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Palaeobathymetrical changes in NW Sarawak during the Oligocene to Pliocene

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Abstract: Data from some 88 wells in the Luconia and Balingian provinces was used to unravel the palaeobathymetrical history of NW Sarawak from Oligocene to Pliocene times. A comparison of the Sarawak palaeobathymetrical curve with the global sea-level curve suggests that from Middle Miocene to Pliocene times changes in bathymetry were largely controlled by eustacy, while during the Late Oligocene to Early Miocene the effect of global sea-level changes was largely masked by important tectonic movements.

INTRODUCTION

The Oligocene to Pliocene deposits of NW Sarawak (Fig. 1) were deposited during a number of successive transgressions and regressions. These cyclic phases are relatively well known and they are used within Sarawak Shell for a subdivision of the stratigraphical record into informal lithostratigrapahical units consisting of sediments deposited during one cyclic sedimentation phase.

Little is known about the nature and origin of the palaeobathymetrical changes which caused the transgressions and regressions, and little information is available on the individual impact of the main factors controlling these relative sea-level changes: eustacy, tectonics, epeirogenesis, sedimentation rate and compaction.

Moreover the relative importance of the successive transgressions and regressions in terms of geographical distribution and palaeobathymetrical changes has never been examined systematically.

A study was therefore initiated which focused on the following:

1. What were the main factors controlling the palaeobathymetical changes which occurred in NW Sarawak during the Oligocene to Pliocene?
2. What were the lateral and vertical dimensions of these palaeobathymetrical changes?
3. To what extent were these palaeobathymetrical changes isochronous over the area?
4. Are these changes a local feature or can they be correlated with global events?

METHOD

To find the answer to above questions the following method was applied:

The palaeobathymetrical history was interpreted for each adequately documented well on file in SSB (Fig. 2). This was done by plotting palaeodepths of deposition against geological time. Palaeodepths of deposition were mainly inferred from sedimentological

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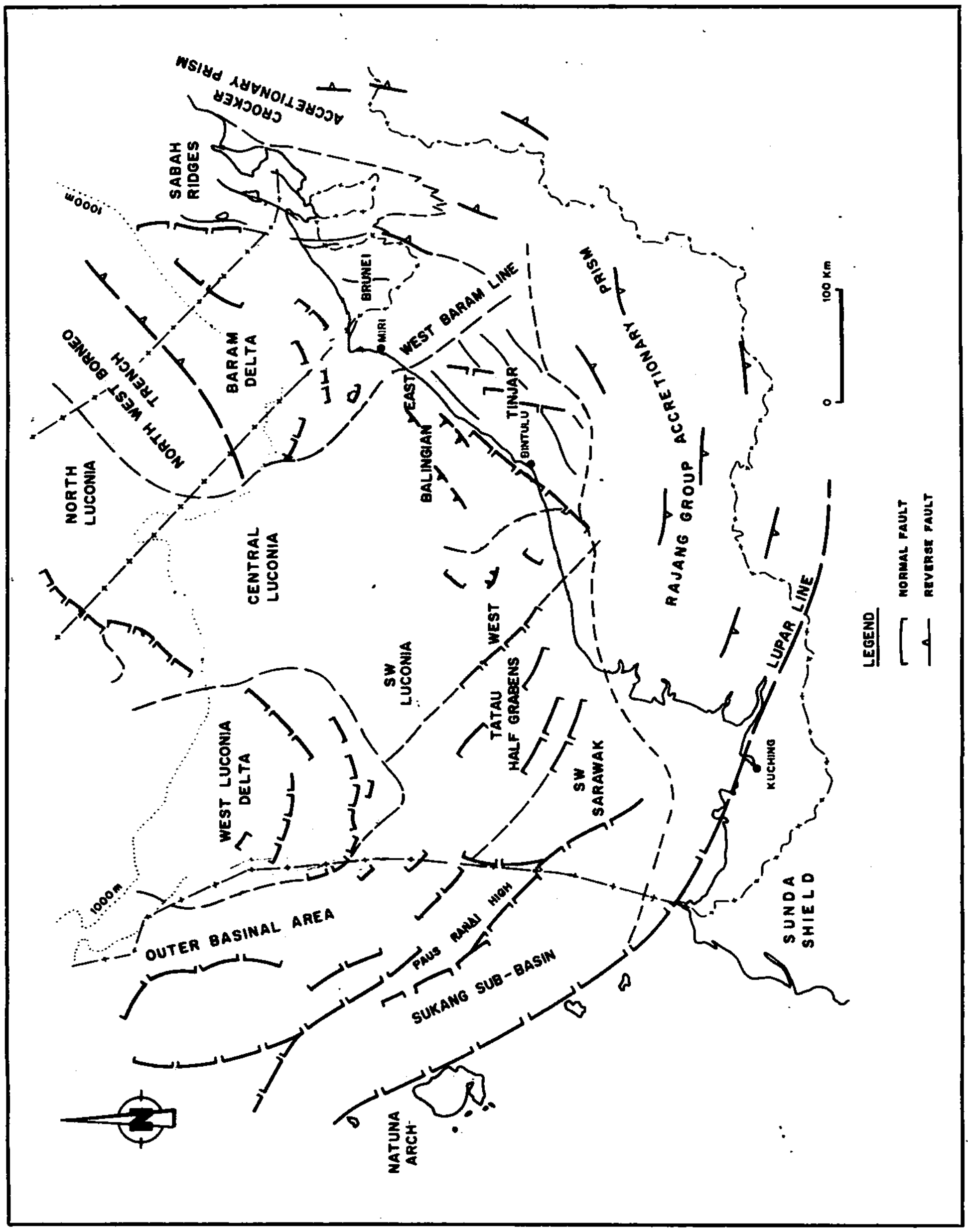


