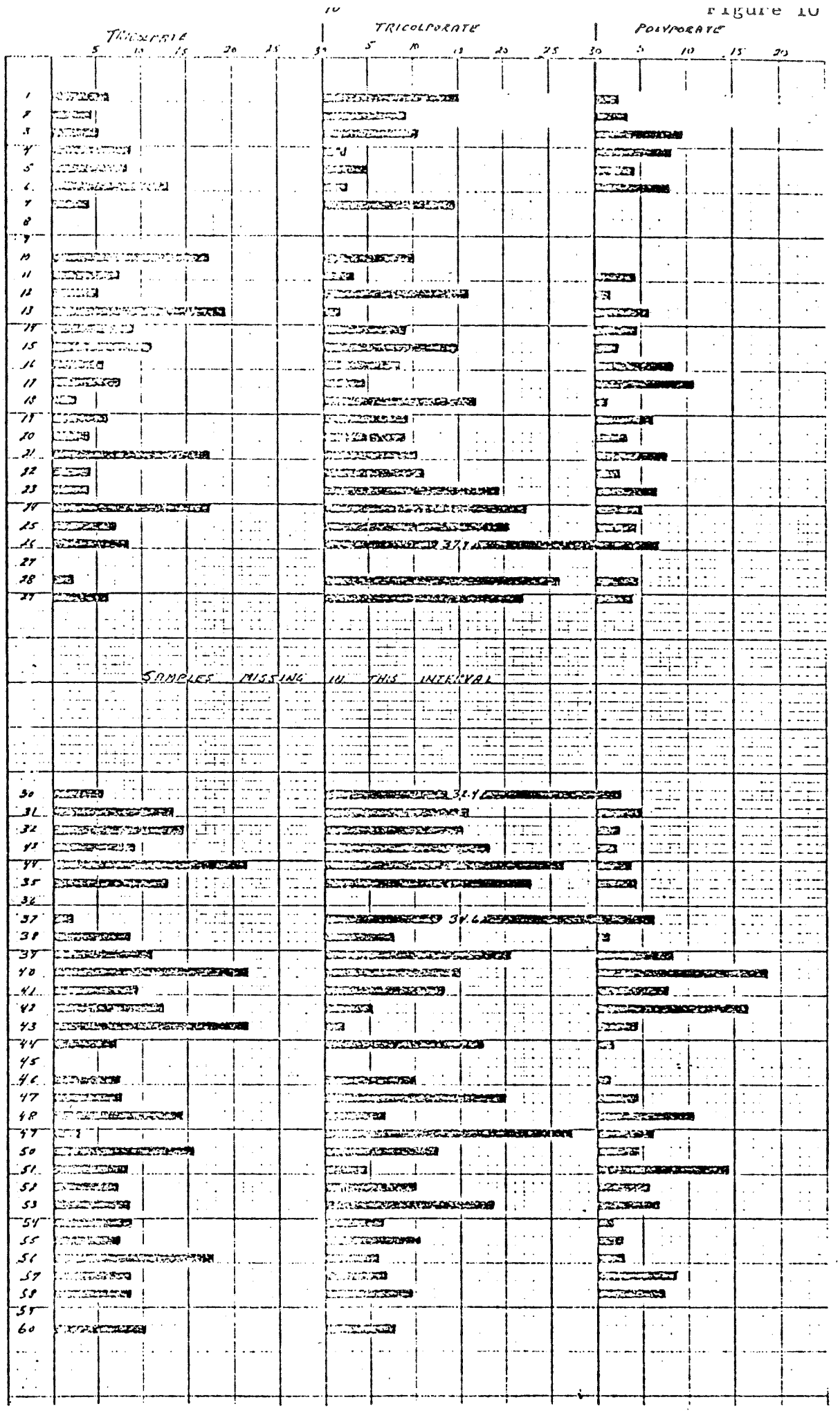

PINUS, 6-PORE
BRYOPHYTES, LYCOPODS, FERNS
PINACEAE
TAXODIACEAE
SAMPLES MISSING IN THIS INTERVAL
68
41.2
43.5
51.7
54.8
57.6
65.1
74.1
57.8
51.7
52.4
56.7

Figure 8


ANGIOSPERMS (AS % OF TOTAL COUNT)
TRIPORATE
TRICOLPATE
TRICOLPORATE
POLYPORATE
MISCELLANEOUS
SAMPLES MISSING IN THIS INTERVAL

TRIPORATE + PLURUS (% OF TOTAL ANGIOSPERMS)




TRICOLPORATE
TRICOLPORATE
POLYPORATE
SAMPLES MISSING IN THIS INTERVAL

P R E L I M I N A R Y R E P O R T

PALYNOLOGICAL STUDY OF SHELL ANGLO OFFSHORE D-36

W.S. Hopkins, Jr.

Introduction and Geology

Information in this section largely derived from Shell Canada (1968). This well was located approximately 97 km (60 mi) northwest of Cape Scott, Vancouver Island, or approximatey 56 km (35 mi) south west of the Shell Anglo Harlequin D-86 well. Depth of water is 59 m (192 ft). The well was spudded 1 September 1968 and was plugged and abandoned 16 September 1968 at a depth of 2530 m (8302 ft).

Clastic sediments were encountered exclusively to a depty of 1871 m (6140 ft) and interbedded volcanics and sands from there to total depth. Although sandsonte is dominent, mudstone, siltstone and shale are abundant. Coal and lignite are absent except for several thin coal seams interbedded with the basalt at arqund 2347 m (7700 ft). One conventional 6 m (20 ft) convention core (2m (6.3 ft) recovery) plust three sidewall core runs. None of these cores were available to me.

