The Ammonite Zones of the Middle Jurassic Beds of East Greenland

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(PLATES XVII–XVIII)

ABSTRACT

New discoveries have established the presence of nine ammonite zones in the Middle Jurassic beds of East Greenland. The top two are Lower Callovian; the remaining seven yield ammonites unknown from extra-Boreal provinces and are presumed to range down through the Bathonian, possibly into the Bajocian.

I. INTRODUCTION

SEDIMENTS of Jurassic age are now well known to occur extensively along the coast of East Greenland between 70° and 77° N. Their geology, and history of research, has recently been summarized in an excellent review by Donovan (1957). In the lower part, thick and probably largely complete Lias follows conformably on Rhaetic and Trias; its facies is partly estuarine, although sharply terminated by marine Toarcian dated by ammonites to lower *Jurense* Zone. The fossil faunas differ little from those of Europe and stratigraphic correlation presents no special problems. The upper Jurassic part of the succession starts in the *Plicatilis* Zone of the Oxfordian, again with faunas of typically N.W. European aspect, and continues with probably few breaks into the Lower Cretaceous.

The Toarcian and Oxfordian are separated by, but are conformable with, up to 600 m. of marine Middle Jurassic. The first few ammonites were brought back by the Danish expedition of 1898–1900 and described by Madsen (1904); but the beds from which they came were not closely examined till 1926–27, when members of the Danish Government Expedition, the first of many to East Greenland led by Dr. Lauge Koch, with few breaks, in the thirty years since, wintered in the Scoresby Sound region. In particular, a large collection of well-preserved ammonites was made by A. Rosenkrantz and submitted for examination to L. F. Spath in London, who published the results in a monograph (Spath, 1932).

With the stratigraphical information at his disposal, Spath deduced the presence in Jameson Land of four successive ammonite faunas, with indications of possibly others. In attempting to correlate these with standard European successions, immediate difficulties were encountered, for the Greenland and European faunas had no species and barely a few genera in common. The closest resemblance appeared to lie between the *Kepplerites* and *Cadoceras* of the top Greenland fauna (*tychonis* horizon) and the fauna of the Kellaways Beds (top

Lower Callovian, *Calloviense* Zone). This left the three preceding Greenland faunas hanging, uncorrelated, between top Lower Callovian and Toarcian. Various estimates of the time-span involved were made. Spath considered the Greenland faunas as ranging down through the Upper Bathonian (although he defined his Bathonian to include zones which are correctly already Callovian), partly to be able to ascribe to each Greenland fauna a time-span which seemed, by general experience, not too short; and partly to allow him to evolve the peculiar Greenland ammonites from well-known European ancestors, the Macrocephalitidae, which he thought themselves appeared not much before the beginning of the Upper Bathonian. Arkell (1956, chapters 22, 28) based his judgment on a view of the Bathonian in the world as a whole; he noted that quite generally the Bathonian was a time of marine regression, followed by an equally general Callovian transgression especially widespread, e.g. over the Baltic and Russian shields. He assumed, therefore, that Bathonian is absent in the Arctic, and placed all four Greenland faunas in the Lower Callovian. A third viewpoint has been put forward by Imlay (e.g. 1952), based not upon the Greenland faunas themselves, but upon very similar sequences discovered in recent years in North America. Here the time-gap is narrowed from below by the presence of normal faunas up to Middle Bajocian. Moreover, there is no evidence of subsequent regressions or discontinuities, and Imlay is led to spread the equivalent of the Greenland faunas over the whole of the Bathonian into Upper Bajocian.

It has been my privilege, as a member of Dr. Koch's expeditions to East Greenland in the summers 1957–58, to re-examine the Jurassic outcrops of Jameson Land. It was possible to record and collect in detail from numerous well-exposed sections and, with the modern techniques of transport which have been evolved, to bring back a considerable collection of ammonites. These have yielded much new information. As publication of full details in *Meddelelser om Grønland* will take time, and as other regions of the Arctic are currently being actively explored, the preliminary results are summarized here.

