Middle Jurassic Ammonites from the Cendrawasih Bay Coast and North Lengguru Fold-Belt, West Papua: Implications of a 'forgotten' 1913 Paper

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ABSTRACT

Occurrences of Middle Jurassic bathyal shales with typical ammonite faunas were reported from the 'Birds Neck', West Papua, in 1913 and 1927 publications but these appear to be largely forgotten. They signify an eastern limit for the gas-productive Middle Jurassic sands of Bintuni Bay and thus have significant negative implications for the potential of Mesozoic hydrocarbon plays in Cenderawasih Bay.

Introduction

Almost 100 years ago, in 1913, German paleontologist Georg Boehm from the University of Freiburg, published a paper on Middle Jurassic ammonites from locations along the coast of Cenderawasih Bay in West Papua's 'Bird's Neck' and from nearby locations in the North Lengguru foldbelt. It is entitled 'Unteres Callovien und Coronaten-Schichten zwischen MacCluer Golf und Geelvink-Bai' (translated: 'Lower Callovian and Coronatus beds between MacCluer Gulf and Geelvink Bay' (MacCluer Gulf= west Bintuni Bay, Geelvink Bay = Cenderawasih Bay). There is no record in the literature that these outcrops have ever been revisited, except probably by NNGPM geologists around the 1950's (Visser and Hermes 1962; Loc. 16 on Encl. 6).

Most of the ammonites described by Boehm were collected during the 1903 'Dutch scientific expedition to New Guinea in 1903', a 9-month journey along the northern coastal regions of West Papua, led by Arthur Wichmann, professor of geology and geography at the University of Utrecht, Netherlands. Additional, similar Middle Jurassic ammonite material was available from material collected by BPM geologist, Hirschi, around 1906 from localities farther inland, west of the main divide of the northern outliers of the Lengguru foldbelt. All fossil material ended up in the collections of the University of Utrecht.

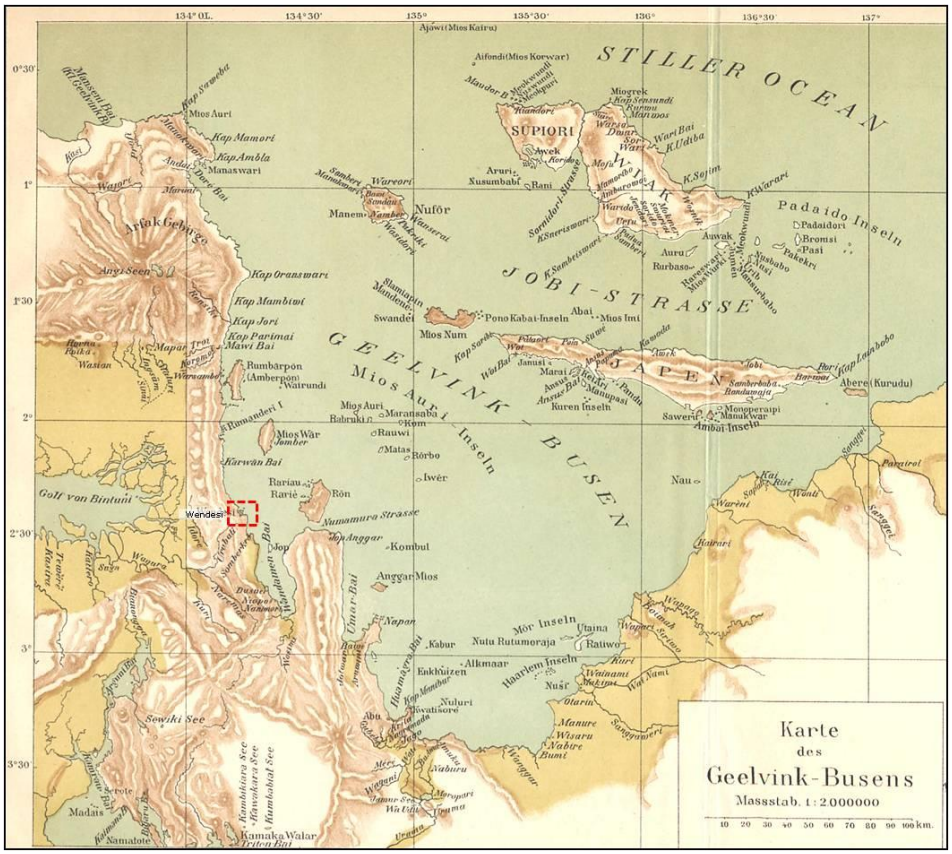


Figure 1. Overview map of Cenderawasih Bay (then called Geelvink Bay; Wichmann, 1917).

Boehm (1913) claimed that this paper was the first record of ammonites from New Guinea Island that could be reliably dated, although Etheridge (1889) had already reported similar ammonite finds at the Strickland River of Papua New Guinea. Similar ammonite faunas were also known from Taliabu and Mangoli in the Sula islands of eastern Indonesia (Boehm 1912).

A later paper by Gerth (1927) entitled 'A new occurrence of the bathyal cephalopod facies of the Middle Jurassic in Netherlands New Guinea' largely confirms the Boehm results. It describes a collection of Middle Jurassic ammonites collected by a Dutch government official from Fakfak. Unfortunately, location information is very poor, only described as Wairor River and its Weriangki tributary, supposedly near Fak Fak. Ammonites are from geodes in hard black limestone, and species are similar to those from Cenderawasih Bay and the Sula islands.

The Boehm (1913) paper now appears to be largely forgotten, but the presence of Middle Jurassic open marine black shales is an important

control point in paleogeographic reconstructions of the region, and may be particularly relevant to the distribution and provenance of the presumably age-equivalent gas reservoir sandstones of the Tangguh complex of Bintuni Bay.