Samples

Because no conventional or sidewall cores were available, this study is based entirely on cuttings. Comments regarding processing are the same as those for Murrelett L-15. Although 60 samples were examined, only 31 were suitable for plotting.

Palynology

Many of the comments regarding palynomorph preservation are the same as those mentioned in the first paragraph of the section in the Harlequin report.

1) There is a pronounced decrease in ferns and bryophytes with depth
2) Conifer ratios stay essentially the same
3) Proportion of 4-pored alnust increases with depth
4) Broadly speanking angiosperm pollen increases with depth.

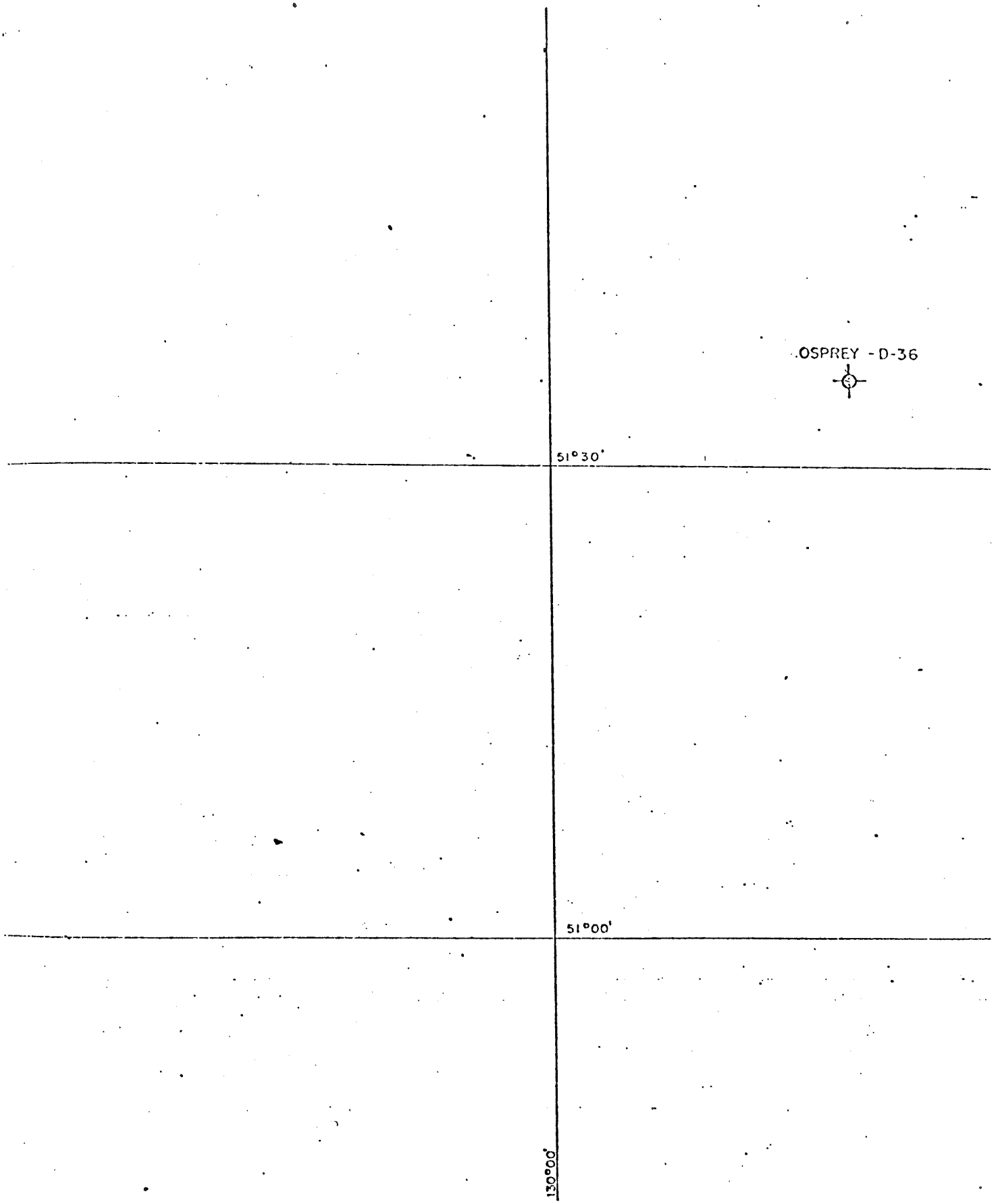


Figure 1. Index map showing location of Shell Anglo Ospredy D-36/
Taken from Well History Report (Shell Canada Limited, 1968)

