

MIDDLE JURASSIC AMMONITE DISTRIBUTION AND THE AFFINITIES
OF THE ANDEAN FAUNAS

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Abstract -- Dice and Simpson Coefficients of similarity are applied to presence-absence data of genus-level taxa in the principal Middle Jurassic ammonite areas. 'Microconch taxa' are omitted if corresponding 'macroconch taxa' are known. On a reconstructed Jurassic globe, similarities indicate for the Andean faunas during (1) Aalenian: direct connections to West Tethys and also to North Cordillera fauna; (2) Lower Bajocian: close connections to both West Tethys and North Cordillera area, and lower but distinct trans-Pacific seaway to Oceania; (3) Upper Bajocian: free migration along entire eastern Pacific margin (including? Antarctic Peninsula), less conspicuous routes to West Tethys and no trans-Oceanic connections; (4) Lower Callovian (Bathonian not considered): strong connections to Mexico area and West Tethys, weak trans-Pacific routes to Oceania and Japan, North Cordillera area poorly connected; (5) Late Lower-Middle Callovian: main connections to West Tethys and, secondly, to Mexico area, but isolated from west and north Pacific margins. Thus throughout Middle Jurassic, Andes Ammonitina were most closely affiliated to those of (West) Tethys.

Resumen -- Sobre la base de la presencia-ausencia de taxa correspondientes a la categoría de género, y mediante la utilización de los coeficientes de Dice y Simpson, se establece la similitud composicional entre las principales áreas con amonitas del Jurásico medio mundial. Se omiten las denominaciones taxonómicas pertenecientes a microconchas en los casos en los que se conocen las correspondientes macroconchas. Las similitudes existentes y la paleogeografía del mundo en el Jurásico permiten inferir para la fauna de los Andes, durante el (1) Aaleniano: relación directa con la fauna del Tethys occidental y oeste de norteamérica; (2) Bajociano inferior: relación estrecha con las mismas áreas y, en menor grado, con Oceanía mediante una vía transoceánica; (3) Bajociano superior: migración libre a lo largo de la margen oriental del océano Pacífico (incl. península Antártica?), relación de menor importancia con el Tethys occidental y ausencia de conexiones transoceánicas; (4) Caloviano inferior (Bathoniano no incluido en el análisis): vinculación importante con México y Tethys occidental, débil comunicación transoceánica con Oceanía y Japón, escasa conexión con el área nordoccidental de norteamérica; (5) Caloviano inferior tardío-Caloviano medio: comunicación principal con el Tethys occidental y, secundariamente, con México, y ausencia de relaciones con las márgenes occidental y norte del océano Pacífico. En consecuencia, durante el Jurásico medio en general, la fauna de amonitas del área andina estuvo más estrechamente relacionada con aquellas del Tethys (occidental).

INTRODUCTION

In the last dozen years, the Middle Jurassic ammonite faunas along the entire Pacific, from Alaska to the southern Andes, have become sufficiently well known to permit a quantitative approach to compare the different regional faunas of the globe, and to estimate the affinities of the Andean faunas. Ideally, quantitative techniques, i.e. coefficients of similarity and cluster analysis, should be used to discriminate distinctive faunistic areas within the entire geographic distribution by using the data from the many restricted fossil localities (cf. Waterhouse and Bonham-Carter, 1975). In this study, however, we have mainly accepted the geographic areas of Jurassic ammonite faunas discriminated by previous authors on a qualitative basis, and we have used numerical techniques only to assess the degree of similarity and difference among them.

Since we are here essentially concerned with the relationship of the Andean ammonite faunas with those of other areas of the world, we have not attempted for the present time to discuss the validity of either the different names previously proposed for palaeobiogeographic units, their boundaries and ranks, or the supposedly exclusive geographic or ecologic factors on which the units may be based (cf. Middlemiss and Rawson, 1971). We have followed Valentine (1968, 1973) and accepted that the different palaeobiogeographic units are defined by the characteristic taxonomic composition of their faunas.