Fig. 1. Sarawak Geological Provinces.

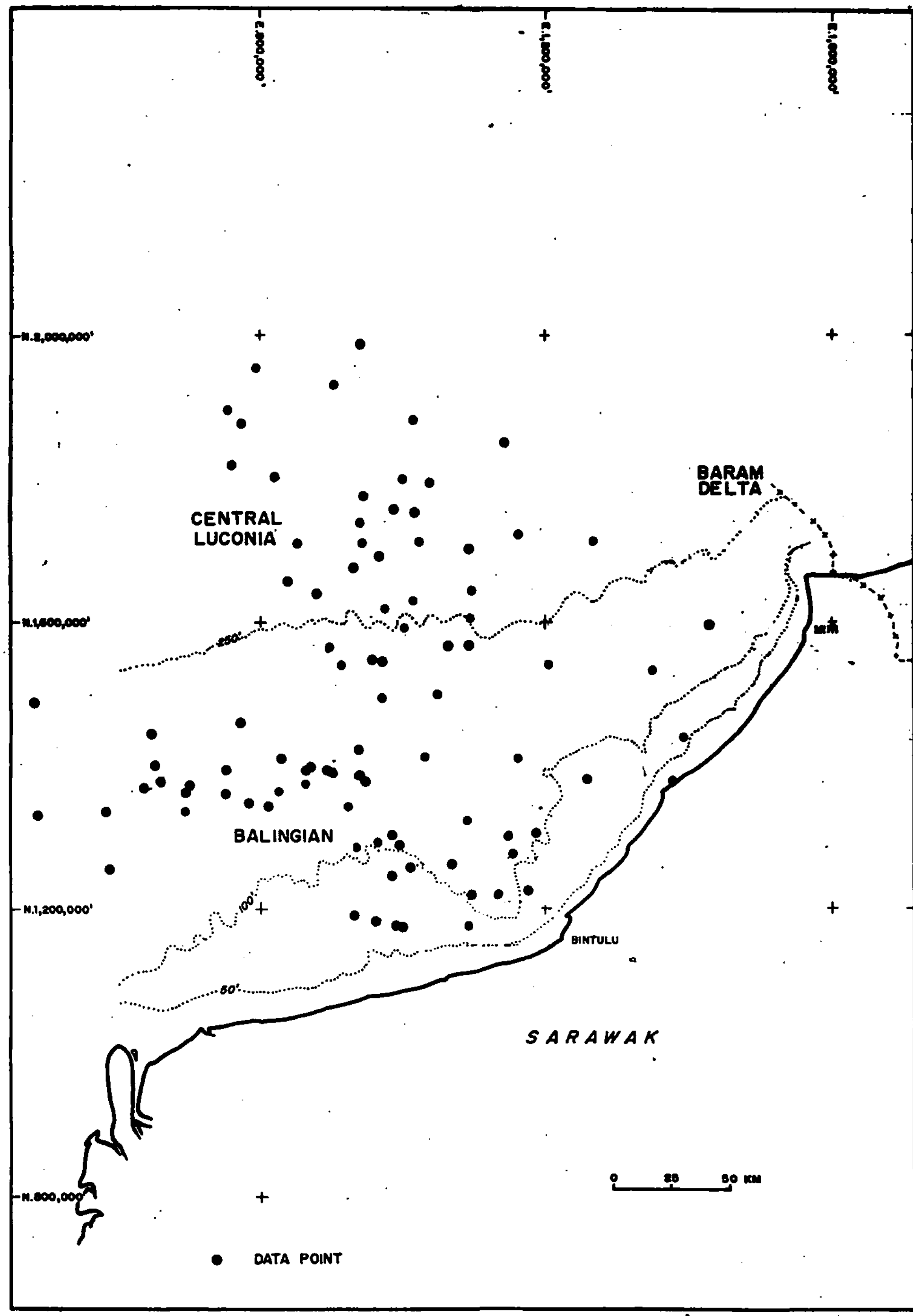


Fig. 2. Data point location map.

and palaeontological data (Fig. 3). For periods of erosion an arbitrary palaeoaltitude of 30 meters was taken. Since changes in depositional environment generally have a gradual character, a smooth "palaeobathymetrical curve" was constructed through the interpreted depth ranges, and the turning points on the curve and the amount of the relative sea-level change in the corresponding transgression or regression were defined. In addition, the average sedimentation rate per bio-zone was plotted (see for example Fig. 4). Next the main palaeobathymetricl events in each well were defined and compared with data from all the other wells.