GSC LOC NO C-55932 GULF D-36

SAMPLE NO	DEPTH FEET	METRES	
1	970 - 1000		
2	1090 - 1120		
3	1290 - 1310		
4	1400 - 1430		
5	1584 - 1616		
6	1710 - 1750		
7	1860 - 1900		
8	1990 - 2020		PLIOCENE/
9	2180 - 2210		
10	2310 - 2340		
11	2550 - 2600		UPPER MIOCENE
12	2850 - 2900		
13	3050 - 3100		
14	3250 - 3300		
15	MISSING INTERVAL		
16	5567 - 5598		
17	5691 - 5723		
18	5806 - 5859		
19	5963 - 5994		
20	6200 - 6210		
21	6240 - 6250		
22	6300 - 6310		
23	6340 - 6350		
24	6420 - 6430		
25	6521 - 6550		
26	6582 - 6613		UPPER MIOCENE/
27	6700 - 6710		
28	6740 - 6750		MIDDLE MIOCENE
29	6800 - 6810		
30	6840 - 6850		
31	6900 - 6906		
32	6950 - 6960		
33	7050 - 7060		
34	7110 - 7120		
35	7150 - 7160		
36	7210 - 7220		
37	7280 - 7300		
38	7350 - 7360		
39	7410 - 7420		
40	7450 - 7460		
41	7510 - 7520		
42	7550 - 7560		
43	7610 - 7620		
44	7650 - 7660		
45	7710 - 7720		
46	7750 - 7760		
47	7810 - 7820		
48	7850 - 7860		
49	7910 - 7920		
50	7950 - 7960		
51	8010 - 8020		
52	8030 - 8040		
53	8110 - 8120		MIDDLE MIOCENE/
54	8150 - 8160		LOWER MIOCENE
55	8170 - 8200		
56	8200 - 8210		
57	8220 - 8230		
58	8240 - 8250		
59	8260 - 8270		
60	8280 - 8290		
61	8301		
62	2750 - 2800		

