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SUMMARY OF A GEOLOGICAL HISTORY OF EASTERN NEW GUINEA

by

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Summary

A distinction must be made between the continental basement, which underlies the south-western stable flank of the Papuan Basin and extends north into the central highlands, and the oceanic basement which underlies the north-eastern unstable flank of the Papuan Basin. The Australian geological continent has extended to the central highlands of eastern New Guinea, at least since the Permian.

Granodiorite basement formed low islands in the central highlands area in Permian time. Emplacement of the Bismarck Granodiorite in the Upper Triassic caused high, fault-bounded, islands to emerge. The clastic sedimentary record preserved in down-faulted segments indicates nearby sub-aerial dacitic vulcanism and vigorous erosion. Some of these islands persisted as land or shoal areas through subsequent marine transgressions and tectonic episodes.

After tectonic and isostatic stability was re-established in the central highlands region in the Lower Jurassic, the sea spread southwards across a low stable continental platform area on which Jurassic continental sandstone, with coal measures, unconformably overlay older terrestrial acid volcanic rocks and granite. This transgression culminated in the Lower Cretaceous, by which time, at least one third of the present-day Australian continent was covered by a shallow epeiric sea in which was deposited a blanket of fine-grained, dominantly clastic, sediment derived from pre-existing superficial sand, soil and clay. Fresh angular feldspars in these sediments were probably derived from contemporaneous vulcanism associated with granodiorite emplacement in eastern Queensland.

There is ample record of Lower Cretaceous marine blanket deposition of clastic sediments on the broad continental platform area of western Papua. At the northern continental front there was thick marine shale deposition and some submarine basaltic vulcanism. There is no stratigraphic record of Lower Cretaceous or older sedimentation, either deep marine, littoral, or continental, in the Morobe Arc - eastern Papua region. It is assumed that Lower Cretaceous and older terrigenous sediments are incorporated in the undivided metasediments in the Owen Stanley Range.

In the <u>late Cretaceous</u>, the epeiric sea receded from the continent and a large platform area in western Papua was again exposed and marine clastic sediments were deposited on a continental slope in the Purari hinterland, in the central and western highlands, and in the Snake River area near Bulolo. Foliated red limestone of Upper Cretaceous age in the Port Moresby region and farther east in the Mullins Harbour area are oceanic sediments with very little terrigenous clastic contamination. On the western platform area there was normal faulting (the Komewu Fault) and erosion before the next transgression in the Lower Miocene. On the eastern front of the platform and on the continental slope, block faulting is suggested by facies changes but details are obscured by late Tertiary folding and faulting.

During Mesozoic time, the western platform area did not support reef limestone-forming organisms although water depth and tectonic stability were probably within tolerable limits. It is assumed that low water temperatures inhibited reef formation. This may have been due to latitudinal changes by pole or land shift, or to cold marine currents. A drastic change took place in late Cretaceous to early Tertiary time, and by the Lower Miocene this platform and probably also its continuation south, fronting the Queensland coast, was extremely favourable for algal and bryozoal reef-forming communities. The Great Barrier Reef was initiated at this time. The northern part of the Miocene reef was involved in late Tertiary tectonics and it is now elevated to 16,000 ft above sea-level in the main range in West Irian, and, to the south on the Queensland coast, it is concealed beneath younger reef limestone.

Until Lower Tertiary time, marine deposition was on a simple open continental shelf and slope, and clastic sediments deposited there were derived only from the continental land mass. There was no north-east flank to the Papuan Basin as we know it to-day and there were no clastic sediments derived from that direction until the Lower Miocene when a landmass with a basement of oceanic crust emerged orogenically. By late Tertiary time, this new landmass occupied roughly the area and position of the present-day mountainous part of eastern Papua.

At the scale of this discussion, <u>Upper Cretaceous to Lower Miocene</u> time can be considered essentially a period of marine regression. In detail the situation is complex. The major regression initiated in the Upper Cretaceous probably continued into the Paleocene. This was followed by slight transgression in the Eocene and then further regression in the Oligocene. In Lower Miocene, a major transgression commenced. The early Tertiary short-lived, short distance, reversals can be attributed to either eustatic sea-level changes or to tectonic causes.

A thick sequence of <u>Eocene</u> dark marine shales and limestone on the northern flank of the central highlands represents a continental slope deposit of sediment derived from poorly consolidated muddy Cretaceous sediments exposed behind the retreating sea. The Eocene coast in this area was probably protected from the open sea by high basement islands, representing the Kubor and Bismarck Granodiorites, and by volcanic islands. Both types of islands may have supported narrow fringing reefs.