DISCUSSION

A compilation of all observed palaeobathymetrical change in Balingian and Luconia wells is shown in Fig. 5. It demonstrates that a great number of the relative sea-level changes observed in the individual wells are of a more or less general character, suggesting that they occurred over a wide area within a relatively short time interval, i.e. within one foram or pollen zone (0.5 - 4 Ma). By combining all data, a "best fit" curve could be constructed which shows the major palaeobathymetrical changes in the Balingian and Luconia Provinces for Late Oligocene to Pliocene times (Fig. 6). It should, however, be kept in mind that these observed "general" palaeobathymetrical changes reflect the combined, averaged result of eustacy, subsidence, sedimentation rate and compaction.

Although it appears that the constructed palaeobathymetric curve is valid on a regional scale, local deviations do occur frequently as can be concluded from Fig. 5. For example the important deepening phase which occurred ±18 Ma ago was observed in only 28 of the 33 wells studied. The reason for these deviations is probably mainly the difference in magnitude between epeirogeny/sedimentation rates on one hand and regional relative sea-level changes on the other. This is demonstrated in Fig. 7, a "geohistory" diagram of a Balingian well, which shows sediment accumulation and palaeobathymetry versus time, together with the constructed palaeobathymetric curve for Balingian/Luconia. The figure shows that the subsidence rate is generally several times greater than the amount of relative sea-level change, indicating that local minor changes in the subsidence/sedimentation ratio may obscure regional palaeobathymetrical changes.

The palaeobathymetric curve for Sarawak was constructed with data from the Balingian and Luconia Provinces only. In the thicker, mainly Upper Miocene/Pliocene deposits of the Baram Delta Province these major oscillations cannot be identified with certainty. There, palaeobathymetrical changes are generally small (less than 30 meters) and numerous (several per biozone), as demonstrated for example on the palaeobathymetrical curve of a typical Baram well (Fig. 8). It appears that in this area, where average rates of deposition are often 3 to 5 times as high as in Balingian/Luconia (see Figs. 4, 7, 8 and 9), the depositional history was largely controlled by high subsidence and sedimentation rates, which largely obscured regional sea-level changes.

In Fig. 10, the composite palaeobathymetric curve of NW Sarawak is set against the global sea-level curve. In the interval between 16 and 3.5 Ma the similarity between this curve (modified after Vail and Hardenbol, 1979) and the curve for NW Sarawak is striking, and suggests that in the Balingian/Luconia province an equilibrium between subsidence (compaction) and sedimentation existed during this time interval, whereby regional transgressions and regressions were largely controlled by eustacy.