Since the work of Arkell (1956) which had modified Uhlig's (1911) scheme, there has been general agreement about the existence of a Boreal and a Tethyan realm throughout most of the Jurassic and Cretaceous. However, no consensus has been reached with respect to the existence of a Pacific realm and the subdivision of these principal units (cf. Imlay, 1965; Krimholz et al., 1968; Hallam, 1969; Hallam, ed. 1973; Khudoley, 1974). We have not followed any author in particular, although in most cases, our 'areas' (a loose term without biogeographic rank; cf. Makridin, 1973) coincide with a formal palaeobiogeographic unit of a previous author. The 'areas' which are indicated in Text-figures 1-5 naturally differ somewhat for the different stages considered, because any one of them may be unknown from large regions, or the faunistic boundaries of contiguous areas may shift significantly with time. The 'areas' used here are:

- 1/ *Andes area* -- West-central Argentina, central and northern Chile, northern Peru.
- 2/ *Mexico area* -- Southwest Mexico.
- 3/ *North Cordillera area/Boreal area* -- Aalenian: *N.C. area* for W. U.S.A., and S.W. Canada; Bajocian: *N.C. area* for W. U.S.A.; S.W. Canada and S. Alaska; Callovian: *N.C. Boreal area* for W. North America except Mexico.
- 4/ *Boreal/Eurasian Boreal area* -- Aalenian: *B. area* for Alaska, W. Canada, and N. Siberia; Bajocian: *B. area* for Arctic N. America and N. Siberia; Callovian: *E. B. area* for Eurasia north of lat. 45-50 N. and Greenland.
- 5/ *Eurafrica area* -- Europe south of Boreal area and N.W. Africa (West Tethys).

- 6/ *S.W. ASIA area* -- Asia south of the Boreal area, from Turkey to Himalayas (East Tethys).
- 7/ *Indo-East Africa area* -- East Africa, Madagascar, Arabian Peninsula, India.
- 8/ *Oceania area* -- Western Australia, New Guinea, Moluccas.
- 9/ *East Asia area* -- Indochina, Philippines, Japan.

We have taken the plate tectonic theory into account and adopted what we consider a good reconstruction and most useful projection for the Middle Jurassic globe, i.e. that of Seyfert and Sirkin (1973, fig. 12-1b).

In our study, as in most biogeographic accounts, a single higher taxon has been used, i.e. the suborder Ammonitina. Yet other higher taxa would probably have resulted in similar groupings and relationships since the major palaeobiogeographic areas defined by different higher taxa have usually been fairly coincident (cf. Hallam, ed. 1973; Waterhouse and Bonham-Carter, 1975).

Probably the most important prerequisite for a quantitative comparison is the correct choice of the taxonomic rank, so that the data of presence-absence per area and taxa-in-common between areas are meaningful. In this regard several factors have to be taken in consideration. First, the chosen taxa should allow ready and reliable comparisons, between papers of different authors, between more or less thoroughly studied areas, and between better or worse preserved faunas. In any circumstance while the first condition can only be met by critical judgement and a thorough knowledge of the fossils involved, including re-identification and re-classification through published figures, the last two would require the examination of all fossil localities and can obviously only be approximated (we have seen many of the most important localities along the eastern Pacific margin as well as in Northwest Europe). Second, as pointed out by Arkell (1956, p. 607), the time factor is of paramount importance because geographic distributions of single taxa and of entire faunas are changing quite rapidly. Therefore distributions should be plotted for as short a time interval as possible (and practical). Ages (stages) seem to be most appropriate (cf. Middlemiss and Rawson, 1971, p. 209; Johnson, 1971, p. 258).

Although the family level may be considered to best reflect endemic elements since their taxonomic rank is assumed to be related to duration of isolated residence in the area (Ekman, 1953, p. 371), the phyletic turnover of families would be too low for their consideration within distinct ages (most ammonite families range through more than one stage). Furthermore, the small number of families per stage would inhibit significant statements about relative similarities between the faunas (cf. Hallam, 1969).

Consequently this study, as most previous ones on Mesozoic palaeobiogeography, has been based on the distribution of genera and subgenera. This is believed to optimize information with due regard for reliability of the data (Kauffman, in Hallam, ed. 1973).