II. Stratigraphical Results

The Middle Jurassic beds of southern Jameson Land constitute the Vardekløft Formation, replaced in part northwards through facies-changes variously by the Fossil Mountain Formation and Yellow Series. Nine successive and distinct ammonite-zones have now been established. They cover the whole formation but for a ubiquitous lowest series of black shales about 50 m. thick resting on Toarcian, and yielding only plants and rare belemnites. The zonal succession is summarized in Table 1 and notes on the separate zones are listed below.

(*a*) Zone of *Cranocephalites borealis* (Spath). Spath named this species on the basis of a single, wholly septate nucleus in the Rosenkrantz collection (1932, pl. 14, fig. 4) and placed it in *Xenocephalites*,

TABLE 1.

GREENLAND	N.W. EUROPE		
	Jason	Middle	CALLOVIAN
(Non-sequence)			
Calloviense	Calloviense	Lower	
Tychonis	Macrocephalus		
Variabile	Discus	Upper	BATHONIAN
Kochi	Aspidoides		
Greenlandicus	Subcontractus	Middle	
Nudus	Progracilis		
Pompeckji	Zigzag	Lower	
Indistinctus	Parkinsoni	Upper	BAJOCIAN
Borealis	Garantiana		
	Subfurcatum		

a genus known at the time only from the Andes. A second small but poorly preserved specimen had been collected during the 1898–1900 expedition. It transpires that the species represents one of the commonest and most widespread Greenland faunas. The complete adults are typical *Cranocephalites* and have nothing to do with *Xenocephalites* (see pl. XVII, figs. 1, 2; pl. XVIII, fig. 3).

(*b*) Zone of *Cranocephalites indistinctus* nov. The *borealis* fauna is followed by small, compressed, evolute, feebly-ribbed species hitherto undescribed (see p. 510 and plates). Two specimens figured by Frebold (1958, pl. 8, figs. 2, 3) from Prince Patrick Island are closely similar, and may indicate the zone in Arctic Canada.

(*c*) Zone of *Cranocephalites pompeckji* (Madsen). This is the zone of the " *Cranocephalites* Beds " with the lowest of Spath's four faunas. His tentative subdivision into " *pompeckji* and *subbullatus* horizons " has not been confirmed. Formal designation as Zone was by Donovan (1953, p. 130). The *pompeckji—vulgaris* fauna is by far the most profuse, and prompted Rosenkrantz to write as footnote to a photograph (1929, p. 146): " In the foreground thousands of ammonites lie spread over the ground." It is also known from Prince Patrick Island (Frebold, 1958) and Novaya Zemlya (Sokolov, 1913, pl. I).

(*d*) Zone of *Arctocephalites nudus* Spath: his " *Arctocephalites* Beds ", designated Zone by Donovan (1953). The index-species, as exemplified by the holotype, is atypical of the fauna as a whole; the commonest forms are medium-sized compressed species like *A. ornatus* Spath, *elegans* Spath, and *arcticus* (Newton and Teall). The fauna from Windy Gully, Northbrook Island, Franz Josef Land (see Newton and Teall, 1897; Whitfield, 1906) belongs to this zone; it is also known from Novaya Zemlya (Salfield and Frebold, 1921, pl. 1, fig. 1).

(*e*) Zone of *Arctocephalites greenlandicus* Spath. Large compressed *Arctocephalites*, considerably larger than those of the *Nudus* Zone retaining dense, fine ribbing to correspondingly larger diameters; also inflated forms such as " *Cadoceras* " *crassum* Madsen.

(*f*) Zone of *Arcticoceras kochi* Spath; his " *Arcticoceras* Beds ", designated Zone by Donovan (1953). Now that abundant material is available, it appears that the differences between *Arcticoceras* (dating from 1924) and *Arctocephalites* (1928) lie solely in the character of the secondary ribbing. This becomes very strong, sharp, and coarse in *Arcticoceras*, with a tendency to swing forward on a sharpened venter; it is the first step towards the ultimate extreme of *Chamoussetia* in the *Calloviense* Zone. The average size is large (up to 200 mm. in adults), retaining ribbing to diameters at which the predecessors of the *Nudus* Zone are complete and wholly smooth. The zonal index as exemplified by the holotype is again somewhat atypical and quite rare. *A. ishmae* (Keyserling) from the Petchora belongs in this zone, which is thus present in N. Russia.