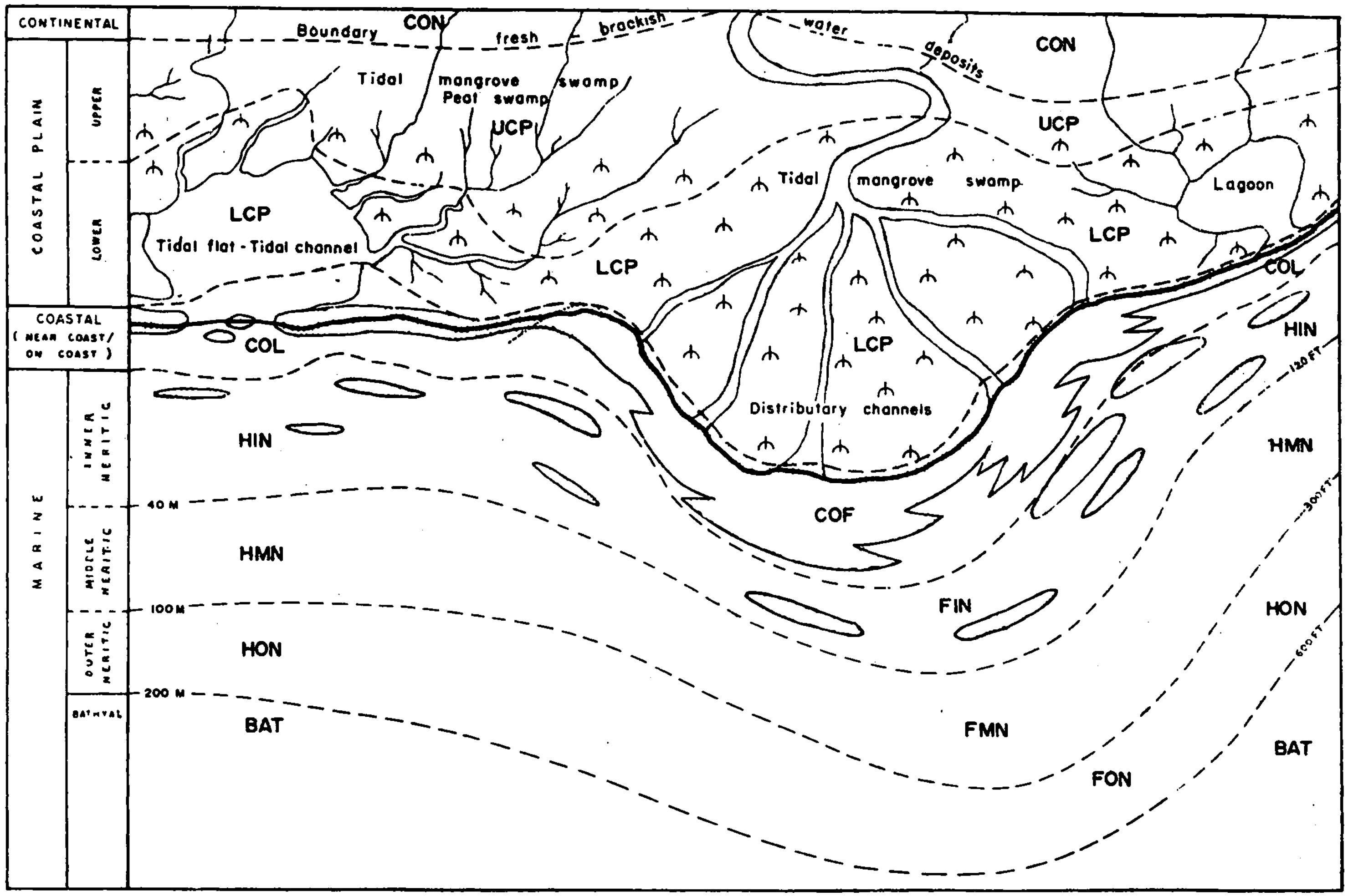


Fig 3. Schematic Palaeoenvironmental Framework.