The presence-absence data on genus and subgenus distribution have been essentially restricted, reflecting the very unusual genus-group level classification of the Ammonitina. Only "macroconch genera/subgenera", and taxa including both sexes have been considered. The dimorphic status of these "taxa" and their genus-group level correspondences have been

established well enough to allow for reduction to the "true" number of taxa without loss of information (cf. Westermann, ed. 1969b). It is well-known that "microconch taxa" are more difficult to identify than "macroconch taxa", that "macroconch taxa" are more easily differentiated sometimes corresponding to more than single "microconch taxa", and that macroconchs are more easily found than microconchs. Consequently, more "macroconch taxa" (females) than "microconch taxa" (males) are known. Therefore the use of "macroconch taxa" and true dimorphic taxa only is expected to result in a more simple and natural distributional pattern.

While most genus-group level taxa of Jurassic ammonites are restricted to single substages of the Bajocian and Callovian or to the Aalenian stage (the units here chosen), the problems of extended vertical range through more than one substage and of regional occurrences in different substages, or both (e.g. *Asthenoceras*) have to be solved. Because of frequently unknown regional ranges and/or correlations, the taxon is counted only once, usually in the substage where it is most prolific and/or wide-spread. The Bathonian stage has been deleted from this study because of its poor and not yet certain record from the Andes area (cf. Hillebrandt, 1970).

The numerical comparison of the Ammonitina faunas from the different 'areas' is based on the *Simpson* and *Dice Coefficients* which relate number of taxa-in-common to total number of taxa in different ways. They are:

$$\text{Simpson Coeff. } \frac{C}{N_1} \qquad \text{Dice Coeff. } \frac{2C}{N_1 + N_2}$$

where C is the number of taxa-in-common, N_1 the total number of taxa in the smaller fauna and N_2 the total number of taxa in the larger fauna. While the Simpson Coefficient (abbreviated S) stresses similarities between the faunas without reflecting diversity (true or a result of sampling), the Dice Coefficient (D) recognizes also the dissimilarities between the two faunas by including both in the denominator. The Dice Coefficient is therefore also less effected by small changes of information in a disproportionately small fauna (the more extreme Jaccard Coefficient $C/(N_1 + N_2 - C)$ is not used here; cf. Hughes, 1973, p. 228). However, the problem of comparing faunas of very different taxonomic diversity remains, and both coefficients are therefore given. The degree of endemism of the single 'areas' is defined by the *Endemism Coefficient* (abbreviated E) which is the number of strictly endemic taxa as a percentage of total number of taxa ($E/N \times 100$).

The endemism at the genus-group level of Ammonitina *within* the two great Jurassic realms (Boreal and Tethyan) is comparatively low. The percentages of endemism defining different biogeographic units as proposed by Kauffman (*in* Hallam, ed. 1973) based on Cretaceous bivalves and accepted by Boucot (1975), for Devonian brachiopods, are therefore not applicable in this case. The same applies to Johnson's (1971) *Provinciality Index*. Possibly because of the particular problem facing the cephalopod palaeobiogeographer owing to the exceptional possibilities of post-mortem transport, it may be necessary to include a coefficient of relative taxonomic abundance in future ammonite studies (i.e., even if

single occurrences of taxa outside of their 'normal' province may reflect post-mortem drifting of the empty shells the different coefficients of similarity would include them).