On the eastern front of the late Cretaceous platform in western Papua, there were no plutonic or volcanic complexes and consequently no high islands. There may have been fault blocks of soft Cretaceous sediments but these would soon have been levelled down to wave base and may have served as foundations for Eocene or Lower Miocene outlying reefs. At this time there was no land mass corresponding to present-day eastern Papua and the eastern platform of soft Cretaceous sediments was exposed to the full impact of wave action from the Pacific. At the onset of Eocene transgression, these waves reworked muddy Cretaceous sediments of the platform edge and produced strand deposits, or fan deposits, of quartz sand. This process was soon arrested, for, when the transgression got under way, reef growth sealed the Cretaceous sediments from further erosion. These Eocene quartzose sandstones are represented in A.P.C. wells, WANA and IVIRI. They could be important hydrocarbon reservoirs for they occupy a critical stratigraphic position adjacent to thick marine shale sequences on the east. They are the only quartzose sandstones in the entire Tertiary clastic sedimentary pile in the Papuan Basin in which good permeability might be expected.

A thick, slumped and tightly folded, Eocene chert sequence on the north-east flank of the Papuan Basin, represents sea-floor chemical and biogenic deposits accumulated beyond the reach of terrigenous clastic sediments and before the orogenic emergence of eastern Papua. The slumping of this sequence is attributed to gravity sliding following arching of the sea floor and the larger-scale folding was superimposed in the Miocene when this arching developed into full-scale orogeny by faulting and rapid isostatic uplift of pre-Tertiary metasediments.

Scattered, thin, Eocene limestone patches are the first stratigraphic record of deposition in the Northern New Guinea Basin. They occur on or near basic igneous basement rocks, particularly in the western part of the Basin. These limestones indicate either uplift of parts of the ocean floor or lowering of sea-level. It was not until Middle Miocene time that the Northern New Guinea Basin started to receive a flood of ill-sorted clastic, tuffaceous, sediment from the south where the northern continental front was being elevated along the Markham - Ramu Fault and sympathetic faults.

The Lower Miocene was a distinct turning point in the history of the Papuan Basin. In fact, it is difficult to justify the retention of the name "Papuan Basin" for the packet of sediment deposited from Lower Miocene to Recent time, because the pre-Tertiary and post-Lower Miocene depositional regimes were so vastly different.

In the Lower Miocene, the sea advanced across the continental platform to the spur of basement which extends north from Cape York, across Torres Strait, to the south coast of western Papua. In this sea, algal and bryozoal reefs flourished and, by the Middle Miocene, reef and reef detritus, from a few hundred feet thick on the landward side to about 2,000 ft thick on the outer part of the platform, had been built up. Within the platform, the Omati Trough, a northwesterly aligned deep, narrow trough was formed. It was isolated from clastic sedimentation, except in its very early history, and accumulated some 10,000 ft of Lower Miocene deep-water calcareous mud and ooze. In Middle Miocene time, there was probably both regression and transgression but the former Lower Miocene limit of transgression was not reached.

The Omati Trough was filled at the time of the Middle Miocene transgression and it was blanketed with reef and shoal limestone. The Miocene limestone blanket on the western platform cut off any further supply of terrigenous sediment from the continent to the Papuan Basin and the 40,000 to 50,000 ft post-Lower Miocene clastic succession in the Aure Trough came almost entirely from a new orogenic landmass corresponding to the present-day Owen Stanley Range. There was some contribution of clastic sediment from orogenic land at the northern front of the continent in the New Guinea highlands but most of the erosion products from this region were shed northwards into the Northern New Guinea Basin.

Until Upper Miocene time a narrow seaway existed between the Owen Stanley metamorphic block and the eastern highlands of New Guinea. This was closed in late Miocene or early Pliocene time when magmatic activity in the Wau - Bulolo area, on the east, and in the Kainantu area, on the west, caused elevation. This magmatic activity resulted in acid vulcanism and high-level emplacement of plugs, sills and dykes of quartz-feldspar porphyry possibly from the same magma source as granodiorite batholiths emplaced in the same areas in pre-Lower Miocene time. At the same time transcurrent movement, in a right-lateral sense, on the Markham - Ramu Fault caused northerly deflection and further uplift of the Owen Stanley metamorphic block. Unconformity between Miocene and Pliocene sediments in the Tauri River area may be a reflection of these magmatic and tectonic events.

Gravitational folding and diapirism of the sedimentary pile in the Aure Trough has been proceeding since Upper Miocene time and many of the stratigraphic complications there are attributable to concomitant folding and faulting. Small fringing reefs grew along parts of the north-eastern margin of the Papuan Basin. They flourished for short periods, during lulls in sedimentation, particularly on headlands distant from prograding deltas at the mouths of major rivers. Andesitic and basaltic vulcanism was prevalent from Miocene to Pleistocene time on the south flank of the Owen Stanley Range, mainly in the foothill region between Yule Island and Port Moresby.