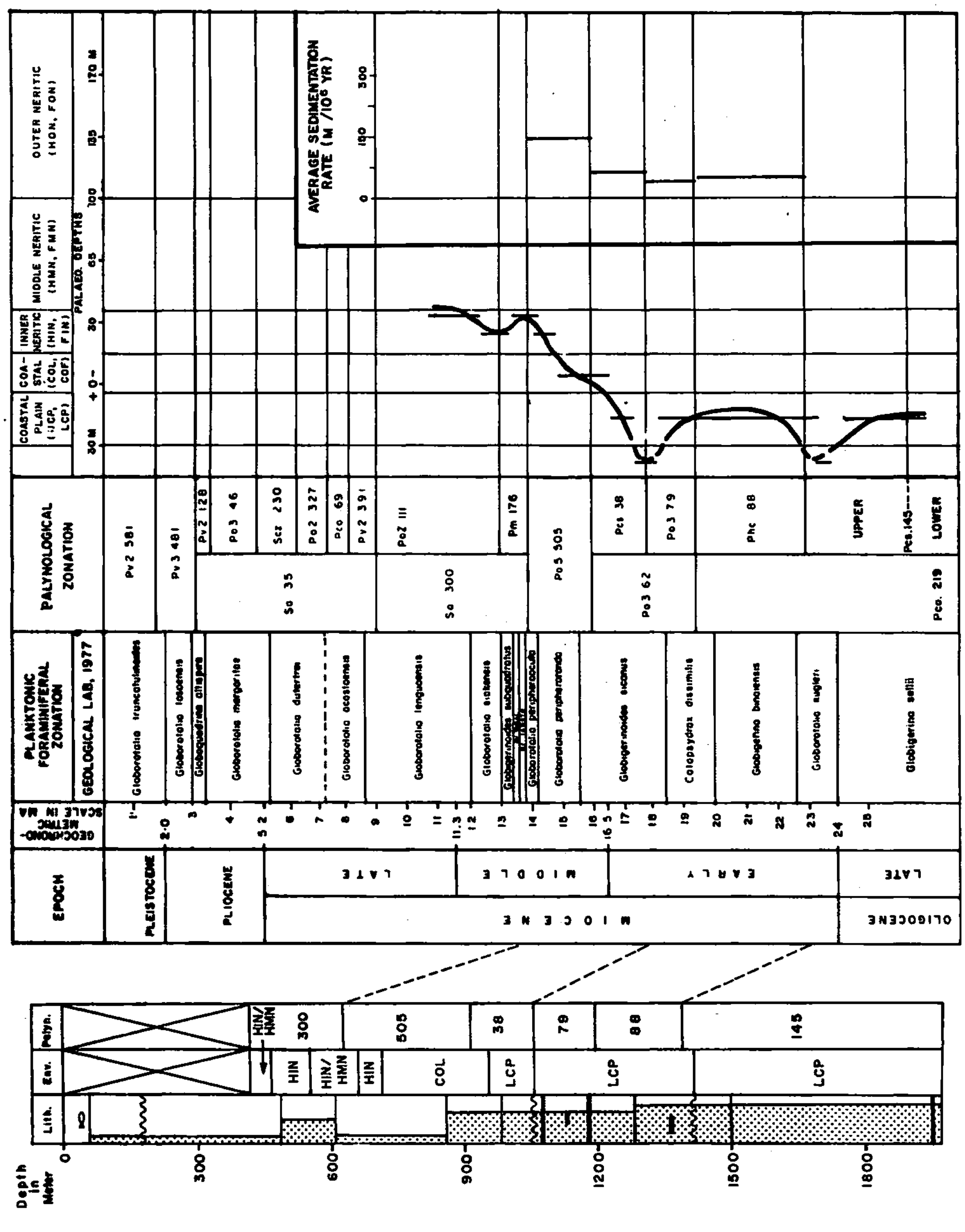


Fig. 4. Well A, Balingian Province. Stratigraphic Log, Palaeobathymetrical Curve and Average Sedimentation Rates.

M.Y.	BATHYMETRICAL CHANGE (fall ← rise → meter)	NO. OF WELLS WITH STRATIGRAPHIC INTERVAL PRESENT	NO. OF WELLS IN WHICH PALAEOBATHYMETRICAL CHANGE IS OBSERVED	REMARKS
2				
3				
4	← 50	32	24	ONLY OBSERVED IN LUCONIA
5				
	→ 100	43	42	
6				
7	← 80	15	12	BATHYM. CHANGE PROBABLY GREATER IN VIEW OF IMPORTANT EROSION
8	→ 40	17	7	
9				
	← 60	16	12	
10				
11				
12				
13	→ 30	21	16	
14	← 25	30	14	
15				
	→ 40	35	22	
16	← 15	34	15	
17				
18	→ 60	37	31	
19				
	← 25	31	26	Many sedimentary breaks and unconformities with unknown regional significance.
20				
21				
22				
23	→ 25			
		21	18	
24				
25				
	← 25	18	18	
26				

Fig. 5. Compilation of Observed Palaeobathymetrical Changes in Balingian/Luconia Wells.