Localities

Several localities were mentioned by Boehm (1913), but not described in great detail. More details can be found in the lengthy report of the 1903 North New Guinea expedition by Wichmann (1917). There are some inconsistencies between the Boehm (1913) and Wichmann (1917) maps of the Wendesi area. We assume the Wichmann maps are the more accurate ones (Figures 1, 2).

The richest ammonite assemblages were collected along the Mamapiri and Papararo and creeks, SE of the coastal village of Wendesi (Figure 2). The Mamapiri Creek assemblages are particularly rich, probably belonging to multiple horizons, and include up to 30 cm large specimens of *Phylloceras mamapiricum* n.sp. Most of the ammonite material was not collected in situ, but as float in the riverbeds. Wichmann described the few small outcrops in Mamapiri creek as steeply dipping dark shales (Wichmann 1917, p. 343).

Rocks are described as black, very fine-grained, hard calcareous marl at Mamapiri and as non-calcareous, slightly metamorphic shaly claystone at Papararo. Most of the ammonites are in non-calcareous black geodes. At Mamapiri the ammonites are typically undeformed, only a few are clearly squeezed. At Papararo creek almost all ammonites are more or less deformed.

Similar Jurassic ammonite material was collected farther inland by BPM geologist Hirschi, around 1906, west of the main divide of the northern outliers of the Lengguru foldbelt. The locality is named Aramasa and was described as steeply dipping dark shales from 'the western foot of the Wiwi Mountains, specifically from a right tributary of the upper Aramasa called Urubate' (Figure 3). This locality description is rather vague and it will probably be difficult to re-locate the

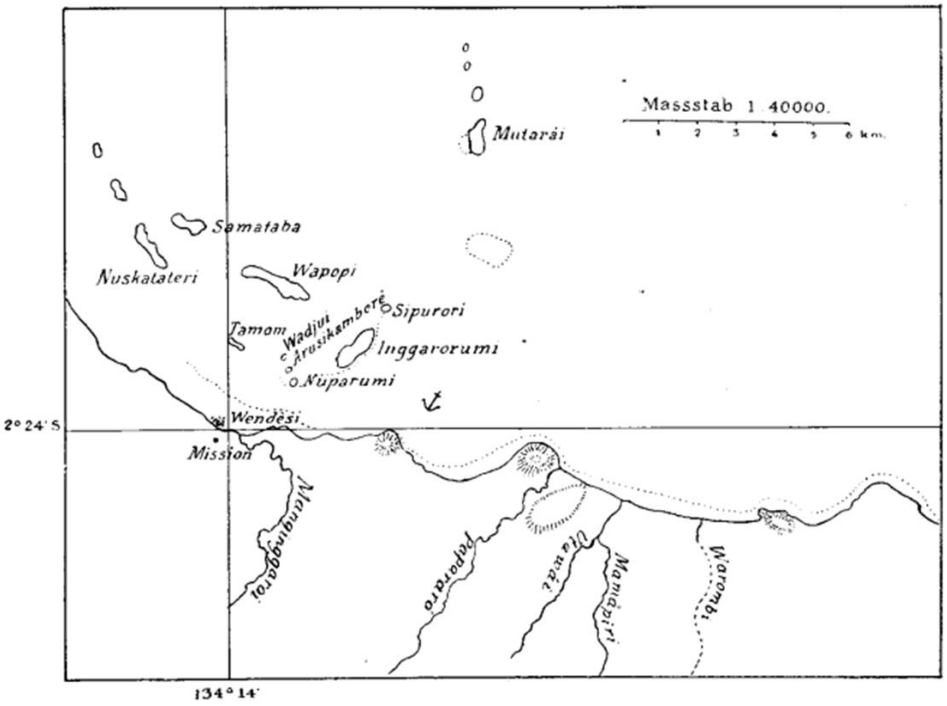


Figure 2. Map of Wendesi area, showing Mamapiri and Paporaro creeks (Wichmann, 1917).

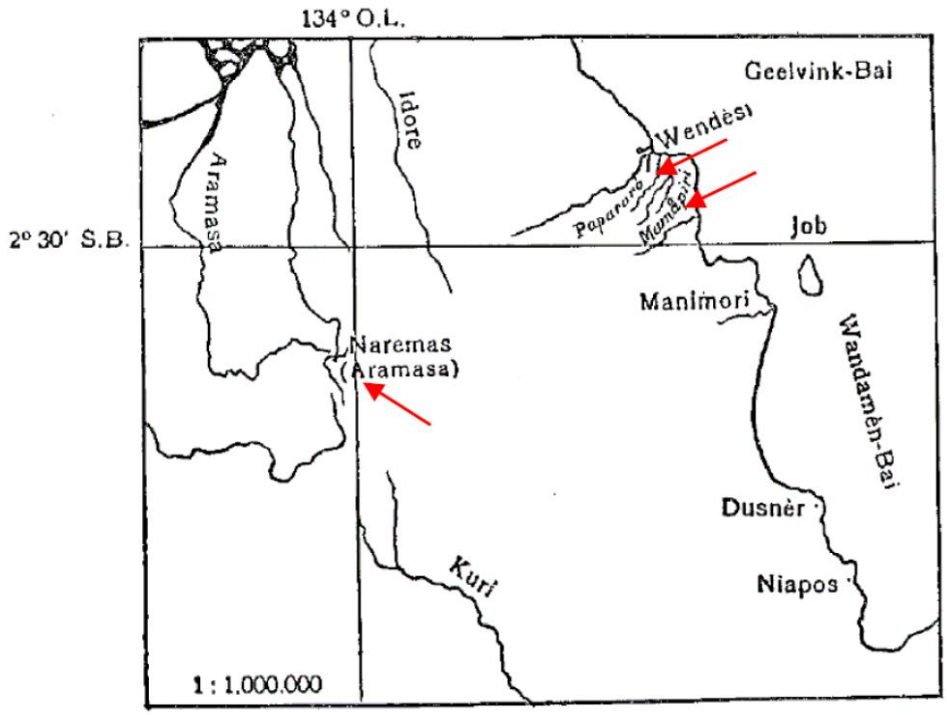


Figure 3. Locality map of Boehm (1913), showing Wendesi area localities of Wichmann and upper Aramasa area, where Hirschi collected Middle Jurassic ammonites.

site, but it does suggest that Middle Jurassic open marine shaly facies are present inland near the Northern termination of the Lengguru foldbelt as well.