(*g*) Zone of *Cadoceras variabile* Spath. In this zone the first true *Cadoceras* is found, taking as criterion a sharp edge between steep umbilical walls and whorl sides. The commonest species are very evolute compressed forms hitherto undescribed; some are evolute

and inflated, e.g. *C. calyx* Spath. All the species are of medium size. Typical *Arcticoceras* also still occurs, some species now with quite acute venter, others with very strong, coarse ribbing to the end. To the latter belong the peculiar forms one of which was figured by Madsen (1904, pl. 10, fig. 2) as ?*Olcostephanus* (a Lower Cretaceous genus), and in a sense Rosenkrantz was correct (1929, p. 147) in referring them " to the cardioceratids ". The zone also sees the first appearance n Greenland of *Kepplerites*, mostly small finely-ribbed forms close to tne type of *K. tychonis* Ravn and large, compressed finely-ribbed forms resembling *K. antiquus* Spath. The beds are most clearly exposed in northern Jameson Land, near Mt. Mikael and Fossil Mountain, where the overlying zone is poorly fossiliferous; and Spath (1932, p. 31) already noted the difference in general appearance between the " *tychonis* " fauna of Mikael (*Variabile* Zone) and Vardekløft (mostly *Tychonis* Zone) further south. The *Variabile* Zone does occur in the Vardekløft area—indicated in the Rosenkrantz collection by *C. variabile*, *C. franciscus*, *C. calyx*, and *K. tychonis* var. *fasciculata*—but because of steep slopes and screes is there not easily identified stratigraphically. It seems to occur in Spitsbergen, represented by *K. svalbardensis* Sokolov and Bodylevsky.

(*h*) Zone of *Kepplerites tychonis* Ravn; Spath's " *Kepplerites-Cadoceras* Beds ", designated Zone by Donovan (1953). The fauna consists of *Kepplerites*, very large *Cadoceras* (*victor* Spath), but no *Arcticoceras*. The exact position of *tychonis* itself is not yet known, for the type came from Store Koldewey island, far to the north, and there are no specimens that exactly match it among those figured by Spath or collected in the last two summers. However, the forms of *Kepplerites* are so variable that at present they have little stratigraphical value, and it seems best to follow Spath in adopting a broad interpretation of *tychonis* for the time being. *Kosmoceras pauper* is not uncommon in this zone, and there is no separate " *pauper* horizon " (Spath); it is merely the microconch of *Kepplerites*.

(*i*) Zone of *Sigaloceras calloviense* (Sowerby). The index is known only from southern England and northern France (see Callomon, 1955) for apparently ecological reasons, but the associated fauna is so characteristic that the same zonal name is used almost universally. This associated fauna has now been found in the top beds of the Fossil Mountain Formation, on Fossil Mountain itself, which are lateral equivalents of shales at the top of the Vardekløft Formation unfossiliferous except for huge petrified treetrunks. The forms found include *Kepplerites* (*Gowericeras*) spp., cf. *crucifer* (Buckman), or *curtilobus* (Buckman); *Kosmoceras* spp. aff. *gulielmi* (Sowerby), one specifically identical with an undescribed species not uncommon in the English Kellaways Rock; *Cadoceras* of the *sublaeve* group;

Pseudocadoceras spp. conspecific with English forms; and *Proplanulites* sp. nov. aff. *koenigi* (Sowerby). The overall resemblance to the fauna of the English Kellaways Rock is most striking. In addition, among ammonites collected by Stauber during the Danish Two-Year Expedition, 1936–38 (Koch, 1955), in the same general area (but from unspecified beds) are nuclei of typical *Chamoussetia*.

