CHAPTER 2

2 THE BASEMENT OF BORNEO

2.1 "CONTINENTAL BASEMENT" & THE SUNDA SHIELD

2.1.1 It has been customary to refer to the largely granitic terrain occupied by the Schwaner Mountains in west Borneo as "continental" basement which forms part of a larger area termed "Sunda Shield" implying a largely ancient continental core or craton. Recent chemical and radiometric data now show that there would appear to be no ancient cratonic continental rocks in that part of West Borneo known as the "Sunda Shield". The Schwaner Mountains composite batholith forming the largest plutonic mass in Borneo is a Cretaceous volcano-plutonic arc which some authors have linked with subduction associated with the Boyan and Lubok Antu - Kapuas mélange zones 100 - 200 km to the north. The granitoids intrude the Pinoh metamorphics, the oldest autochthonous rocks are thought to be Carboniferous-Permian or earlier in age. The term "Continental Basement" would therefore appear to be a misnomer as is the term "Sunda Shield" for which Haile (1969) suggested the term "west Borneo hinterland". Perhaps a more appropriate term would be "Pre-Carboniferous Basement" to remove the continental affiliation and the term "Sunda Shelf" would be more appropriate than "Sunda Shield" as the area comprising Malaya, west Borneo and between has been emergent during the late Cenozoic. Although a small number of late intrusions tend to be alkaline, there is a difference between the onshore, predominantly I-type (Chappell & White,1974), calc-alkaline, volcano-plutonic rocks of West Kalimantan and the apparently rift-related granites on the islands further west in the South China Sea (Karimata, Natuna and Anambas) which are distinctly alkaline and give slightly younger radiometric ages. Hutchison (1989) questions whether the Late Cretaceous radiometric ages obtained from the rift-related granites represent emplacement ages or a subsequent hydrothermal modification and remarks that the Late Cretaceous epizonal granites may be included in the Late Yenshanian rifting province which extends from south China to the environs of the South China Sea.

2.2 DEVONIAN

2.2.1 The oldest fossiliferous rocks in Borneo have been recorded only from one locality in Sg. Telen (116° E, 1°N) in central Borneo (Rutten, 1940). The locality was revisited by students from Institute Teknologi Bandung and a copy of their map if shown in Fig 2.1. About 300m of section is exposed in the river surrounded almost entirely by intermediate largely volcanic rocks including andesite, diorite, liparite and dacite together with hornblende garnet schist, epidosite and radiolarian chert (Fig 2.1). A 1989 preliminary survey by students from Institute Technology Bandung reported wackstone and sandy limestone strata above and below the main limestone and that the margins of the limestone are composed of crushed sandy limestone and/or crushed claystone indicating

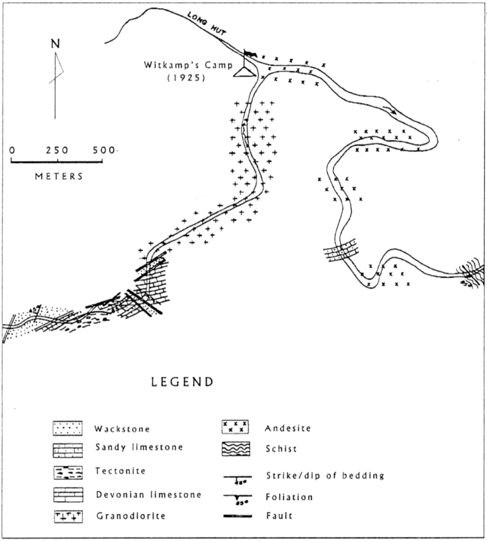

Fig 2.1 Sketch map showing locality of Devonian limestone in Sg. Telen, central Kalimantan. (after Institute Teknologi Bandung Report March, 1989)

fault contacts with the surrounding rocks (ITB,1989). The main limestone, according to Witkamp's 1925 expedition is 25m thick. Granodiorite and schist are the main rocks adjacent to the limestone (Fig 2.1) (ITB,1989). The rocks appear to be blocks within a mélange but the matrix is not described. The Devonian coralline limestone occurs as an allochthonous block of dark, recrystallised limestone within a highly disturbed mélange zone (Pieters,P.E. & Supriatna,S. 1989b). No autochthonous counter-parts are known. *Heliolites porosus* is clearly identifiable in thin sections of recrystallised limestone, locally impregnated with black matter (?carbon) and the internal structure of the coral is well preserved; *Clathrodictyon cf.spatiosum* occurs in thin and polished section (Rutten, 1940).