Faunas

The macrofaunas are composed mainly of ammonites (Figures 4, 5), some quite large (30 cm). They are associated with rare and poorly preserved canaliculate belemnites, brachiopods (*Rhynchonella* aff. *moluccana*) and bivalve mollusks.

Ammonite assemblages are dominated by species of the subfamily Macrocephalitinae and the older, but morphologically similar subfamily Sphaeroceratinae. Dominant species

are *Macrocephalites keeuwensis* and *Phylloceras mamapiricum*.

Boehm grouped many of the *Macrocephalites* species in informally named varieties of *M. keeuwensis*, a species he first described from the Sula Islands in 1912. Taxonomy of this group is somewhat difficult; genus and species names have been revised multiple times (see e.g. Kruizinga 1926, Westermann and Getty 1970, Westermann and Callomon 1990).

Westermann and Callomon (1990) described a new genus and species of Sphaeroceratidae, named *Satoceras satoi*, which is quite abundant at the Mamapiri locality (= *Macrocephalites keeuwensis* B of Boehm 1913?)

Age

Boehm (1913) recognized the Cenderawasih Bay/ N Lengguru ammonites as Middle Jurassic species, assigning them to the Lower Callovian and 'Coronatenschichten' (an old German term for Bajocian). Westermann and Getty (1970) in their description of ammonite assemblages from the West Papua Central Range, revised some of the genus/ species names of Boehm (1913), but essentially concurred with Boehm's Bajocian to Early-Middle Callovian age assignments (Fig. 6).

The ammonite faunas described by Gerth (1927) from the Werianki River (Fakfak District?) contain *Macrocephalites keeuwensis*, *Sphaeroceras* cf. *bullatum* and *Peltoceras*, suggesting an Early Callovian age. From the Wairori River two *Stephonoceras* species indicate a probable Bajocian age

Other localities on New Guinea and depositional/ paleotectonic position

Since the Boehm (1913) and Gerth (1927) papers, additional occurrences of similar Middle Jurassic ammonite assemblages were reported from the Birds Neck/ Cenderawasih region by Donovan (in Visser and Hermes, 1962; Roemberpon Island and South Cenderawasih Bay/SE Lengguru).