Beds of the *Calloviense* Zone are overlain conformably, with a sharp but often inconspicuous lithological change, by black shales or sandstones of the Koch Fjaeld Formation which, in the Vardekløft area, have now yielded *Amoeboceras* and Perisphinctids indicating Upper Oxfordian (*Bimammatum* Zone).

III. Palaeontological Note

Cranocephalites indistinctus sp. nov. Pl. XVII, figs. 3, 4; Pl. XVIII, figs. 1, 2. *Holotype*; pl. XVIII, fig. 1 (no. 1435).

Description of holotype: the specimen is a complete adult, somewhat crushed; maximum diameter 62 mm., septate to about 40 mm., with 5/8th whorl body chamber. The last few sutures are degenerate and approximated; the umbilical seam uncoils; and the peristome is modified by a broad shallow constriction, typical of the genus. The coiling is consistently involute—umbilical width 10 per cent of diameter at 40 mm.—and the whorl-section compressed. The ribbing persists to the end, and is fine but rather feeble and indistinct throughout.

Variability and comparisons: some 30 specimens are available, varying between extremes which, with fewer and better-preserved specimens, would conventionally be classed as several species. The holotype is of average size, but some of the shells become as large as the one shown in Pl. XVII, fig. 3. Others (e.g. Pl. XVIII, fig. 2) are more evolute than the type.

The species resembles the succeeding group of *C. pompeckji* in the style of ribbing, but differs from it in being consistently more feebly and densely ribbed, smaller, and markedly more compressed; the two faunas barely overlap in their range of forms. The new name is here introduced to avoid a *nomen nudum* as zonal index.

IV. Correlation

Correlation of the *Tychonis* Zone with the European *Calloviense* Zone has always been in some doubt, for Spath himself pointed out that Greenland *Kepplerites* (alias *Seymourites*) from this zone resembles European *Kepplerites* sensu stricto (*Am. keppleri* Oppel, *Am. macrocephalus evolutus* Quenstedt, and "*Cerericeras*" *cereale* Buckman) more than *Gowericeras* etc. from the *Calloviense* Zone. Unfortunately

the German *Kepplerites*, although abundant, came from the " Macrocephalenoolith ", a condensed diachronic bed whose age was uncertain in terms of the standard zones, belonging locally to as high as the topmost subzone of the *Calloviense* Zone (see Callomon, 1955). On the other hand, from England, where the zonal ages of the beds are known, only a single, incomplete specimen (*cereale*) was at the time available. Further evidence has since come to light (to be published), and some eight *Kepplerites* s.s. (and one *Toricelliceras*) are now known from English Upper Cornbrash, five definitely from basal Callovian (*Macrocephalus* Zone and Subzone; *Siddingtonensis* brachiopod Zone). Some are practically indistinguishable from syntypes of Quenstedt's *macrocephalus evolutus* (I am greatly indebted to Dr. H. Hölder of Tübingen for furnishing me with casts of Quenstedt's originals), and one from *Kepplerites* (*Seymourites*) *traillensis* Donovan (1953, Pl. 17, fig. 1) from East Greenland. Thus both the Greenland *Tychonis* Zone and the Württemberg (Ehningen) Macrocephalenoolith are now dated to *Macrocephalus* Zone. Final confirmation in Greenland comes from the presence of *Calloviense* fauna above.

There remain seven ammonite zones in Greenland to be accommodated below basal Callovian. The basic difficulty remains, and estimates have still to be based partly on zoological arguments, e.g. the relative durations of ammonite faunas. However, all seven zones must be considered as definitely pre-Callovian and hence at least in greater part Bathonian. Moreover, previous arguments in which the Cadoceratinae and Kosmoceratidae are derived from Macrocephalitidae must fall, for resemblance between the former and, despite Spath's assertions, the only known pre-Callovian forms of the latter—*Morrisiceras*—rapidly decreases on descending down the zones. For a number of reasons the ancestors of both Kosmoceratidae and Cadoceratinae are in my opinion to be sought independently in earlier Stephanocerataceae. The most likely candidate in the case of the former appears to be *Cadomites-Polyplectites*, known in Europe throughout the Bathonian but commonest in the Upper Bajocian. The earliest of the Cadoceratinae in the wide sense is *Cranocephalites* of the *borealis* group, and its closest resemblance is to *Chondroceras* of the Middle Bajocian. To my mind the most satisfactory picture is obtained by placing the *Borealis* Zone of Greenland in the Upper Bajocian, the others in the Bathonian. In this picture, the great separation of ammonites into faunal realms occurred in the Middle Bajocian, as shown by Arkell; thereafter, following Imlay, the Arctic province evolved steadily and uninterruptedly and the widespread peculiarities of the Bathonian stage stressed by Arkell reside in the European and Tethyan rather than Boreal realms.