Fossil identifications from the literature have in most cases been critically evaluated and some of the records are based on our own unpublished work. Faunal lists alone have been considered unsatisfactory unless there are special reasons for their trustworthiness (scientific authority, independent record by different authors, contiguity with known distributions, etc.). The data have been compiled from the works cited by Arkell (1956 and *in* Arkell et al., 1957), from those included in both Jurassic Colloquia (Maubeuge, ed. 1964, 1974) and from the following later sources: *Andes* -- Hillebrandt (1970), Westermann (1964c), Westermann and Riccardi (1972a & b, 1975, and unpublished work); *Mexico* -- Erben (1956), and Ochoterena (1963, 1966); *U.S.A. and Canada* -- Frebold (1957, 1958, 1960, 1961, 1963, 1964a-b), Frebold and Tipper (1967), Frebold et al. (1969), Imlay (1961, 1962a & b, 1963, 1964a & b, 1965, 1967, 1973, 1975), Imlay and Detterman (1973), and Westermann (1964a & b, 1969a); *Northern U.S.S.R.* -- Basov et al. (1967), Dagens and Zakharov, eds. (1974), Krimholz and Tazychin, eds. (1972), Meledina (1973, 1974); *Japan and Southeast Asia* -- Andal et al. (1968), Sato (1960, 1962, 1974, 1975), Takahashi (1969); *Oceania* -- Gerth (1965), Westermann and Getty (1970); *East Africa, Madagascar, Arabian Peninsula and India* -- Agrawal (1956), Collignon (1958, 1966), Imlay (1970), Westermann (1975); *Southwest Asia (and Southeast Europe)* -- Assereto et al. (1968), Bremer (1966), Krimholz (1961), Krimholz and Tazychin, eds. (1972), Lominadze (1967, 1970, 1975), Seyed-Emami (1971); *Europe and Northwest Africa* -- Bourquin and Contini (1968, 1969), Busnardo et al. (1964), Callomon (1968, 1971), Callomon and Cope (1971), Cariou (1965, 1974a & b), Cariou et al. (1971), Contini (1969), Contini and Girard-Claudon (1966), Dieni et al. (1966), Elmi (1963, 1967, 1971), Geczy (1967), Geister and Geyer (1968), Huf (1968), Mangold (1970), Mangold and Elmi (1966), Marchand and Thierry (1974), Maubeuge (1961-69), Morton (1971, 1972, 1975), Mouterde et al. (1971), Oechsle (1958), Pavia (1971), Rieber (1963), Ruget-Perrot (1961), Sapunov and Nachev (1959), Sturani (1964a & b, 1971), Thierry (1968), Wendt (1964), Westermann (1956, 1967, 1975b), Zeiss (1956); *Greenland* -- Birkelund et al. (1971), Callomon (1959), Donovan (1957); *Antarctica* -- Quilty (1970).

AALENIAN

The stage is unknown from the Oceania and Indo-East Africa areas. Table 1 includes 6 (+ 2) taxa from the Andes area, 3 (+ 1) from the North Cordillera area, 7 from the Boreal area including South Alaska where the North Cordillera and Boreal faunas intermix, 8 from East Asia, 9 from Southwest Asia, and 18 from the Eurafica area (not subdivided).

The only known Andean endemic genus or subgenus is "Hammatoceratidae? n. gen." (Westermann and Riccardi, 1972a) resulting in a similar endemism for the Andes area (15%) as for the Boreal (14%) and East Asia (12%) areas. The higher endemism of Eurafica (32%) may be largely apparent and owing to the much better known fauna (and taxonomic splitting). The Andes fauna resembles the Eurafica fauna which includes all

taxa but the endemic genus most strongly; *Stauffenia* (*Costileioceras*) and *Bredya* are shared between these areas only; the Dice Coefficient (D) is 0.42 (low due to strong sample size asymmetry) and the Simpson Coefficient (C) 0.85. Somewhat less closely related is the North Cordilleran fauna, south of the Boreal area (D 0.44, S 0.67). Although moderate similarities of the Andean fauna exist to the East Asian fauna (D 0.43, S 0.5) and Southwest Asian fauna (D 0.40, S 0.5), the taxa-in-common are all pandemic, so that no trans-Pacific connections are implied (Fig. 1).

The North Cordillera fauna resembles that of Eurafrika closely, in part by elements missing in the Andes (*Graphoceratidae*) or shared only between them (*Abbasites*). Faunal affinities of western Tethys continue strongly from Eurafrika through the eastern Tethys (S.W. Asia and Indochina) to Japan (D 0.82, S 0.9), and from there onward to British Columbia (D 0.67, S 0.7). In the late Aalenian, the Boreal *Erycitoides-Pseudolioceras* ["*Tugurites*"] fauna of low diversity, is distinct throughout Alaska, Arctic Canada and northern Siberia. This fauna intermingles with the North Cordilleran fauna in South Alaska where it has furnished the largest Aalenian assemblage of the entire Pacific area, resulting in an apparent increase of diversity and a distortion of the similarity coefficients.