2.2.2 *Heliolites* corals are found in the Silurian and Devonian and are minor reef-building organisms which grow in semi-rough water from occasional agitation to about surf base. They are abundant in the Niagran reefs of the Great Lakes area, USA, Arctic America, N Mexico and Great Britain (Lowenstam, 1967). *Clathrodictyon* is a stromatoporoid coelenterate and commonly a reef builder and is reported from Greenland, E Canada, E and central USA, Great Britain and the Baltic region (Shimer & Shrock,1955). Stromatoporoids flourished especially in the Devonian and true stromatoporoids suddenly and unaccountably became extinct at the end of the Devonian (Easton,-1960).

2.2.3 The age of the limestone from Sg. Telen is considered by Rutten (1940) to be Lower or Middle Devonian most probably Lower Devonian, based on records of *Heliolites porosus* from the Lower-Middle Devonian of Europe and Middle Devonian of the Altai Region of Western Siberia. The *Clathrodictyon* species found in Borneo resembles *Clathrodictyon cf. spatiosum* Boenhke defined from N Germany and Holland (Boenhke, 1915) and in Europe, *Clathrodictyon* occurs almost exclusively in the Silurian and *Clathrodictyon spatiosum* is known only from glacial erratic boulders in NE Germany. According to Kohn (1928), the stromatoporoids tend to be found in younger rocks the further east the fossils are found and it seems likely that *Clathrodictyon* lived during the Devonian in the Far East.

2.2.4 Devonian sediments are widespread in the Asiatic and Australian continents but correlation with west European biostratigraphic scales was formerly unsatisfactory but better correlations are now available, based largely on conodonts (Yolkin *et al.*, 1986). In the Asiatic region, a review of the Devonian in SE Asia is given by Nguyen (1986) in which four main facies zones are recognised. The Burma zone of shelf facies, the Thai-Malayan zone basinal facies, a volcanic Central zone and the North Indochina zone comprising shelf and subordinate basinal facies. Two depositional cycles are recorded, the first from the Silurian- Devonian boundary up to the top of Middle Devonian, Givetian. Givetian and Frasnian are almost absent in Burma, Thailand and Malaya which were emergent but deposition was widespread in N Indochina. The second depositional cycle started in Famennian (uppermost Upper Devonian) with red beds in Thailand and Malaya and manganese red banded limestone in N Indochina and deposition continues into the Carboniferous. Red beds in Langkawi rest unconformably on older rocks.

2.2.5 The nearest Devonian rocks to Borneo are in NW Malaya and comprise shelf limestones and locally, redbeds of Lower - Middle Devonian (Hutchison, 1989). In Vietnam, Lower - Middle Devonian mostly terrigenous sediments with minor limestones containing brachiopods and corals are widespread within 220km N and NW of Hanoi. Smaller areas of continental Lower and Middle Devonian overlying the Lower Paleozoic occur N of Da Nang and as far as NW of Bong Hoi, 290km further N, in central Vietnam. Middle Devonian black limestones overlie the continental sediments in N Vietnam and limestones and shales of Middle - Upper Devonian occur in small areas 60 - 80Km SW of Hanoi. Upper Devonian siliceous shales, siltstones, banded limestones and white limestones containing manganese occur in N Vietnam (Tran & Nguyen, 1986).

2.2.6 S of Borneo, the nearest Devonian rocks are found in Indonesian New Guinea and on the NW and NE Australian continent. There is no Devonian in the Philippines. In New Guinea, Silurian and Devonian rocks occur in isolated outcrops between NE Australia and Papuan New Guinea in the Torres Straits. A thin wedge of Upper Paleozoic shelf strata occurs in the Snow Mountains at about latitude 5°S and between 135° and 140°E comprising Silurian limestone, Devonian limestone and sandstone and Carboniferous(?) and Permian limestone and continental and marine sandstone and shale (F.G.Keyzer *in:* Van Bemmelen,1949).