FIG. 2

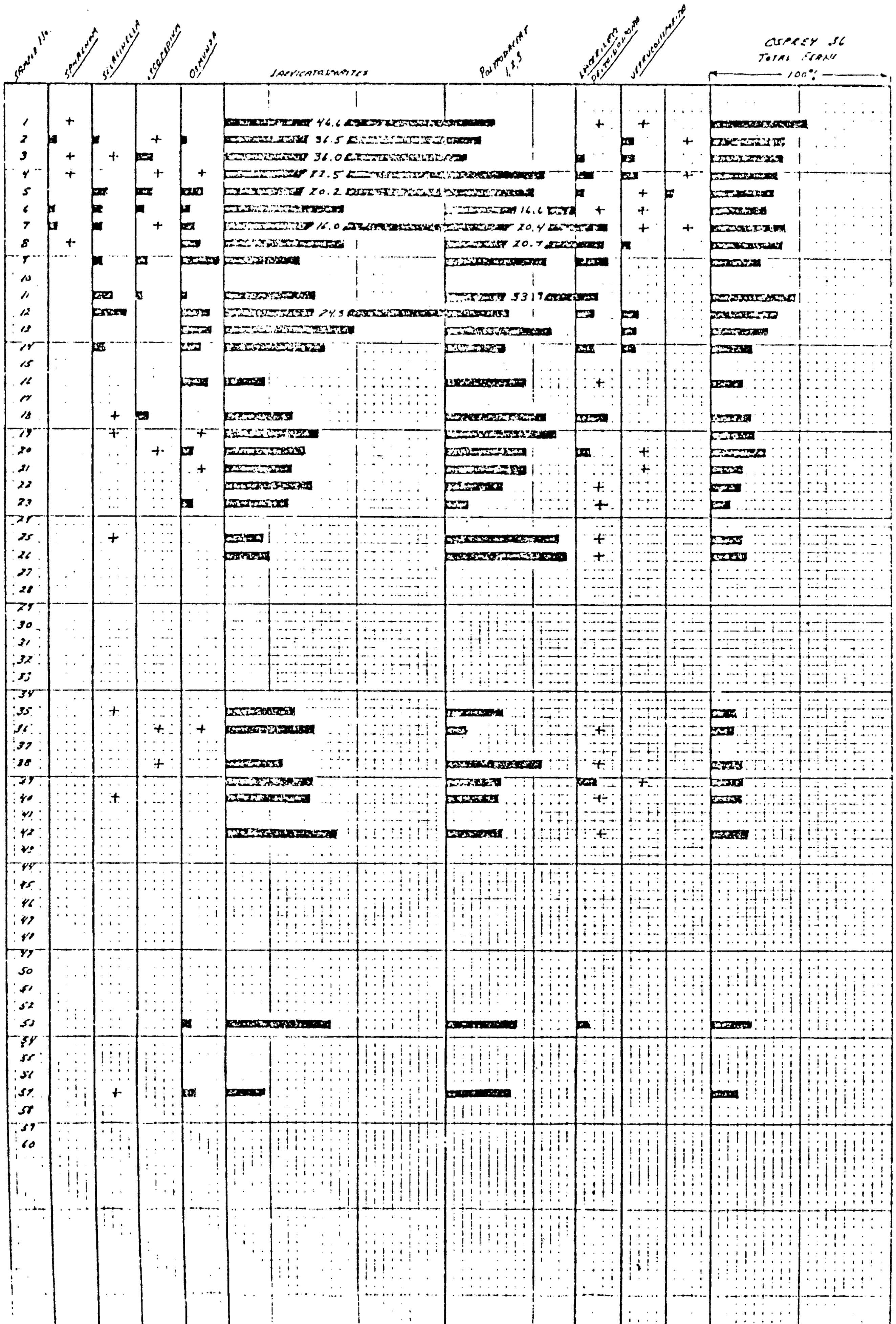


FIG. 3