I should like to express my gratitude to Dr. Koch for inviting me to

take part in his expeditions; and to thank Dr. E. I. White, Keeper in Palaeontology, for providing me with facilities in the British Museum (Natural History) for working out the Greenland collections.

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EXPLANATION OF PLATES

All figures are natural size

PLATE XVII

FIGS. 1, 2.—*Cranocephalites borealis* (Spath). Jameson Land: Ugle Elv, north ridge of Teebjaerg. *Borealis* Zone (bed 18).

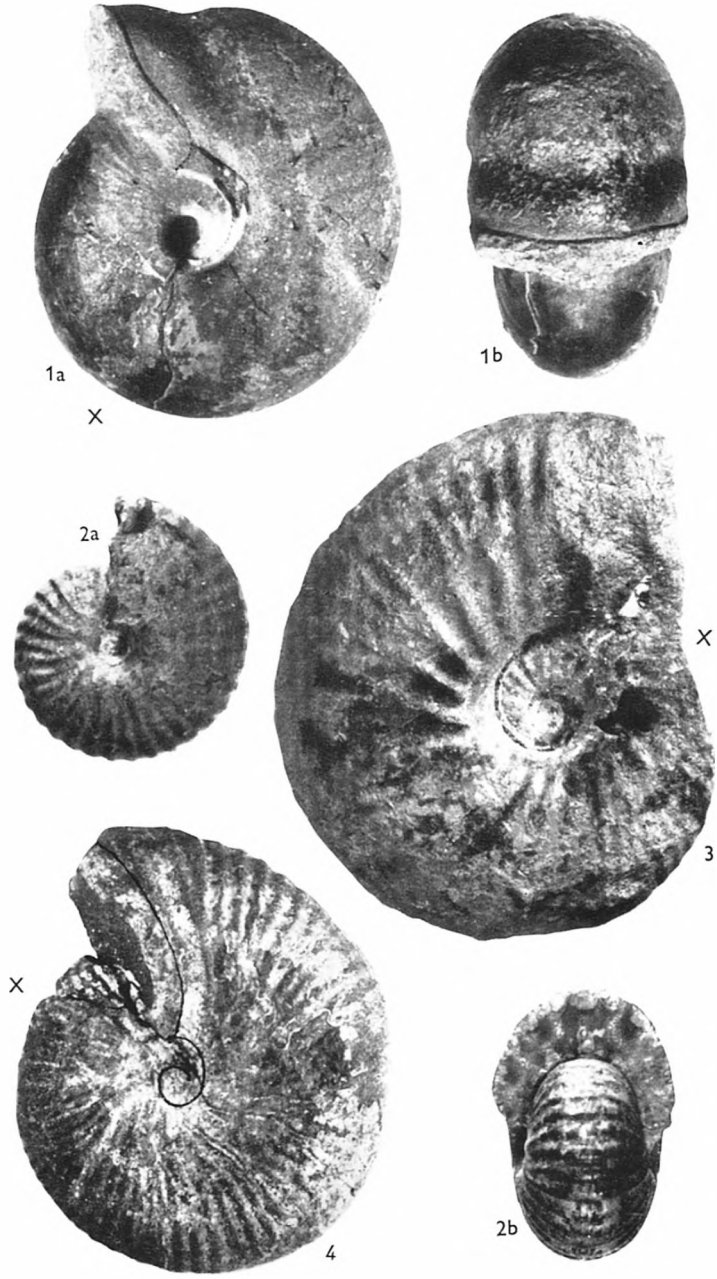
Fig. 1*a*, *b*: a complete adult, of average size, with peristome (no. 1144).