LOWER BAJOCIAN (Discites to Humphriesianum Zones)

The substage is poorly known from the East Asia and Boreal areas. The number of taxa in the different areas and their endemism (E) are as follows (Table 2): Andes 21-23 (E 10%), North Cordillera to South Alaska 34 (E 20%), Oceania 9 (E 0), Indo-East Africa area (Kenya, Madagascar) 4-5 (E 0), Southwest Asia 15-17 (E 0), and Eurafrika 35 (E 16%). Only two genera (*Stephanoceras* and *Sonninia* s.l.) are known from East Asia (Japan). In the Boreal area (Canadian Arctic), the single genus, *Arkelloceras*, cannot be dated with certainty (below); it is improbable that the endemic '*Boreiocephalites*' (N. Siberia) and *Cranocephalites* (entire Boreal area) make their appearance already in the Lower Bajocian.

As indicated in figure 2, the Andean fauna shows equally high resemblance to Eurafrika and the North Cordillera (D 0.57 & 0.59, S 0.8). The similarity with Europe is enhanced by the common occurrence of two or three taxa absent elsewhere, i.e. *Zurcheria*, *Sonninia* (*Fissilobicer*-*as*) and ? *Sonninia* s.s.; while the resemblance with the North Cordillera area is strengthened by two taxa shared only among them, i.e. *Docidoceras* (*Pseudocidoceras*), and *Emileia* nov. subgen. (for '*Stephanoceras*' *giebeli* Gottsche). Furthermore, the often cited genus *Pseudotoites* exists only in the Andes, Oceania, and South Alaska (where it is extremely rare); while the Andes share another taxon, i.e. *Sonninia* (*Papilliceras*) with the North Cordillera and Eurafrika only. The Andes-Oceania resemblance (D 0.41, S 0.7) and particularly the Oceania-North Cordillera resemblance (D 0.45, S 1.0) are so strong that a trans-Pacific connection seems probable. Since all Oceanian genera except for *Pseudotoites* occur also in the Tethys, and since the rare North American species of that genus closely resemble the Andean species, a relatively minor faunal connection via the southern Pacific would perhaps suffice to explain

the known distribution.

The North Cordilleran fauna, in turn, is surprisingly similar to that of Eurafraica throughout the substage (S 0.74, S 0.8) so that the European ammonite chronozones can be used there (Westermann, 1969); the two areas share 5 taxa unknown from other areas, i.e. *Labyrinthoceras*, *Asthenoceras*, *Praeoppelia*, *Praestrigites* and *Hebetoxytes*.

The known small East African fauna of 4-5 genera is pandemic and suggests close interconnection with the Tethys fauna. Toward the East, the affinities of the Tethys fauna are quite strong to the North Cordillera area (D 0.56, S 0.8), but only weak to Oceania (D 0.37, S 0.9).

UPPER BAJOCIAN (Subfurcatum to Parkinsoni Zones)

Late Bajocian faunas have only recently become reasonably well known from the eastern Pacific region, but remain unknown from East Asia. The number of genus-group level taxa and endemism of the areas are (Table 3): Andes 4-5 (E 0), Cordillera area from Mexico to South Alaska 9-10 (E 22%), [? Boreal area 2 (E 100%)], Oceania 3-4 (E 0), East Africa-Madagascar including the Arabian Peninsula 7-9 (E 40%), S.W. Asia 9 (E 0), and Eurafraica 20 (E 30%).