Early in the Pliocene, the newly-emerged eastern Papuan island was linked to the central highland orogenic island area, which was, in turn, linked to the Australian mainland through West Irian. As Pliocene time progressed there was vigorous prograding, particularly in the area corresponding to the present-day middle reaches of the Fly - Strickland rivers, in response to uplift in central New Guinea. In the Pliocene, this southward prograding probably linked western Papua to the Australian mainland across a large expanse of swampy, alluvial lowland. New Guinea was assuming roughly its present shape.

In late Pliocene and Pleistocene time, the Northern New Guinea Basin sediments were being folded, faulted and uplifted, particularly at the eastern end of the Basin where the rugged Finisterre and Saruwaged Ranges were formed. Clastic sedimentation into the Papuan Basin from the Owen Stanley Range continued and deltas spread beyond their present-day limit. The world-wide marine Pleistocene transgressions and regressions modified the south Papuan coastline by inundating deltas and redistributing deltaic sediments. At this time, Torres Strait was formed and the sea encroached across the lowland area between the northern orogenic front of the continent and the stable craton to form the Arafura Sea and the Gulf of Carpentaria.

Continuing uplift in the Owen Stanley Range provided sediment for reclamation of the south Papuan coastline by prograding, and the successions of abandoned strand lines along much of that coast testify to very Recent emergence.

Strong tides in the Pleistocene and Recent Arafura Sea and Gulf of Carpentaria have flushed out much Pliocene and Pleistocene deltaic sediment deposited there from the north. The Arafura Sea is now being reclaimed again by delta encroachment from the north.

The concept of Miocene emergence of a new eastern Papuan landmass relies largely on the interpretation of gross changes in stratigraphy in the Eocene and Miocene sedimentary sequences on the north-eastern flank of the Papuan Basin. If this interpretation is correct, then some radical explanation for the difference in metamorphic grade between Eocene/Upper Cretaceous sediments in the Port Moresby area and the nearby metasediments of probable Mesozoic age in the Owen Stanley Range, is required. In explanation of this apparent anomaly the following sequence of events in late Cretaceous to Miocene orogenic evolution is proposed.

1. Late Cretaceous to Upper Miocene - deposition of red shale, fine-grained pink limestone and chert on the ocean floor beyond the reach of terrigenous clastic sediment. Submarine vulcanism with the outpouring of pillow lavas and increase of silica concentration in sea water. (Fig. 11)

2. Upper Eocene/Oligocene - low arching of ocean floor beyond the limit of terrigenous clastic sedimentation; mass slumping of oceanic sediments and possibly also of pillow lavas, dolerite and gabbro of the upper part of oceanic crust. (Fig. 12)

3. Oligocene - crestal rupturing of arched oceanic crust and thrusting of the north-eastern limb of the arch towards the Australian continent and over Mesozoic and older sediments accumulated at the base of the continental slope. (Fig. 12)

4. Oligocene to Lower Miocene - metamorphism of Mesozoic and older continental slope sediments by the weight of the thrust slice of oceanic crust, compression, frictional heat and magmatic heat. (Fig. 13)

5. Lower Miocene - metasediments reacted as a homogeneous crystalline block and rose isostatically using the original thrust plane as a glide plane. The rapid emergence of the metamorphic block turned up the leading edge of the thrust plate of oceanic crust and exposed deep crust or upper mantle material in the form of ultramafic rocks (the Papuan Ultramafic Belt). (Fig. 13)

6. Lower Miocene onwards - continued emergence of the metamorphic block and tight folding and faulting of Eocene and Upper Cretaceous sediments (e.g. in the Port Moresby area). Complementary north-easterly downward sliding of oceanic thrust plate as part of regional isostatic adjustment. Generation of granodiorite magma from anatexis of metamorphosed pre-Tertiary sediments and rise of magma (e.g. in Wau - Bulolo and Waria Valley areas).

Late Tertiary and Quaternary deformation of clastic sediments in the Aure Trough and south of the central highlands is confined to distinctly linear zones in a three-pronged array centred in the Pie - Purari area. The geometry of this array was determined by two independently active orogenic regions namely, the Owen Stanley block to the east, and, the central highlands block to the north, causing compressional and gravitational folding of the incompetent clastic sediments against a buttress of thick competent Miocene limestone based on a relatively stable platform of continental crust.

Slides will be shown portraying:-

1. Six stages in the palaeogeographic evolution of eastern New Guinea; (Figs. 2-8)

2. A schematic cross-section of Papuan Basin stratigraphy;

3. Quaternary structure and vulcanism, (Fig. 10) and

4. Three stages in the orogenic development of eastern Papua. (Figs. 11, 12, 13)

SUMMARY OF A GEOLOGICAL HISTORY OF EASTERN NEW GUINEA

Illustrations

Palaeogeographic Maps

Evolution of Papuan Basin and Eastern Papua

SCHEMATIC SECTION ACROSS S-W FLANK OF PAPUAN BASIN

FIG 9.

NOT TO SCALE

(DIRECTION OF SEDIMENT TRANSPORT →)