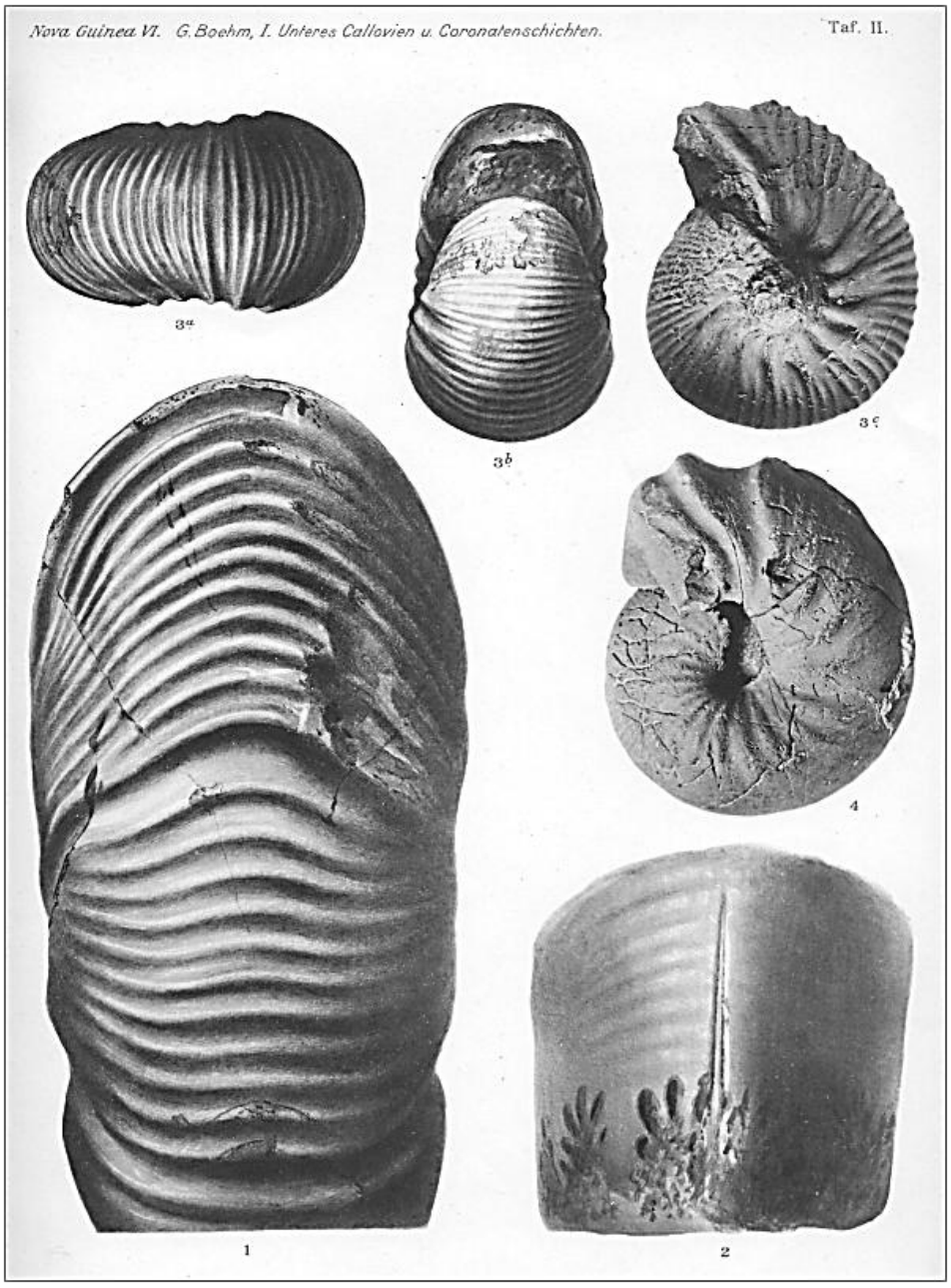


Figure 4. Plate 2 of Boehm (1913), showing '*Phylloceras mamapiricum* n.sp.' (figs. 1-2; re-assigned to *Holcophylloceras indicum* by Westermann and Callomon 1990) and '*Sphaerocers cf submicrostomata* (figs. 3-4; re-assigned to *Sphaeroceras boehmi* by Westermann 1956).

Similar Middle Jurassic ammonite faunas have subsequently been reported from the Central Range of New Guinea, in both in West Papua (Gerth 1965, Westermann and Getty 1970, Helmcke et al. 1978, Westermann and Callomon 1990) and in Papua New Guinea (Etheridge 1889) (Fig. 7). I also observed these in river float North of Wamena/ Tiom. Like at the Cenderawasih Bay locations, the ammonites are found in nodules in black shales and are generally well preserved.

Depositional/ paleotectonic setting

Observations made on the Middle Jurassic *Macrocephalites* shales of the 'Lower Kembelangan Formation' in the Papua Central Range foldbelt include:

1. The outcrops are limited to the northernmost part of the foldbelt, well north of the topographic divide, and immediately south of the Miocene collisional suture zone between the Australian- New Guinea continental plate (south) and the belts of metamorphics, ophiolites and Pacific oceanic and arc terranes (north);

2. These black shales are clearly bathyal marine facies;
3. Age range shows these are a distal facies equivalent of the widespread Middle Jurassic 'Plover'/Tangguh reservoir sandstones. Whether they were deposited on a distal passive margin or within a deepening marine rift setting that subsequently became a passive margin after oceanic break-up, is not clear;
4. The ammonite shales are invariably steeply dipping and highly deformed. They also become gradually more metamorphic to the north, towards the ophiolite belt and much of the metamorphic rock is probably metamorphosed Kembelangan Formation sediment (Visser and Hermes 1962, Cloos et al. 2005, personal observation during Pertamina-Esso 1991 joint study fieldwork). They therefore represent the outer margin of the New Guinea sector of the Australian continental margin prior to Miocene collision with the N-dipping subduction zone of a Pacific volcanic arc system. The collision then caused the accretionary prism-style deformation of sediments and the 'metamorphic sole' below obducted ophiolite.

Distribution of '*Macrocephalites* fauna' outside New Guinea and biogeographic significance

The classic Middle Jurassic *Macrocephalites*-dominated ammonite assemblages from New Guinea and Sula islands are of relatively low diversity and are very similar across the area. Several genera *(Satoceras, Irianites)* and species of this fauna are endemic to East Indonesia- New Guinea. This typical ammonite fauna differs from Middle Jurassic ammonite assemblages from low-latitude Tethys regions like the Mediterranean. Westermann and Callomon (1990) suggested they were a group that flourished in temperate, southern latitudes, perhaps around 35°-40°S or between ~30°-60° S as shown on the restoration in Westermann (2000).

The '*Macrocephalites* fauna' characterizes a distinct biogeographic province, variously named 'Gondwanan-Tethyan', 'Austral- Indo-Pacific', 'Indo-SW Pacific', 'Himalayan', etc. This province can be traced from Nepal/ Tibet in the Himalayas through East Indonesia- New Guinea and possibly east to New Zealand (Uhlig 1911, Enay and Cariou 1997, 1999, Westermann 2000, etc.). On a Middle Jurassic restored map all these occurrences elegantly line up along the northern/ eastern margin of Gondwana, from the North India margin in the west, around the NW Australia- New Guinea margin and farther East (Fig. 8).
Occurrences of '*Macrocephalites* fauna' in Eastern Indonesia outside New Guinea include:

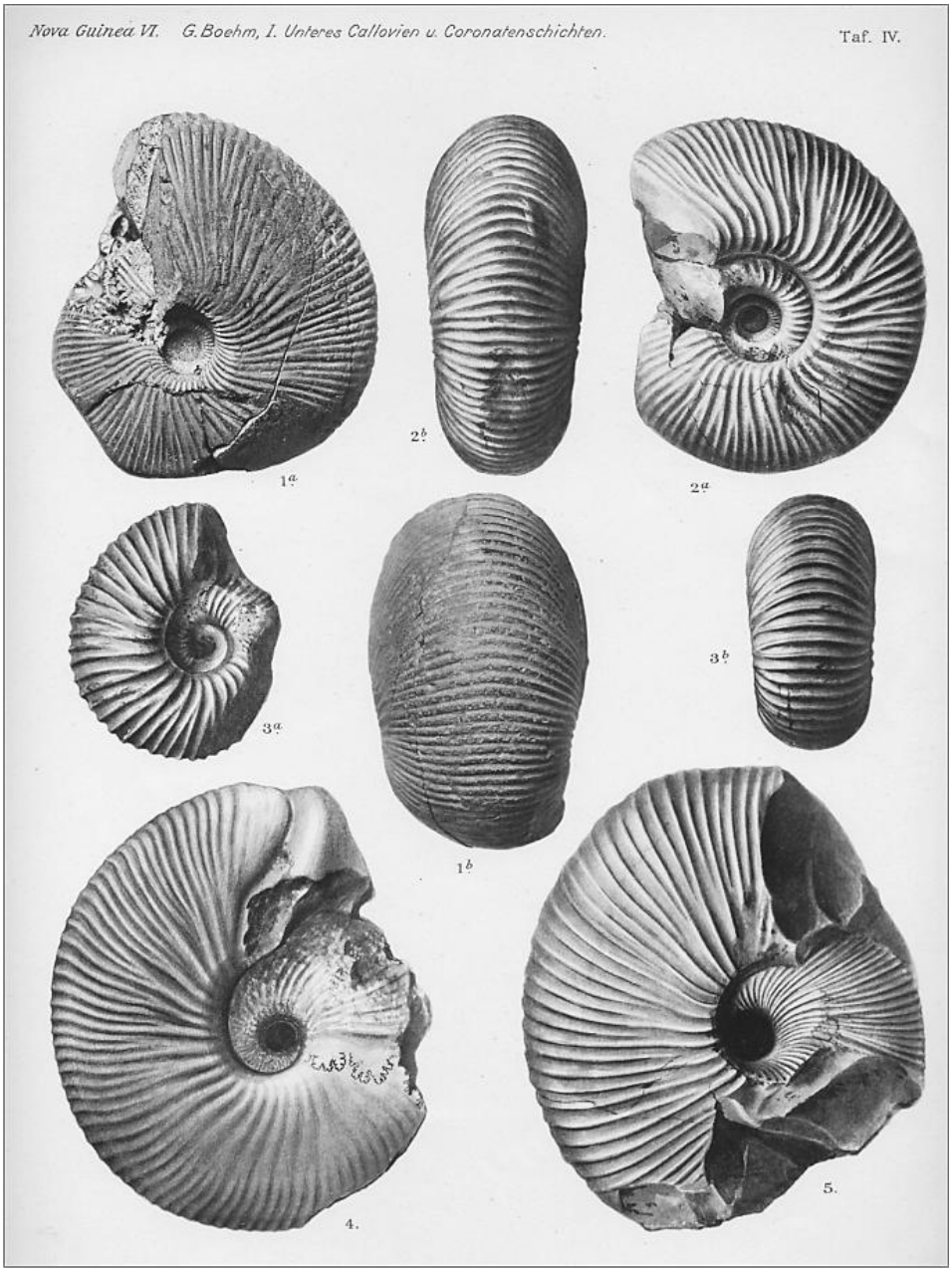


Figure 5. Plate IV of Boehm (1913), showing his *Macrocephalites keeuwensis* varieties y (figs. 1-3) and B (figs. 4-5), species characteristic of 'North Gondwana' Early Callovian. *M. keeuwensis* variety B was renamed *Satoceras satoi* by Westermann and Callomon (1990).

1. Taliabu and Mangoli, Sula Islands (Boehm 1912, Kruizinga 1925)
2. Obi (*Phylloceras, Stephanoceras, Macrocephalites* from concretions in phyllitic shales on SW Obi Besar, indicating Bajocian–Early Callovian; Brouwer 1924)
3. Rote (Roti, Rotti): rare *Macrocephalites compressus* and *Stephanoceras* from a mud volcano in NE Rote. (Boehm in Verbeek 1908, Krumbeck 1922) (some authors argued that this may be part of an allochtonous block, not necessarily part of the present-day Australia NW Shelf margin).