2.2.7 Hamilton (1979) argues that there is a "missing landmass" comprising which is essentially a continuation of the belt of Upper Paleozoic sediments and Triassic granitic rocks forming present-day NE Australia. A basement high continues across the Torres Straits and into the S part of Papuan New Guinea where it is truncated against an E-W zone of mid-Cenozoic melange. The truncation represents, according to Hamilton, rifting of the continent probably in Jurassic or Triassic times. Such a landmass should consist of tin granites on one side and an older platform on the other if it is to match NE Australia. The Indochina-Malay Peninsula-Sumatran plate is cited as the obvious candidate. Tropical climates and faunas in the Cambrian - Devonian match those in NE Australia but the Permian in Australia shows a cold water fauna and flora, hence a proposed rift separation before the Permian is envisaged, not Triassic / Jurassic as Hamilton (1979) suggests. However, cold water Carbo-Permian diamictites of glacial origin occur extensively in S Thailand, NW Malaya and Sumatra (Stauffer & Lee, 1986).

2.2.8 Moreover, there is evidence of links between S China, Malaya and Australia as diamictites have been found in the Carbo-Permian Singa Formation of Langkawi, N.Malaya (Stauffer and Lee,1986), and equivalent Phuket Group further N in Thailand. Almost identical rock types have been found in the Canning Basin, NW Australia (Redfern, J., 1991). Permian tilloids are reported from Hainan Island in S China (Yu,1989) but a re-examination of the exposures by Metcalfe in 1995 indicates the rocks are NOT tilloids (Metcalfe, verbal comm., March 1996) . The tilloids of the Thai-Malaya-Sumatra belt extend for at least 2000km and hence are probably derived from an extensive glaciated sheet rather than localised glaciers. Stauffer and Lee(1986) conclude that there is nothing in the glacial evidence that points preferentially to any one part of the Gondwana margin - India, SE Australia, Arabia, SW South America or West Antarctica. However, the Paleozoic sequences of small allochthonous continental fragments which contain the diamictites also contain Paleozoic trilobites and other invertebrates endemic to Australia and Gondwanalnd (Metcalfe, 1991).

2.2.9 A parallel problem concerns the Permian flora of SE Asia; those floras that show large leaf, warm climate Cathaysian affinities lie E of the Raub-Bentong Line on a different tectonic block from the cold water diamictites in the west.The coralline limestones found at Sg. Telen are presumed to be warm water faunas and hence have a Cathaysian rather than Gondwana affinity. The isolated occurrence of Devonian rocks in Borneo presents a tantalizing enigma which remains to be explained satisfactorily.

2.3 PRE-CARBONIFEROUS BASEMENT - NW KALIMANTAN

2.3.1 The term "Pre-Carboniferous Basement" refers to a sequence of regionally metamorphosed, schistose rocks of largely indeterminate origin occurring as relatively small, detached inliers in Kalimantan and West Sarawak. The oldest *in situ* rocks in Kalimantan (and probably Borneo) are described by a new formation name, the "Pinoh Metamorphics" which replaces the nomenclature of Zeijlmans van Emmichoven (1939) and van Bemmelen (1939) who referred to the rocks as "Kristallijne Schisten, Permocarboon en Mesozoicum der Schwaner Genergtezone" (Crystalline schists, Permo-Carboniferous and Mesozoic of the Schwaner Mountains area).

2.3.2 The Pinoh Metamorphics outcrop principally in a 50km - wide latitudinal belt extending discontinuously across the northern flank of the granitoid Schwaner Mountains from near Pontianak eastwards to the margin of the West Kutei basin (see Fig 5.1, Chapter 5). A smaller area, mapped as Seminis Formation, occurs in NW Kalimantan S of Sambas (Fig 5.2, Chapter 5). The Pinoh Metamorphics comprise slate, hornfels, phyllite, quartzite, schist, gneiss, migmatite and minor metavolcanics and amphibolite; some areas contain distinctive calcareous psammites and pelites. The type locality is situated in the Nangapinoh quadrangle, in the area of Sg. Pinoh (111° 45'E, 0° 30'S) (Amiruddin & Trail,- 1989).