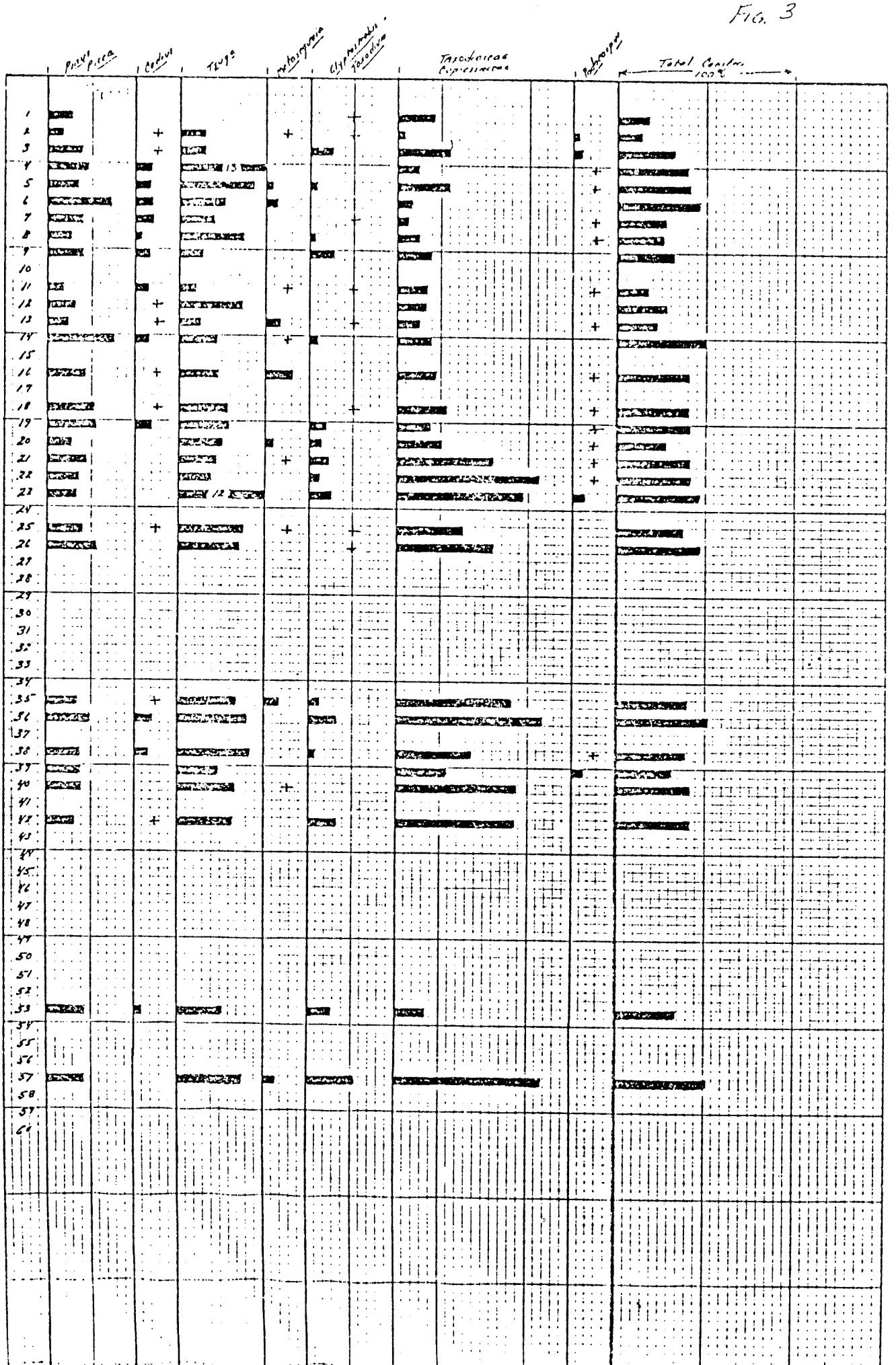
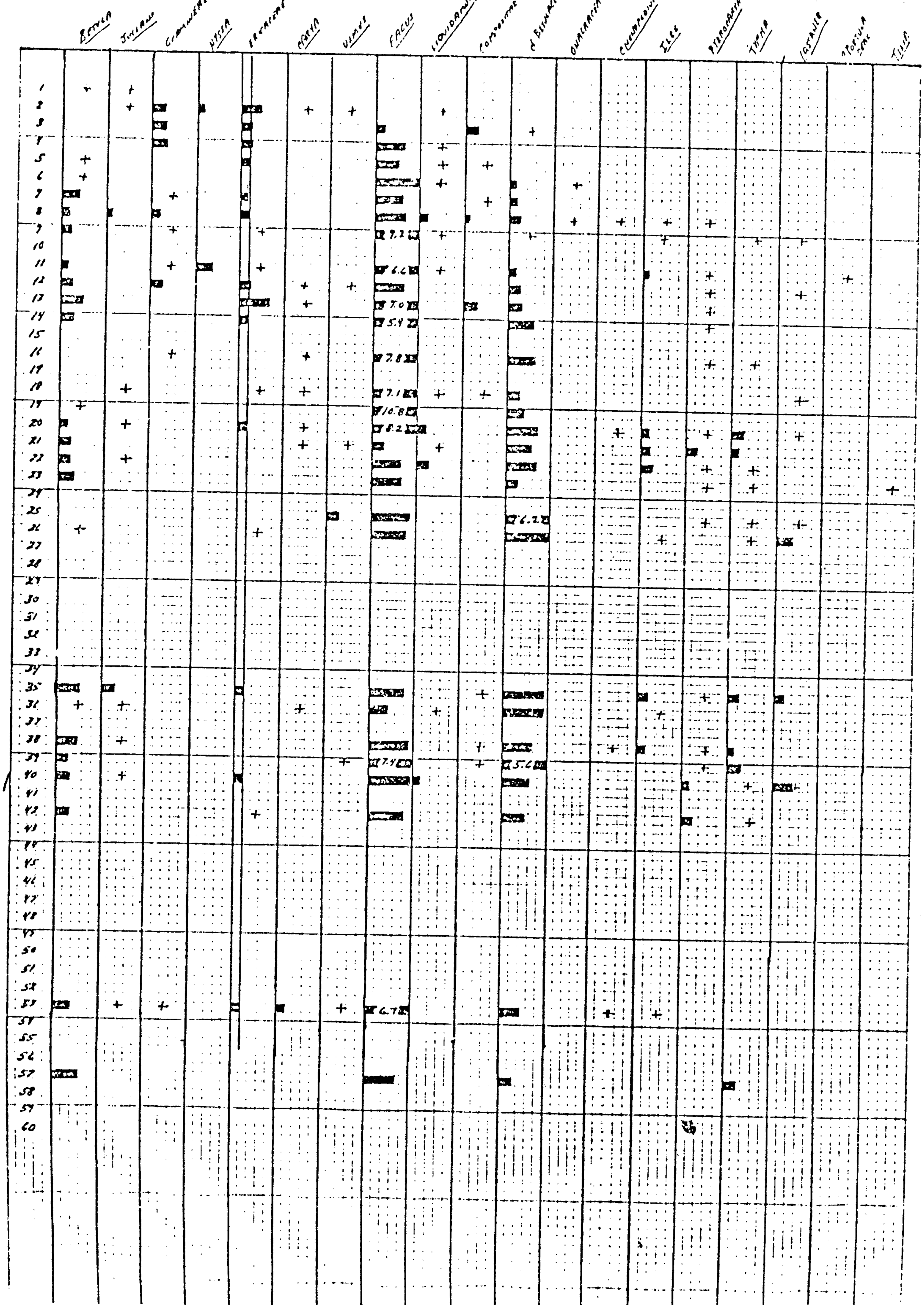