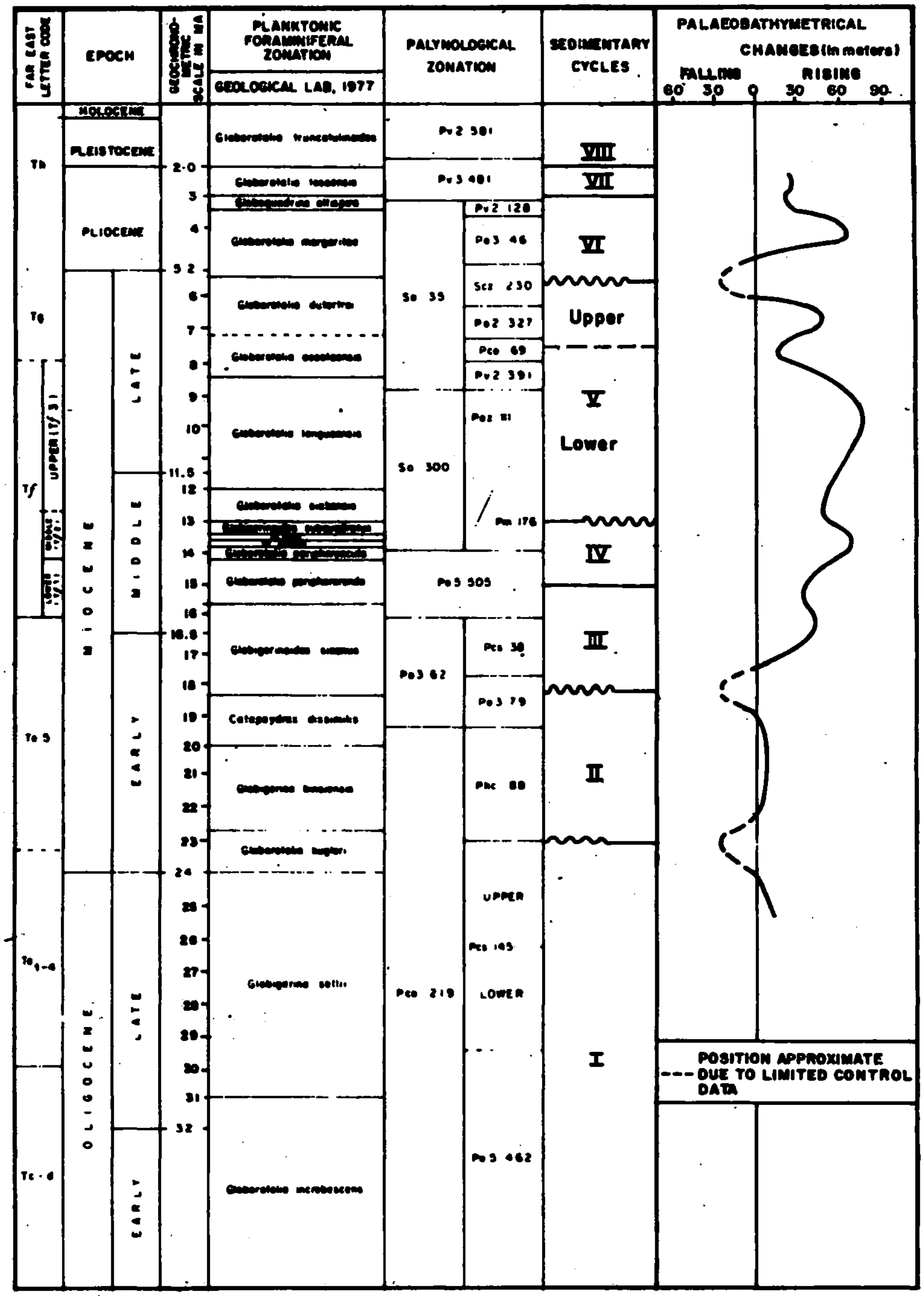


Fig. 6. Stratigraphy and Composite Palaeobathymetrical Curve of