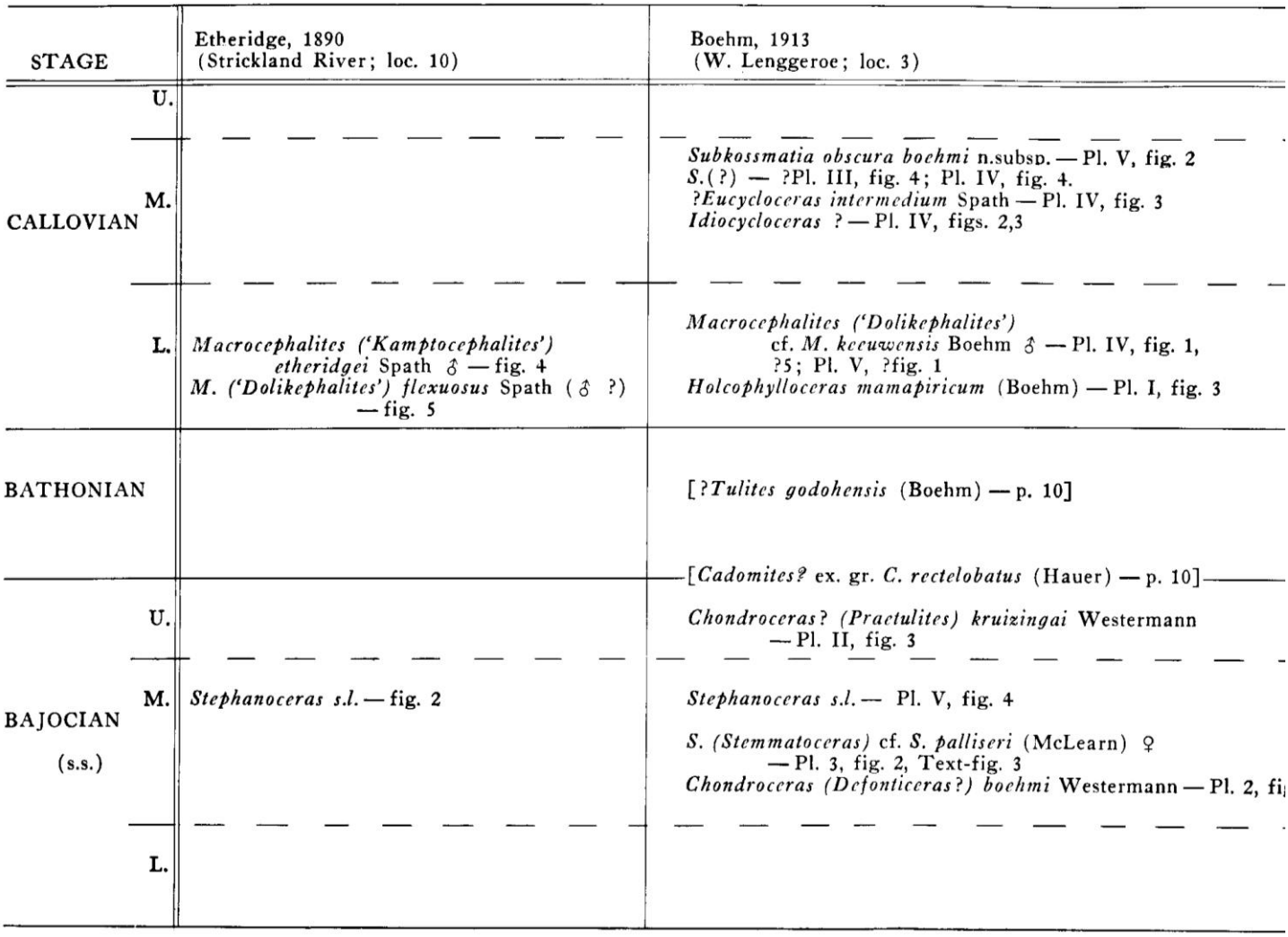


Figure 6. **Taxonomic revision of species described by Boehm (1913) with age interpretation by Westermann and Getty (1970). Specimens from Mamapiri placed here in *Subkossmattia boehmi* were originally described by Boehm (1913) as *Macrocephalites keeuwensis var. y.*, then renamed *Satoceras boehmi* by Westermann and Callomon (1990).**

4. Babar Island: *Macrocephalites* fauna ammonites from outcrop and mud volcano material, dominated by *Satoceras satoi* (Callomon and Rose 2000) (also subject to the allochtonous-autochtonous debate).

Macrocephalites faunas have never been reported from West Indonesia (Sumatra, NW Kalimantan) or the Indochina/Malay Peninsula area (e.g. Sato 1975). Marine Middle Jurassic deposits are present in these places, but whether the absence of *Macrocephalites* fauna reflects different paleogeographic positions (more equatorial) or whether these deposits are not of exactly the right age and facies, remains to be determined.

Macrocephalites faunas have also not been reported from other East Indonesia islands with Jurassic sediments. Misool and Timor do have Middle Jurassic marine sediments, but probably not in the right facies (too shallow?). Buton, Buru and Seram have marine Early and Late Jurassic sediments, but Middle Jurassic sediments appear to be very thin or absent, which was interpreted as the expression of a 'breakup unformity' by Pigram and Panggabean (1984)

Conclusions/ implications of the Boehm (1913) paper

1. Distal continental margin setting?

The Middle Jurassic ammonite-rich black shales described above from the Birds Neck/Cenderawasih Bay clearly represent a relatively distal, deep and open marine facies. They are very similar in lithology, fauna and deformational history to the ammonite-bearing 'Kembelangan Formation' black shales in the northernmost part of the Central Range fold-thrust belt and are also situated adjacent to a belt of young metamorphic rocks (Wandamen Metamorphic complex). It is very tempting to also interpret the Cenderawasih- North Lengguru localities as part of the outermost zone of sediments along the Jurassic Australian-New Guinea passive margin, which became the frontal collision zone in the Neogene.

2. Nature of Cenderawasih Bay basement

If the Cenderawasih/North Lengguru bathyal Middle Jurassic ammonite shales do indeed represent distal Australia-New Guinea continental margin clastics, it is unlikely that there is much, or any, Australian continental crust outboard of this (Cenderawasih Bay). The traditional view that Cenderawasih Bay is underlain by North New Guinea-equivalent volcanic arc and oceanic terranes that originated in the Pacific realm, perhaps with a fringe of metamorphics and ophiolites (e.g. Dow and Hartono, 1982), appears more likely than a floor of continental crust, as argued in some recent papers

(e.g. Sapiie et al., 2010). Sula-like microcontinental blocks that rifted off the New Guinea margin in Jurassic or Cretaceous time may be present here, but no direct continuation of the Mesozoic 'Plover' hydrocarbon plays of Bintuni Bay/ Australia-New Guinea margin should be expected here.

3. Bintuni Bay- Birds Head Middle Jurassic sandstone distribution models

The Bajocian- Middle Callovian age range of the ammonite-bearing shales appears to be of the same that of the principal gas reservoir sandstones in the Tangguh field complex of Bintuni Bay (Roabiba Sand, etc.). These marginal marine- shallow marine, quartzose sandstones are compositionally and texturally mature and generally interpreted to be derived from a cratonic source (Australia-New Guinea). They may be compared to the widespread Middle Jurassic sandstones of the Australian NW Shelf, known as Plover Formation.