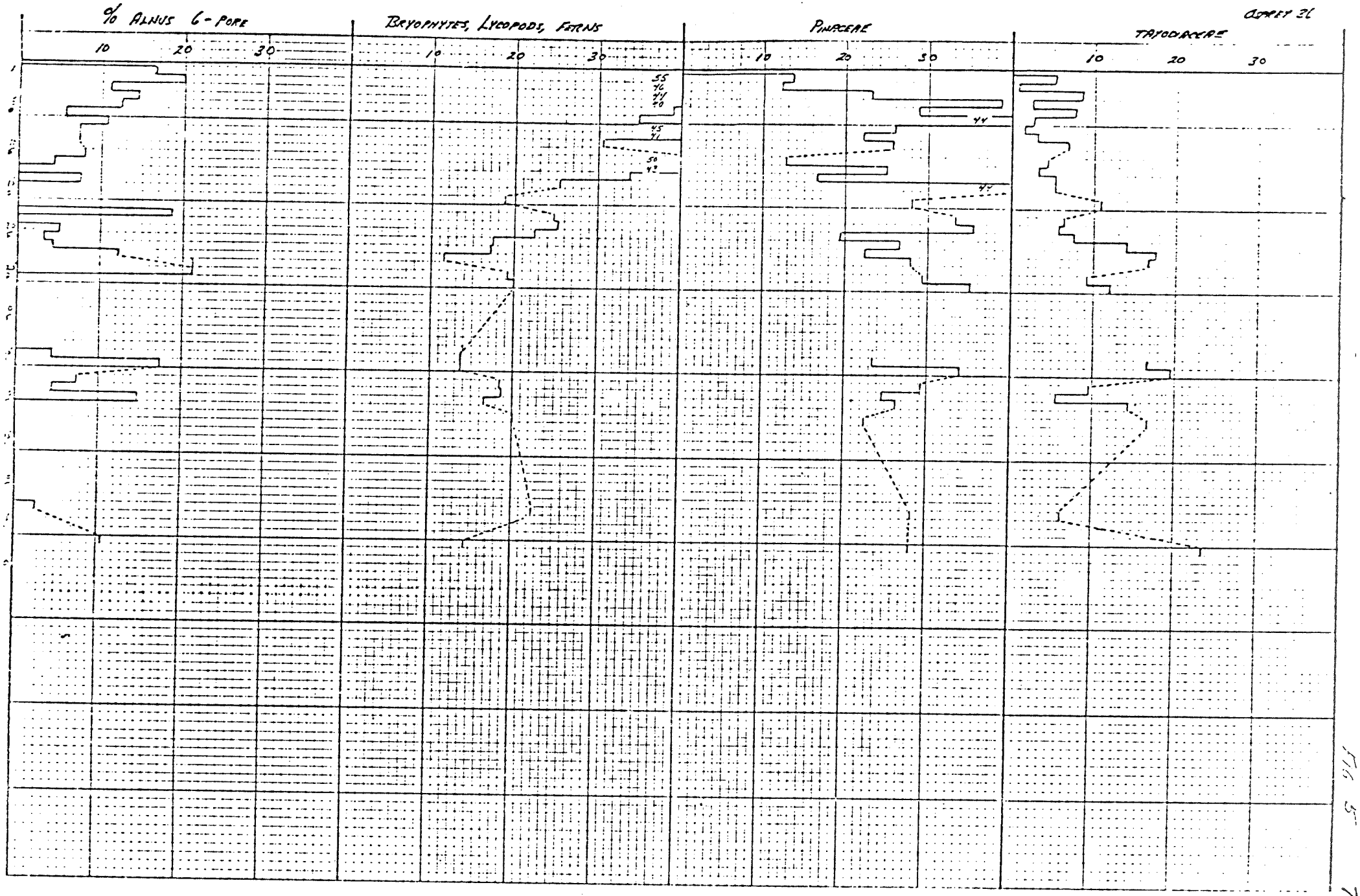