Fig. 2*a*, *b*: a complete adult phragmacone (no. 1140).

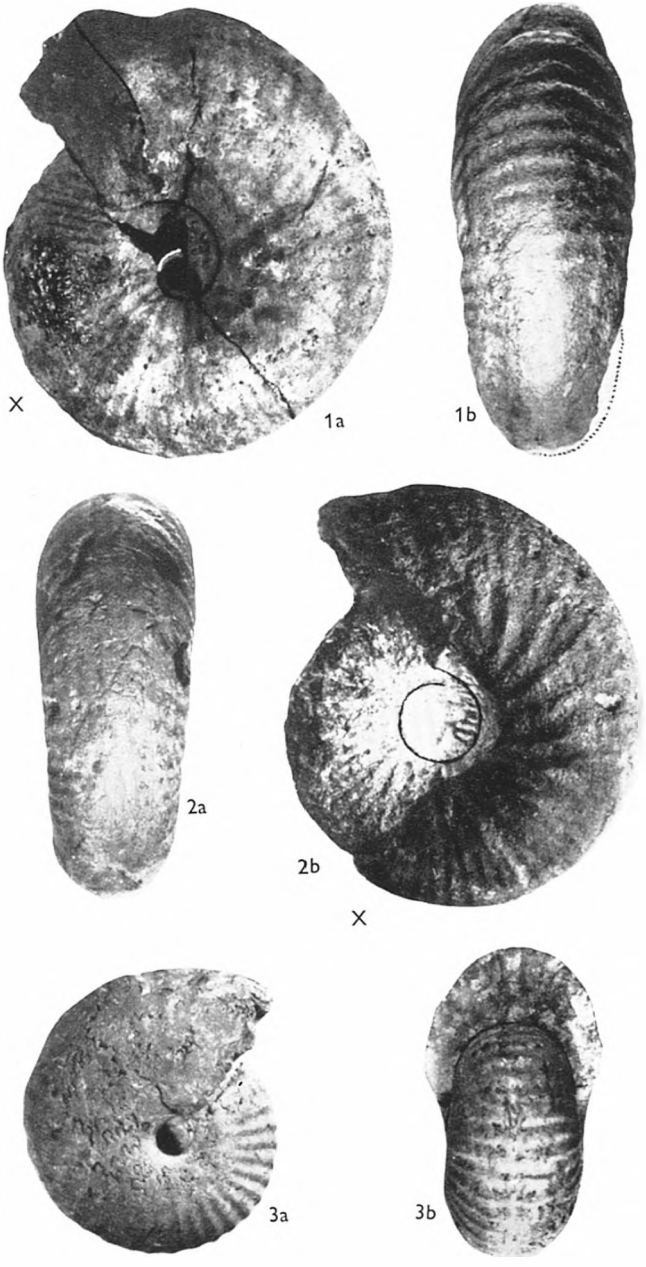
FIGS. 3, 4.—*Cranocephalites indistinctus* sp. nov.

Fig. 3: a complete adult of above average size (no. 1439). Top ridge of Teebjaerg, *Indistinctus* Zone (bed 28).

Fig. 4: complete adult (no. 1306). Ugle Elv, ridge on west side of Statuebjaerg, *Indistinctus* Zone (bed 20).



CRANOCEPHALITES FROM EAST GREENLAND.



CRANOCEPHALITES FROM EAST GREENLAND.

PLATE XVIII

FIGS. 1, 2.—*Cranocephalites indistinctus* sp. nov. Teebjaerg, *Indistinctus* Zone (bed 28).
Fig. 1*a*, *b*: holotype; complete adult with peristome (no. 1435).
Fig. 2*a*, *b*: complete adult; somewhat evolute variety (no. 1437).
FIG. 3.—*Cranocephalites borealis* (Spath). Teebjaerg, *Borealis* Zone (bed 18). Another complete, adult phragmacone (no. 1156).