2.3.3 In the Nangataman Data Record (Pieters & Sanyato, 1989) rock types in the Pinoh Metamorphics are described as,in decreasing order of abundance : mica and quartz-mica schist, phyllite and quartz phyllite, slate, hornfels, metaquartzite, quartz-mica-felspar hornfels and gneiss. Calc-phyllite, calc-schist, calc-silicate hornfels, greenschist, greenstone and hornblende-plagioclase and hornblende-quartz schist occur locally. Most rocks are grey in colour but the finer grained rocks are dark and contain much disseminated iron-oxide and carbonaceous material. The remaining rocks are green. Locally, porphyroblasts of garnet, andalusite and sillimanite occur in slate, phyllite and schist. Amphibole, felspar and quartz are visible in some of the greenschist hand specimens. Sedimentary bedding is sometimes preserved as thin, compositional. textural and colour banding in metapelite and metapsammite. Migmatites consist basically of three main rock types,leucogranitoid, mafic diorite or gabbro and granoblastic to gneissic rocks. The gabbro is described as a biotite,hornblende, quartz,plagioclase gneiss; the leucogranitoid as medium-grained, biotite sparse tonalite and the intermediate rock as fine-grained weakly foliated granoblastic quartz-biotite-hornblende-plagioclase hornfels. In thin section, andalusite, sillimanite, cordierite, rare garnet and staurolite occur as incipient porphyroblasts and often markedly poikilitic, overgrowing the schistosity and show clearly that the original rocks have been strongly affected by the surrounding granite plutons. Generally, the rocks display retrograde metamorphism biotite altered to chlorite, plagioclase to sericite and epidote/clinozoisite and andalusite to sericite. Exceptionally, cordierite rarely shows alteration to pinite. The calc-silicate rocks are described as plagioclase-epidote-quartz schist, hornblende-quartz schist and biotite-hornblende-quartz-plagioclase schist containing brown to bluish green pleochroic hornblende with accessory iron oxide and sphene. The tonalite - quartz diorite migmatite contains quartz,plagioclase,K-felspar,biotite with or without hornblende and clinopyroxene. The mafic diorite comprises andesine, hornblende and biotite with accessory iron oxide,sphene, apatite and zircon.

2.3.4 Pieters & Sanyato (1989) speculate on the protolith as being wide ranging in composition from high-aluminum pelite to quartz-rich psammite generally with little calcareous admixture. Some of the metasediments are said to contain carbonaceous material but it is not clear whether the presence of carbon has been proved analytically. Intermediate to mafic volcanics formed a minor component.

2.3.5 There are two metamorphic grades, a low, greenschist facies and a higher, garnet facies. In addition to the regional metamorphism, thermal metamorphism related to the subsequent intrusion of Schwaner Mountains granitoid plutons has imprinted andalusite hornfels. Mineral assemblages reported by Pieters & Sanyoto (1989) include: quartz + muscovite + biotite + albite ± andalusite (chiastolite); quartz + muscovite + biotite + plagioclase + andalusite + cordierite; and quartz + muscovite + biotite + plagioclase + K-felspar ± andalusite + cordierite + sillimamite. Plagioclase varies in composition from oligoclase to andesine. Retrogressive metamorphism is present in some of the phyllites which contain staurolite and garnet; porphyroblastic andalusite overprints the foliation and is the effect of the thermal metamorphism of the surrounding granitoid intrusions.

2.3.6 The dominant trend in the regional structure of the Pinoh Metamorphics shown by the strike of cleavage or schistosity is WNW - ESE. The consistency of the trend between inliers separated by large masses of plutonic rock belonging to the Sepauk Tonalite Suite suggests that emplacement of the latter has done little to disturb the pre-existing structure of the country rock. There is however, local variation of strike of the schistosity and it ranges from ENE through E to SE. Trendlines on aerial photographs trend SE. Major faults have been mapped between metamorphics and plutons in several places and trend generally ESE and SE. Others trend S and a few trend NE. Contacts between the Pinoh metamorphics and other pre-Mesozoic rocks are faulted and contacts between Cenozoic sediments are moderately dipping unconformities (Amiruddin & Trail, D.S., 1989).

2.3.7 The distribution of the Pinoh metamorphics seems to be largely restricted to the northern and central parts of the Lower Cretaceous batholith which forms the largest of all the granite areas within the Schwaner Mountains. Moreover, they form a relatively narrow zone about 55 km at its widest part and extend latitudinally for 420 km in central Kalimantan and a further 50 km in NW Kalimantan. If the Pinoh metamorphics comprises essentially metamorphosed oceanic crust, it is tempting to suggest that the linear nature of the exposures may mark a former suture zone rather than granite intruding a more extensive planar fragment of oceanic crust.