FIG 4

Osprey Sc.




% ALNUS 6-POLE
BRYOPHYTES, LYCOPODS, FERNS
PINACEAE
TAXODIACEAE
10
20
30
55
46
44
40
45
41
50
42
44
47

OSPREY 36

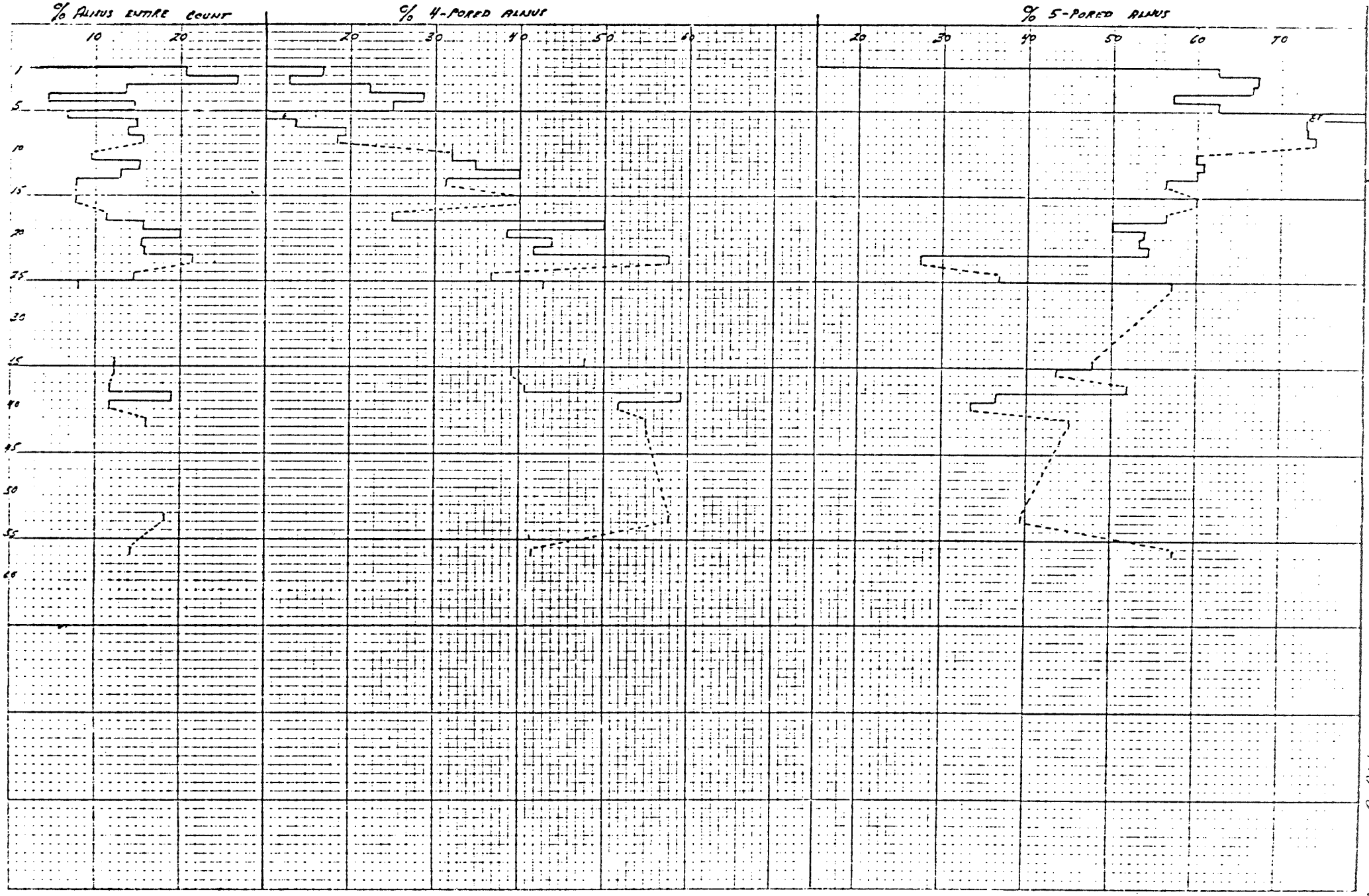
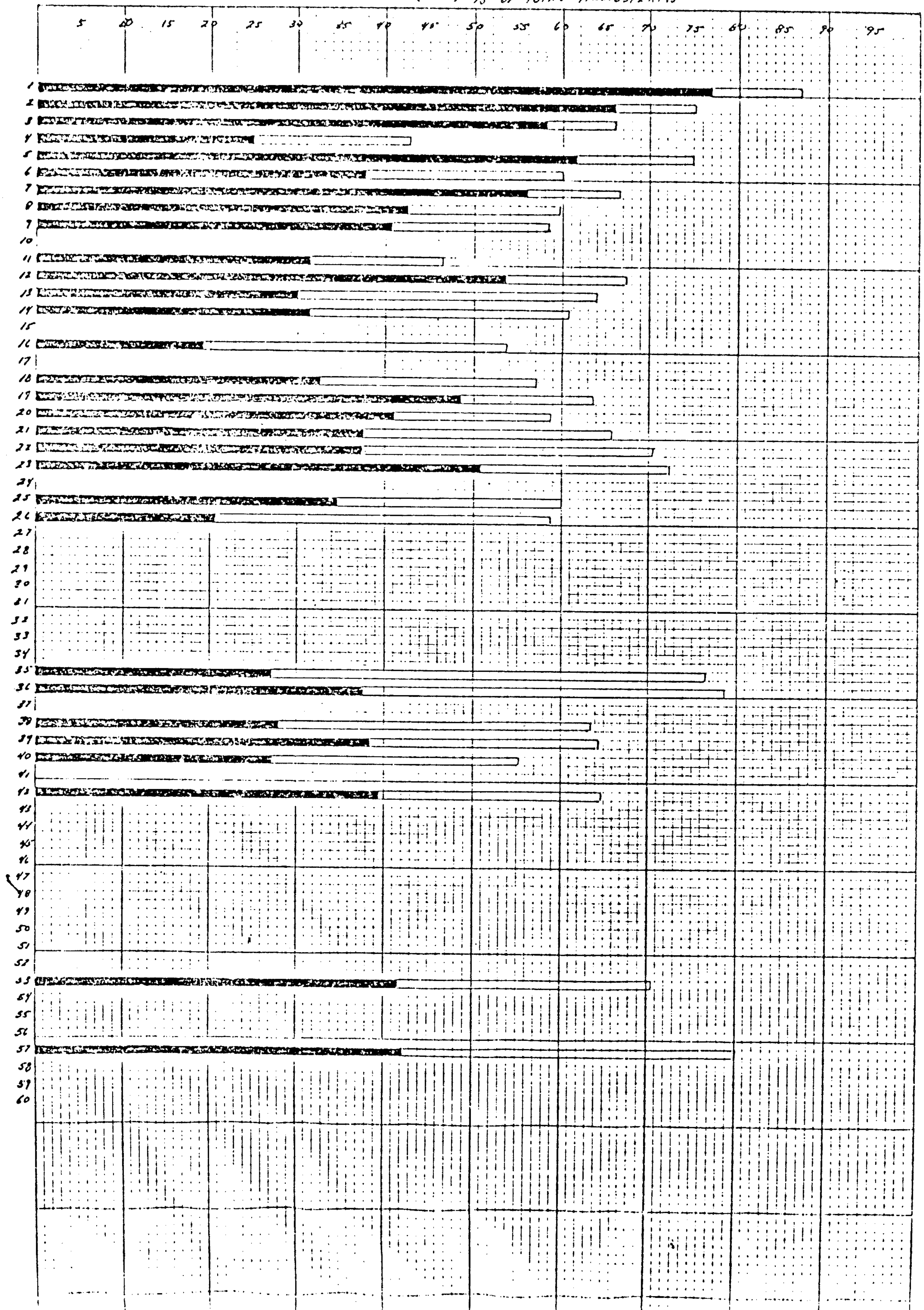