Decker et al (2009, Fig. 15) proposed a model for the Early-Middle Jurassic Tangguh reservoir sands in Bintuni Bay. It shows deposition confined within an extensive E-W trending 'incised valley', with Early–Middle Jurassic shallow marine-non marine sand systems backstepping towards a provenance area in the East. However, the Boehm (1913) and other papers document control points east of that 'valley' system, where Middle Jurassic is represented by distal marine shales. This shows that this part of the Birds Neck is not in the sand fairway that fed the Bintuni Bay Tangguh sands and that the Cenderawasih Bay-North Lengguru area was not part of the provenance area for these quartzose sediments in Jurassic time. Therefore, this Bintuni Bay sand distribution model can only be correct if some structural discontinuity (terrane boundary or a major transcurrent fault) is invoked between the Birds Head/Bintuni Bay block and the Cenderawasih Bay-North Lengguru area, as indeed suggested by Decker et al. (2009).

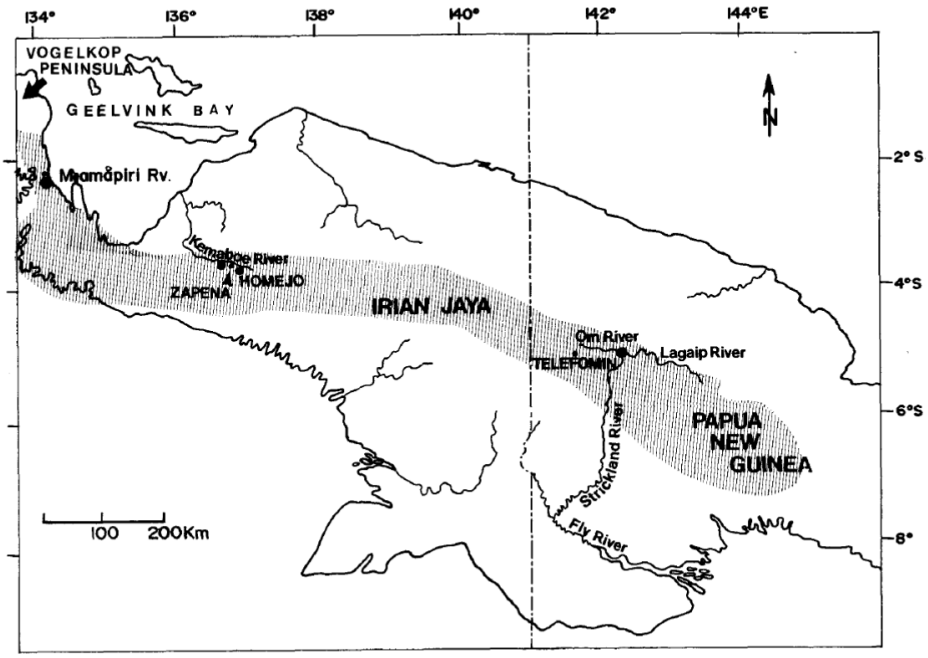


Figure 7. Outcrop localities with Middle Jurassic ammonites, New Guinea island (Westermann and Callomon 1990) (not showing all known localities)

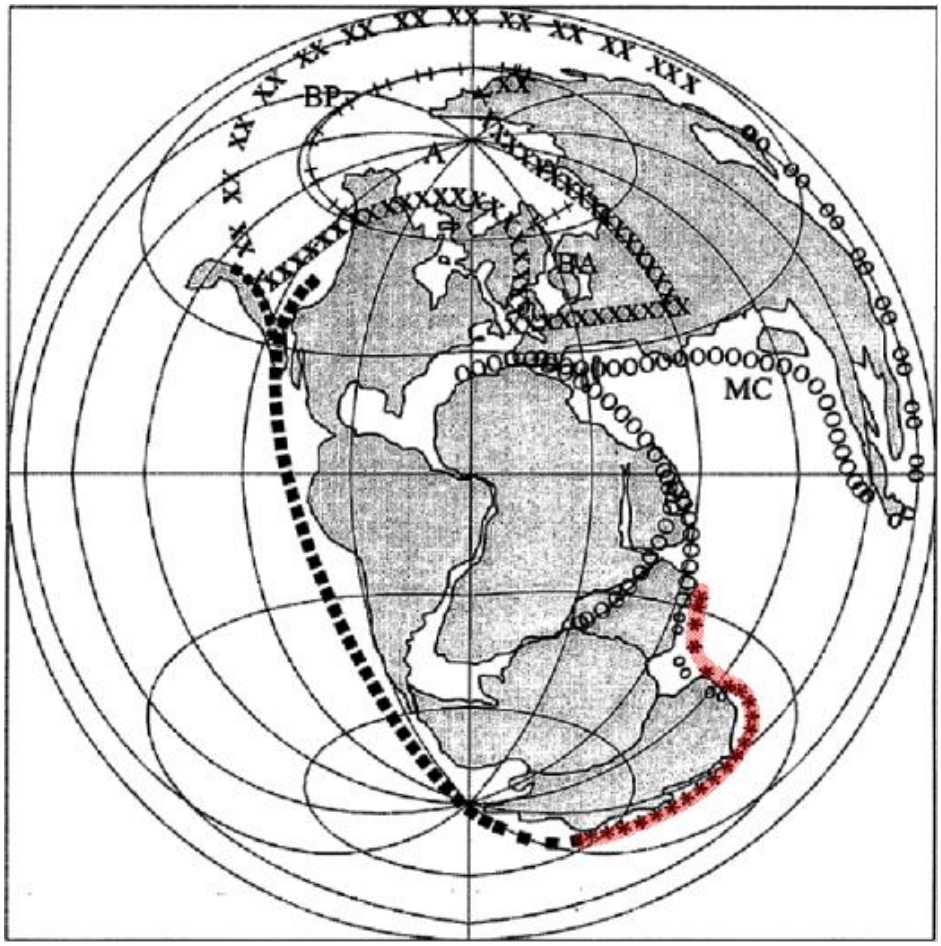


Figure 8. Restoration at Bathonian time, showing Middle Jurassic ammonite paleogeographic realms (Westermann 2000). Highlighted in red is the belt of the *Macrocephalites*-dominated 'Austral-Indo Pacific Realm', which is known from Nepal, the NW Australia- New Guinea margin and possibly New Zealand, and which restores nicely as a continuous zone along the North/ East Gondwana margin, in temperate-latitudes.