2.3.8 The Seminis Formation is poorly exposed (Rusmana *et al.*,- 1989) and comprises well-cleaved slates and phyllites cut by quartz veins and indurated, micaceous meta-sandstones and there are indications of deep water turbidites. Intruding and overlying the Seminis Formation are the widespread intermediate to basic Sekadau Volcanics which are thought to be equivalent to the

Late Triassic Serian Volcanics in Sarawak. In mapping the Sambas-Siluas 1:250 000 quadrangle, Rusmana *et al.*,(1989) remark that the age of the Seminis Formation is poorly constrained and assumed tentatively a ?Late Paleozoic-Early Triassic age based on structural and stratigraphic evidence. They state that the Seminis Formation is overlain unconformably by relatively unmetamorphosed, mainly tuffaceous and carbonaceous clastics and possible turbidites of the ?Late Triassic to Lower Jurassic Bengkayang Group which would indicate that the Seminis Formation is older than Late Triassic. Rusmana *et al.*,(1989) also suggest that some of the volcanics in the southern part of Sambas may be related to the Lower Cretaceous Raya volcanics (marked as Kl4 on 1:1 million map) which outcrop widely to the E and SE. Perhaps the Seminis Formation is equivalent to the pre-Lower Carboniferous Tuang Formation around Kuching which has deep water affinities. The inter-relationships of metasediments and volcanics and detailed nature of the various volcanic sequences associated with the Seminis Formation need to be pursued further to establish a reliable age and stratigraphic position for the Seminis Formation. For the purposes of the present correlation, the Seminis Formation is regarded as Lower Carboniferous or older, a stratigraphic position used on the IAGMP 1:1 million preliminary geological map.

2.3.9 The age of the Pinoh Metamorphics is uncertain; no critical contacts have been found with rocks other than Cretaceous granitoids and it has been assumed that the stratigraphic position is older than Lower Triassic and most likely Lower Carboniferous or pre-Carboniferous. Only one radiometric date has been obtained from whole rock biotite hornfels which gives a value of 189±2 (Mouret,1987) which Bladon *et al.*(1987) interpret as being close to the age of metamorphic reconstitution. Radiometric methods applied to the Pinoh Metamorphics are difficult to perform due to the problem in finding suitable samples free of the thermal effects of later plutonism.

2.3.10 The turbiditic and associated basic/?ultrabasic nature of Seminis Formations suggests that it may have been formed in an oceanic environment; certain aspects of the Pinoh metamorphics could also be classified as oceanic especially if the quartzites show grading and the metavolcanics, amphibolites and migmatites are derivatives of sub-seafloor metamorphism as Hutchison & Dhonau (1971) have proved in eastern Sabah.

2.4 PRE-CARBONIFEROUS BASEMENT - W SARAWAK

2.4.1 In West Sarawak, Pre-Carboniferous strata are confined to two Formations, the Tuang and the Kerait Schist. The former occurs in a more or less contiguous area around Kuching and to the south around Kuap and consists of highly deformed, greenschist-grade metamorphic rocks comprising basic and possibly ultrabasic rocks together with boudinaged metasandstones interbedded with graphitic phyllites. The metasandstones show graded bedding and are probably turbidites (Hon,in manuscript). The Formation is thought to be Pre-Carboniferous on the evidence of a dubious fossil tentaculid. The Kerait Schist Formation (Pimm, 1965) occurs as inliers in relatively small isolated areas E and

SE of Serian and comprises muscovite - quartz schists and muscovite - tremolite - quartz schists. It has not been dated and is thought to be contemporaneous with the Tuang Formation. There would appear to be no rocks equivalent to the Kerait Schist Formation in Kalimantan.

2.4.2 In detail, the Tuang Formation is distributed across an area covering about 80 Km^2, and comprises phyllite, some pelitic and basic schists and metasandstone, minor pelitic hornfels and silicified volcanics and chert. The mineral assemblages of the rocks are outlined below:

Phyllite	quartz + muscov + graphite ±chlorite ± albite, ± calcite
Pelitic schist	quartz + muscov + graphite ±chlorite ± albite ± calcite
Basic schist	<u>quartz-epidote schist</u> quartz + epidote + calcite + albite + muscov + chlorite ± actinolite <u>quartz-actinolite schist</u> quartz + actinolite + muscov +albite + chlorite ± epidote ± graphite
Metasandstone	<u>metafelspathic graywacke</u> quartz + K felspar + plagioclase in sericite-chlorite-quartz-felspar matrix

	sericite quartzite (very rare)
	granoblastic quartz with minor interstitial sericite
Pelitic hornfels	very rare and found close to Miocene intrusives.