% ALIUS ENTIRE COUNT
% 4-PORED ALNUS
% 5-PORED ALNUS
10
20
20
30
40
50
60
20
30
40
50
60
70
1
5
10
15
20
25
30
35
40
45
50
55
60
ET

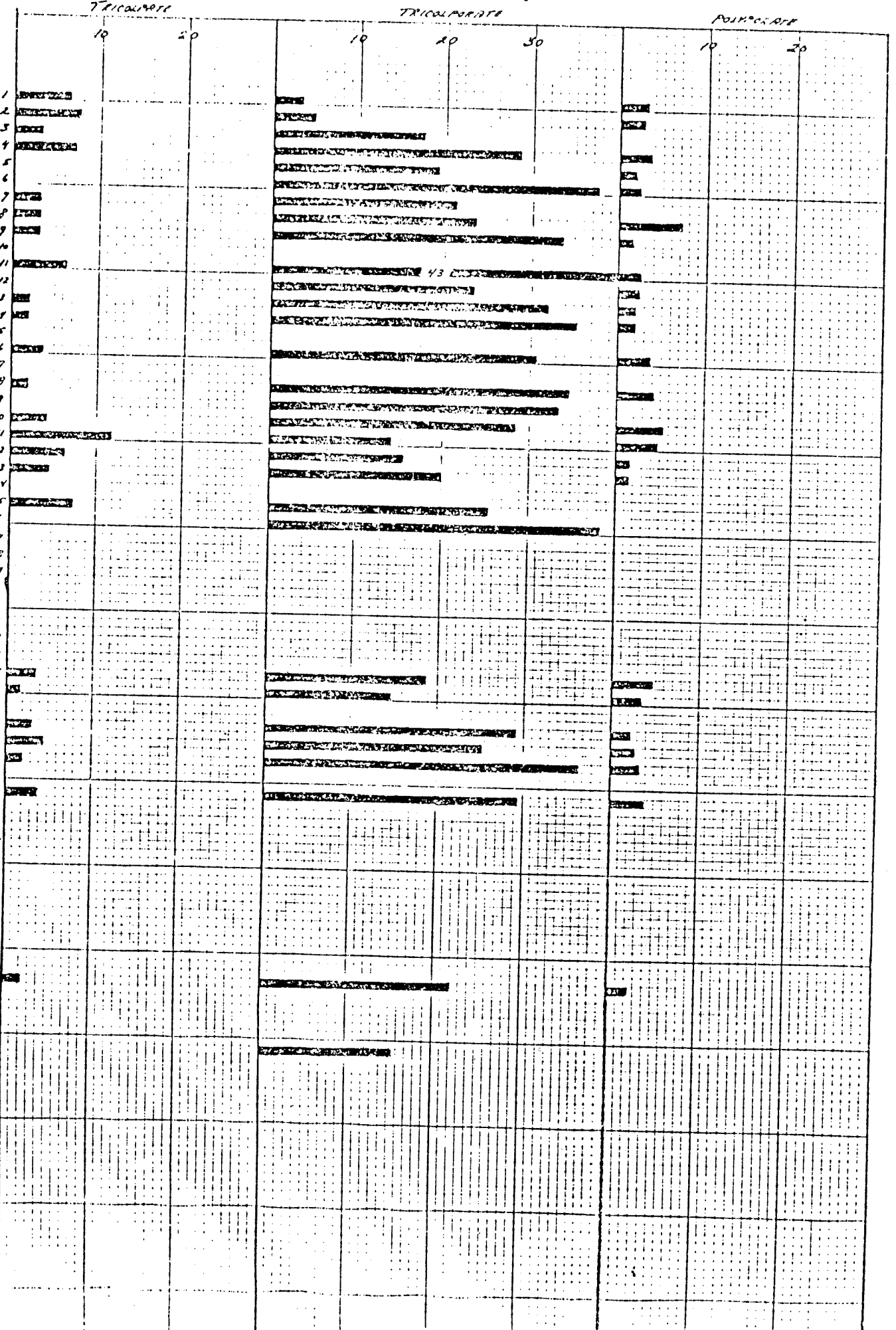
FIG. 7

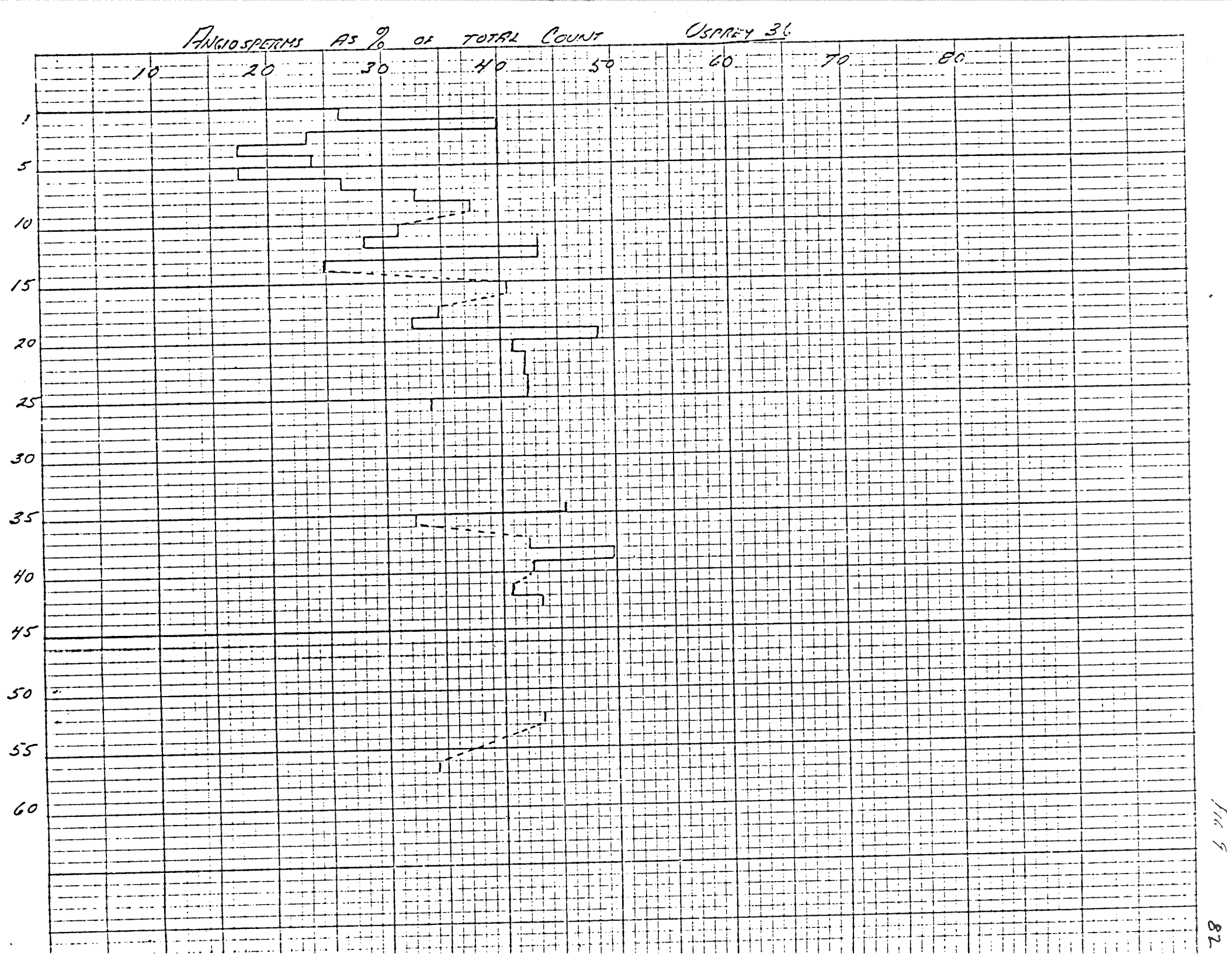
OSNEY 36

TRIPORATE + ALNUS (▬) % OF TOTAL ANGIOSPERMS



% TOTAL ANGIOSPERMS OSMER 56 FIG. 8




ANGIOSPERMS AS % OF TOTAL COUNT
OSPREY 36
10
20
30
40
50
60
70
80
1
5
10
15
20
25
30
35
40
45
50
55
60

PHYTOPLANKTON AS % OF TOTAL COUNT OSPREY 36