Balingian/Luconia Wells.

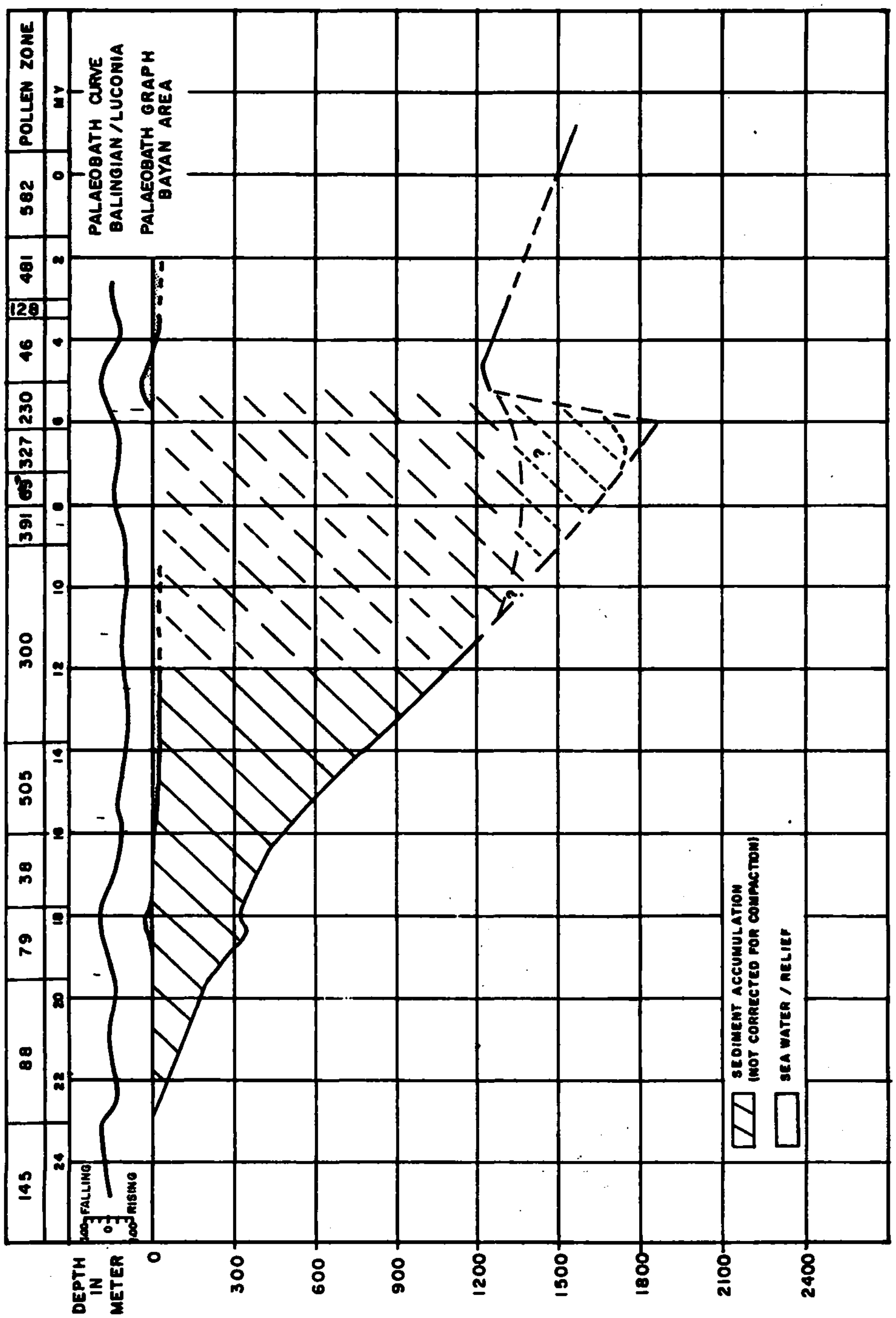
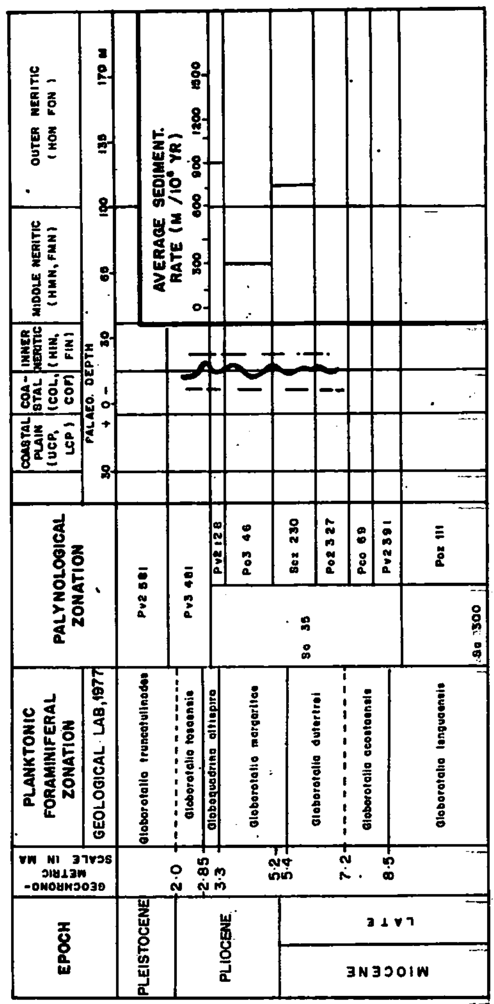