2.4.3 The Tuang Formation has undergone multiphase deformation, commonly with "similar-type" folds and Hon (in manuscript) has recognised at least three phases of folding. The metamorphic grade is greenschist facies. The type locality is in the Sg. Tuang, 17km SE of Kuching and described in Hon (in manuscript). Outcrops in the vicinity of Kuching are generally poor and usually comprise the more pelitic rocks which, when weathered, could be mistaken easily for sheared Pedawan Formation. A recently excavated exposure which shows an excellent section of thick arenaceous layers in graphitic pelite occurs at the new Kim Hin ceramics factory site on Jln. Kg. Sudat, 1.6km from the Kuching-Serian road, 7km from Kuching (110°19'E, 1°29½'N). The metasandstones are probably turbiditic as they exhibit graded bedding and have been stretched and boudinaged and are enclosed in a very graphitic blue-grey pelitic phyllite (Fig 2.2). Boulders of green chlorite schist also occur but are not found *in situ*. Elsewhere on the site, the rocks are predominantly weathered pelites which could be mistaken for Pedawan shales.

2.4.4 Another locality on Jalan Datu Stephen Yong, near Kg.-Semeba, 4.5km N of Jalan Batu Kitang (110°17'E,1°28'N) consists of banded quartzitic schists associated with massive chlorite - epidote schists veined by quartz and with calcite-covered joint planes. The ubiquitous presence of epidote

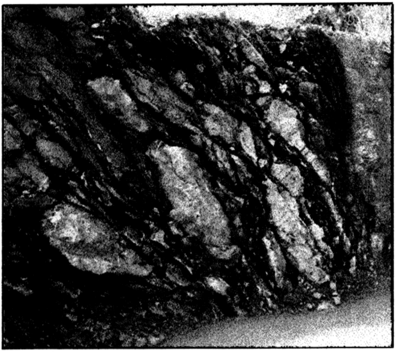

Fig 2.2 Exposure in Tuang Formation, Kin Hin Brickworks, 7 km SE of Kuching, W. Sarawak. Steeply dipping boudinaged quartzites in graphitic shales.

suggests that the rocks are derived from basic or ultrabasic rocks, basalt or gabbro.

2.4.5 The age of the Tuang Formation was thought to be pre-Carboniferous based on the evidence of a "dubious fossil tentaculid" reported by Tan (*in manuscript*).

2.4.6 No basic rocks have been found in the predominantly muscovite-quartz and muscovite-tremolite-quartz schists of the Kerait Schist Formation (Pimm,1965) E and SE of Serian.

2.4.7 Three other Formations in west Sarawak show certain affinities with the Tuang and Kerait Schist Formations, viz: the Serabang, Sejingkat and Sebangan Hornstone Formations (see Appendix IIa).

2.4.8 The Serabang Formation (Wolfenden & Haile,1963) is found to the west of Lundu (captioned JKx on Fig 5.2, Chapter 5). Poorly exposed and poorly dated (?Upper Jurassic - Cretaceous), the ages were obtained from radiolaria studied in thin section (G.F.Elliot *in*: Wolfenden & Haile, 1963) and from two unconfirmed specimens of *Orbitolina* (Hashimoto, *et al.*,1975). It forms a unique unit possessing a regional WNW strike similar to that shown by the Upper Paleozoic Pinoh Metamorphics in Kalimantan but totally discordantly with the rest of the Mesozoic and older rocks in west Sarawak. Unlike the Pedawan Formation alleged to be of the same age, the Serabang Formation is *regionally* metamorphosed to greenschist grade as well as being thermally metamorphosed by Cretaceous adamellite and granodiorite intrusions of Pueh and Gading. The rock types found in the Serabang Formation closely resemble those of the Tuang Formation and are most likely of deep water origin, probably with oceanic affinities, the epidote-rich rocks being derived from oceanic basalts and gabbros. Some of the rocks outcropping on the coast are described as chaotic and sheared " bouldery slate" is reported in Wolfenden & Haile (1963) and both could be interpreted as melange. The contact between the Serabang and Pedawan Formations is largely covered by the younger Kayan Sandstone and is very likely tectonic and not an unconformity as the regional strike parallels the regional structure in NW Kalimantan.