As illustrated in figure 3, the Andean fauna has the strongest resemblance to that of the North Cordillera area (D 0.62, S 1); they share *Megasphaeroceras* known elsewhere only from the Antarctic Peninsula (needing confirmation). No endemic genus is known. The Andean resemblance to the Eurafraican fauna appears to be much lower (D 0.25, S 0.75) but this is partly owing to numerical asymmetry of known taxa. Similarities, however, are mostly due to pandemic elements and no genus or subgenus is shared between the Andes and Eurafraica alone. The Andes-Oceania similarity is moderate (D 0.5, S 0.7) but owing to pandemic taxa; no trans-Pacific faunal connection is indicated. The poorly preserved assemblage from Elseworth Land, Antarctic Peninsula, with *Stephanoceras* s. 1. and *Megasphaeroceras*, resembles early Upper Bajocian Assemblages from the Andes, Oregon and South Alaska. This would extend the range of the 'Megasphaeroceras assemblage' from Alaska to Antarctica.

Although the Cordilleran fauna differs significantly from that of Eurafraica (D 0.34, S 0.6), the two areas also share *Parastrenoceras* and *Sphaeroceras* which are unknown elsewhere. In Eurafraica, these genera are best known around the Mediterranean, while the parkinsoniids and garantianids so common in northwestern Europe, are notoriously absent from the entire Pacific area.

The small known assemblage from the Moluccan Islands of Oceania consists entirely of Tethys genera (the rare *Praetulites* occurs also in Europe but is still unknown from the much less known S.W. Asian faunas, resulting in lower Oceania-S.W. Asia coefficients, D 0.5, S 0.7). The East African fauna has a high degree of endemism, in the *Ermoceras* assemblage, centred on the Arabian Peninsula. Its closest resemblance is to Eurafraica (D 0.3, S 0.6).

The Boreal area, comprising of the Arctic slopes of America (including Greenland) and Eurasia, contains no unequivocal fossil evidence for the Upper Bajocian, with the probable exception of the uppermost Bajocian. The long succession of endemic genera begins with *Cranocepha-*

lites (and '*Boreiocephalites*') probably below the base of the Bathonian, and the Boreal area soon expands to South Alaska.

Lower Callovian

The number of genera and subgenera and endemism are (Table 4): Andes 12-13 (E 8%), Mexico 8-12 (E 0), North Cordillera Boreal area 16-18 (E 44%), Eurasian Boreal area 14 (E 7%), Eurafrika 20-22 (E 15%), S. W. Asia 10-11 (E 0), Indo-East Africa area 16 (E 25%), Oceania 9 (E 11%), and East Asia 4-6 (E 0).

The Andean fauna includes only a single endemic genus (unnamed, for '*Indocephalites*' *gerthi* (Spath) and resembles most closely the Mexican fauna (D 0.70, S 0.87). This affinity is enhanced by the presence of *Eurycephalites* s.s. which both areas have exclusively in common, and by *E. (Lilloetia)* which is also shared with the North Cordillera Boreal area (and Japan?). Markedly lower similarities exist to both the southern Eurafrika or western Tethys (D 0.37, S 0.50). However, the latter resemblance is entirely due to pandemic taxa; all are also known from Eurafrika, and most of them also from Oceania, so that a direct seaway between the Andes and Indo-East Africa areas is not required.

Of particular interest is the presence in the Andes of several exclusively circum-Pacific taxa, i.e. *Xenocephalites* and *Neuquenicerias*. The former occurs from (?Siberia) South Alaska to the Andes and is now known also from New Guinea (unpublished); the latter is known only from the Andes and Japan. At least the *Neuquenicerias* distribution implies trans-Pacific migration since it is absent in the well known contemporaneous faunas of the North Cordilleran area, although the connection could have been via Oceania.

Southern Eurafrika or western Tethys has rather close affinities to the Indo-East Africa area (D 0.6, S 0.7) which exhibits strong endemism (25%: *Pseudoclydonicerias*, *Pseudomicromphalites* in Madagascar and *Cutchisphinales*, *Epimorphoceras* in Kutch). A moderate faunistic connection leads from there to Oceania (D 0.4, S 0.55) which has only one endemic genus, i.e. *Irianites*.