References

Boehm, G., 1906. Neues aus dem Indo-Australischen Archipel. Geologische Mitteilungen aus dem Indo-Australischen Archipel I, Neues Jahrbuch Min. Geol. Pal., Beil. Band 22, p. 385-412.

Boehm, G., 1912. Die Sudkusten der Sula-Inseln Taliabu und Mangoli. 4. Unteres Callovien. Palaeontographica, Suppl. IV, Beitr. Geologie Niederlandisch-Indien 1, p.121-179.

Boehm, G., 1913. Unteres Callovien und Coronaten-Schichten zwischen MacCluer Golf und Geelvink-Bai. Nova Guinea VI, Geologie, Brill, Leiden, 1, p. 1-20.

Callomon, J.H. and Rose, G., 2000. Middle Jurassic ammonites from the island of Babar in the southern Moluccan forearc, Indonesia. Revue Paleobiol., Spec. Vol. 8, p. 53-64.

Decker, J., Bergman, S.C., Teas, P.A., Baillie, P. and Orange, D.L., 2009. Constraints on the tectonic evolution of the Bird's Head, West Papua, Indonesia. Proc. 33rd Ann. Conv. Indonesian Petroleum Assocation, IPA-G-139, p. 491-514.

Dow, D.B. and Hartono, U., 1982. The nature of the crust underlying Cendrawasih (Cendrawasih) Bay, Irian Jaya. Proc. 11th Ann. Conv. Indon. Petrol. Assoc., p. 203-210.

Enay, R. and Cariou, E., 1997. Ammonite faunas and palaeobiogeography of the Himalayan belt during the Jurassic: initiation of a Late Jurassic austral ammonite fauna. Palaeogeogr., Palaeoclim., Palaeoecol. 134, p. 1-38.

Enay, R. and Cariou, E., 1999. Jurassic ammonite faunas from Nepal and their bearing on the palaeobiogeography of the Himalayan belt. J. Asian Earth Sci. 17, 5-6, p. 829-848.

Etheridge, R., 1889. On our present knowledge of the palaeontology of New Guinea. Records Geol. Survey New South Wales 1, 3, p. 172-179.

Gerth, H., 1927. Ein neues Vorkommen der bathyalen Cephalopoden Fazies des mittleren Jura in Niederlandisch Neu Guinea. Leidsche Geol. Meded. 2, 3, p. 225-228.

Gerth, H., 1965. Ammoniten des mittleren und oberen Jura und der altesten Kreide von Nordabhang des Schneegebirges in Neu Guinea. Neues Jahrb. Geol. Palaeont., Abh. 121, 2, p. 209-218.

Helmcke, D., Barthel, K.W. and von Hillebrandt, A., 1978. Uber Jura und Unterkreide aus dem Zentralgebirge Irian Jayas (Indonesian). Neues Jahrb. Geol. Palaeont., Monatshefte 1978-11, p. 674-684.

Hirschi, H., 1908. Reisen in Nordwest-Neu-Guinea: Vortrag gehalten am 30 November 1907. Jahresbericht Geogr.-Ethnogr. Ges. in Zurich 1907-1908. Von Lohbauer, Zurich 1908, p. 71-106.

Kruizinga, P., 1926. Ammonieten en eenige andere fossielen uit de Jurassische afzettingen der Soela eilanden. Jaarboek Mijnwezen Nederl. Oost Indie 54 (1925), Verhand. 1, p. 13-85.

Pigram, C.J. and Panggabean, H., 1984. Rifting of the northern margin of the Australian continent and the origin of some microcontinents in Eastern Indonesia. Tectonophysics 107, 3-4, p. 331-353.

Sapiie, B., Adyagharini, A.C. and Teas, P., 2010. New insight of tectonic evolution of Cendrawasih Bay and its implications for hydrocarbon prospect, Papua, Indonesia. Proc. 34th Ann. Conv. Indon. Petrol. Assoc., IPA10-G-158, 11 p.

Sato, T., 1975. Marine Jurassic formations and faunas in Southeast Asia and New Guinea. In: T. Kobayashi & R. Toriyama (eds.) Geology and Palaeontology of Southeast Asia 15, University of Tokyo Press, p. 151-189.

Sukamto, R. and Westermann, G.E.G., 1992. Indonesia and Papua New Guinea. In: G.E.G. Westermann (ed.) The Jurassic of the Circum-Pacific, Cambridge Univ. Press, p. 181-193.

Uhlig, V., 1911- Die marinen Reiche des Jura und der Unterkreide. Mitt. Geol. Ges. Wien, 4, 3, p. 389-448.

Visser, W.A. and Hermes, J.J., 1962. Geological results of the exploration for oil in Netherlands New Guinea. Verhandy. Kon. Nederl. Geol. Mijnbouwk. Genootschap, Geol. Series 20, p. 1-265.

Westermann, G.E.G. and Callomon, J.H., 1988. The Macrocephalitinae and associated Bathonian and early Callovian (Jurassic) ammonoids of the Sula islands and New Guinea. Palaeontographica A, 203, p. 1-90.

Westermann, G.E.G. and Getty, T.A., 1970. New Middle Jurassic Ammonitina from New Guinea. Bull. Amer. Paleont. 57, 256, p. 231-308.

Wichmann, A., 1917. Bericht über eine im Jahre 1903 ausgeführte Reise nach Neu-Guinea. In: A. Wichmann (ed.) Nova Guinea, Résultats de l'expédition scientifique néerlandaise à la Nouvelle Guinée en 1903, E.J. Brill, Leiden, vol. IV, 492 p.