2.4.9 The lithologies of the Serabang Formation resemble also those in the Pinoh Metamorphics. Besides the main rock types (slate, phyllite, quartzite, schist, hornfels but with the exception of ?chert, ?gneiss and ? migmatite) metavolcanics, amphibolite and greenstone have been reported in both Formations and Cretaceous granitoids intrude both.

2.4.10 The Sebangan Hornstone near Sebuyau, N of the Kerait schist areas around Serian, is a chert-like rock which Haile (1954) suggested was a silicified volcanic rock and most likely of Carbo-Permian age. It is almost certainly a metamorphosed chert sequence as hills of chert, mapped as Sebangan W and SW of the Sebuyau granite, show little or no thermal metamorphism.

2.4.11 The Sejingkat Formation forms a band of sheared cherty rocks across the Bako peninsula, N of Kuching. Isolated occurrences of spilitic basalt, basalt and gabbro together with chert and chert blocks in carbonaceous phyllite have been recorded around Muara Tebas in the Sarawak river delta by Roslan(1987). The metamorphic grade of the Sejingkat Formation, characterized by a prehnite/sericite/muscovite assemblage, is lower than the greenschist grade in the Serabang Formation and the basalts and gabbros are mineralogically little altered and original igneous textures are still preserved (Roslan,1987). Further-more, sedimentological features are preserved in the cherts although there is some post-depositional diagenetic alteration of siliceous horizons. Tan(1980) has identified graded bedding and sole markings in the cherts indicating a turbiditic origin. The Sejingkat Formation is commonly composed of chaotic blocks, mainly of chert and chert in phyllite and the Formation is interpreted as a tectonic melange.

2.4.12 The Sebangan Hornstone and the Sejingkat Formations are probably equivalent as they are both chert sequences and show a roughly parallel spatial relationship. The lithology and metamorphic grade of the Sejingkat/ Sebangan Hornstone Formations indicate that they are similar to the Lupar melange zone further E and are quite unlike the higher grade rocks of the Sera-bang, Tuang, Kerait Schist Formations.

2.4.13 The turbiditic nature of the metasandstones and the basic/-ultrabasic rock association suggests strongly that the Tuang Formation is a deep marine deposit possibly with oceanic affinities. Basic/ultrabasic rocks are not evident in the Kerait Schist Formation but similarities in mineralogy and rock type and the occurrence, apparently a continuation of the main Tuang Formation outcrop to the NW, indicate that the Tuang and Kerait schist are probably equiva-lent. Further west the Serabang Formation shows similar affinities with the Tuang Formation and is also a regionally metamorphosed deep marine sequence with oceanic basalts. Correlation with the Pinoh Metamorphics and Seminis

Formation in Kalimantan indicate the Tuang and Kerait Formations are certainly pre-Lower Cretaceous and probably Carbo-Permian and the Serabang is likely to be the same age. Thus, in west Sarawak, there appears to be two groups of deep water rock sequences with similar compositional varieties but one group shows a consistently higher grade metamorphism and is therefore, probably older. The rocks comprising the Tuang, Kerait Schist and Serabang Formations form an association of essentially deep water deposits with oceanic characteristics, are metamorphosed to greenschist grade and could be of the same age and origin. They probably represent a Carbo-Permian ocean floor. The Sejingkat and - Sebangan Formations have clearly not undergone the same degree of metamorphism as the Serabang /Tuang/Kerait Formations and they show similar lithologies with the Upper Cretaceous - Eocene Lupar zone, although they could be older.

2.4.14 A whole-rock radiometric age determination on the basic rocks from the Tuang Formation would probably give the age of metamorphism and perhaps an original age of eruption. To obtain better paleontological ages, there is a need for careful re-examination of the radiolarian cherts in the Serabang Formation using the modern technique of whole specimen abstraction to enable positive identification of species. A closer examination of the unmetamorphosed cherts in the Sebangan Hornstone Formation may reveal radiolaria which could be dated and perhaps chert in the Tuang Formation may yet yield datable fossils.

2.4.15 In conclusion, previous interpretations concerning the nature of the Bornean part of the "Sunda Shield" and its synonyms appear incorrect; the so-called "Basement" of western Borneo seems to have been constructed of essentially deep water sediments associated with ocean floor extrusives of probable Pre-Carboniferous age. The Devonian limestone blocks are associated with a variety of intermediate to basic volcanic rocks and chert of unknown age. On the present evidence available, their origin seems to be a reef in an oceanic environment.