Fig. 7. Geohistory Diagram Well A, Balingian Province.



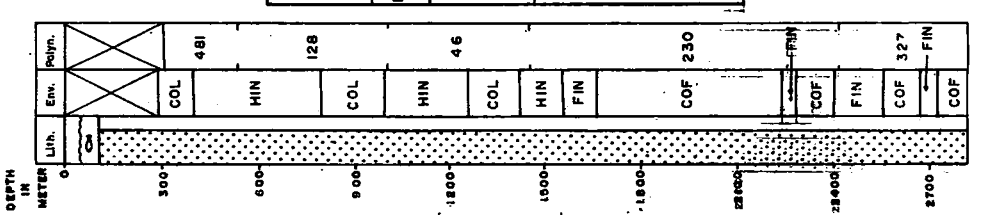


Fig. 8. Well D, Baram Province. Stratigraphic Log, Palaeobathymetrical Curve and Average Sedimentation Rates.

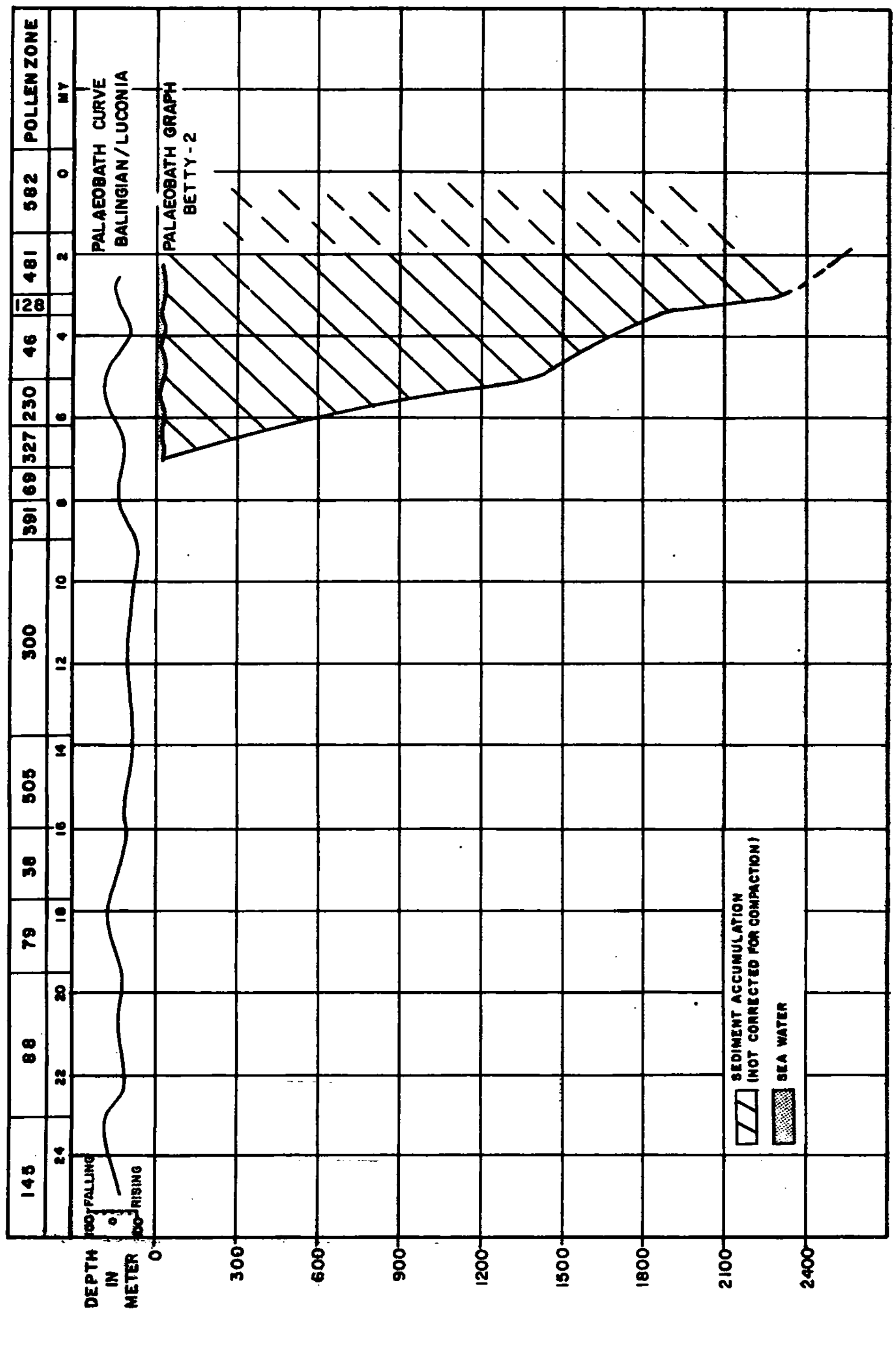


Fig. 9. Geohistory diagram Well D, Balingian Province.

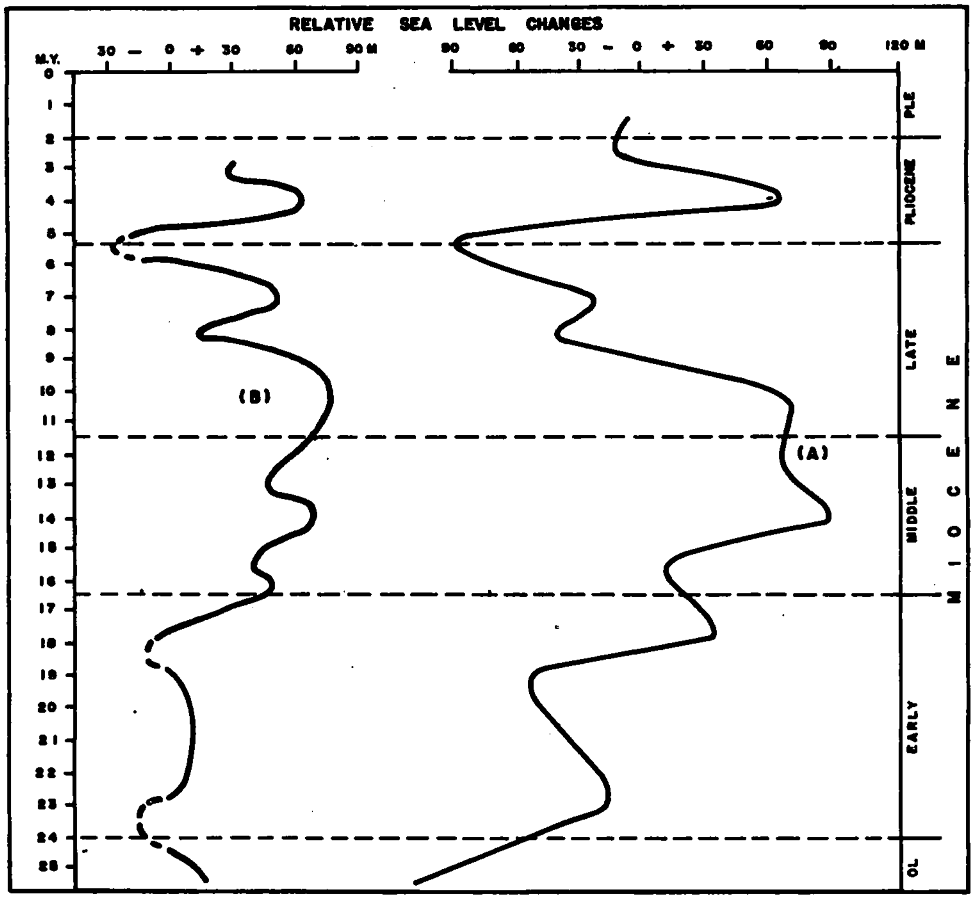


Fig. 10. Eustatic Level Curve, Modified after Vail and Hardenbol, 1979 (A), compared with the Palaeobathymetrical Curve of Balingian/Luconia (B).

For the interval older than 16 Ma no correlation between the global sea-level curve and the palaeobathymetric curve of NW Sarawak is possible. This might be explained by assuming inaccuracies in either age dating or in the interpretation of depositional environments. A more plausible explanation, however, is that during this time the effect of global sea-level changes was largely masked by the major tectonic movements which affected NW Sarawak in the Early Miocene.

REFERENCES

VAIL, P.R. and HARDENBOL, J., 1979. Sea-level changes during the Tertiary. *Oceans*, 22(3), 71-79.

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