The Eurasia Boreal area has a broad overlap with the Eurafrika and southwest Asia areas, so that its endemism of 7% appears too low. This is a result of the extensive southward migrations of the Boreal Cardioceratidae and Kossmoceratidae, so that clear boundaries have to take relative abundance into account. The fauna of the North Cordillera Boreal area, however, is distinct from the Eurasia Boreal area (D 0.4, S 0.43) and differs almost entirely from the other areas of the Pacific margin (e.g. Mexico: D 0.17, S 0.2). In fact, the North Cordillera area yields the highest endemism (44%) of any area here considered, due in part to the restriction of some genera, i.e. *Warrenoceras*, "*Cadoceras*", to the Western Interior of U.S.A. and Canada.

Late Lower-Middle Callovian

The numbers of genera and subgenera and endemism are: Andes 4 (E 0), Mexico 3 (E 0), North Cordillera 2-3 (E 0), Boreal Eurasia 12-15 (E 8%), Eurafrika 16-17 (E 13%), S.W. Asia 14 (E 0), Indo-East Africa 20 (E 25%), Oceania 6 (E 0), and East Asia 1 (Table 4).

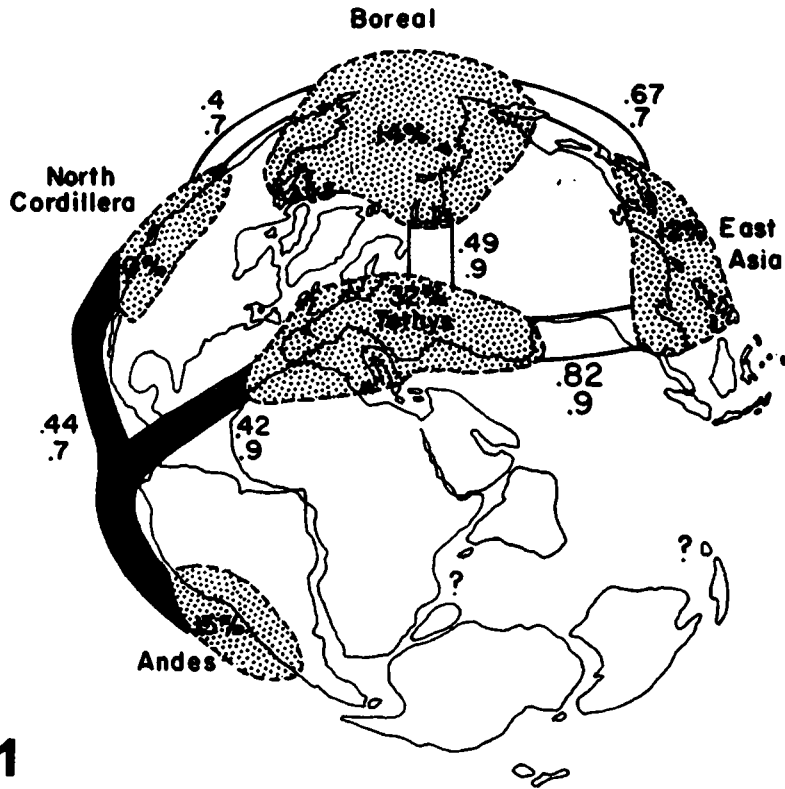
The Andean fauna consists of pandemic genera which are also present in the Eurafrikan, marginal Eurasian Boreal, S.W. Asian and Indo-East African faunas; but half of them appear to be missing in Mexico (note that disproportionate sample sizes result in different Dice Coefficients). Since the North Cordilleran and Oceanian faunas differ entirely, a direct seaway existed between the Andes, Mexico and Eurafrikan areas.

As shown in figure 5, Tethys connected with the highly endemic Indo-East Africa area which, in turn, formed a simple biogeographic unit with Oceania (with a much more poorly known fauna). The Eucycloceratinae are typical for this "Indo-West Pacific Province" which seems to include also Japan.

The Boreal fauna is now quite uniform with all genera known from the North Cordilleran also occurring in Boreal Eurasia. No evident faunal mixture is known between the North Cordilleran Boreal and Mexican fauna, while a broad faunal overlap exist between the Boreal and Tethyan faunas in Eurasia.

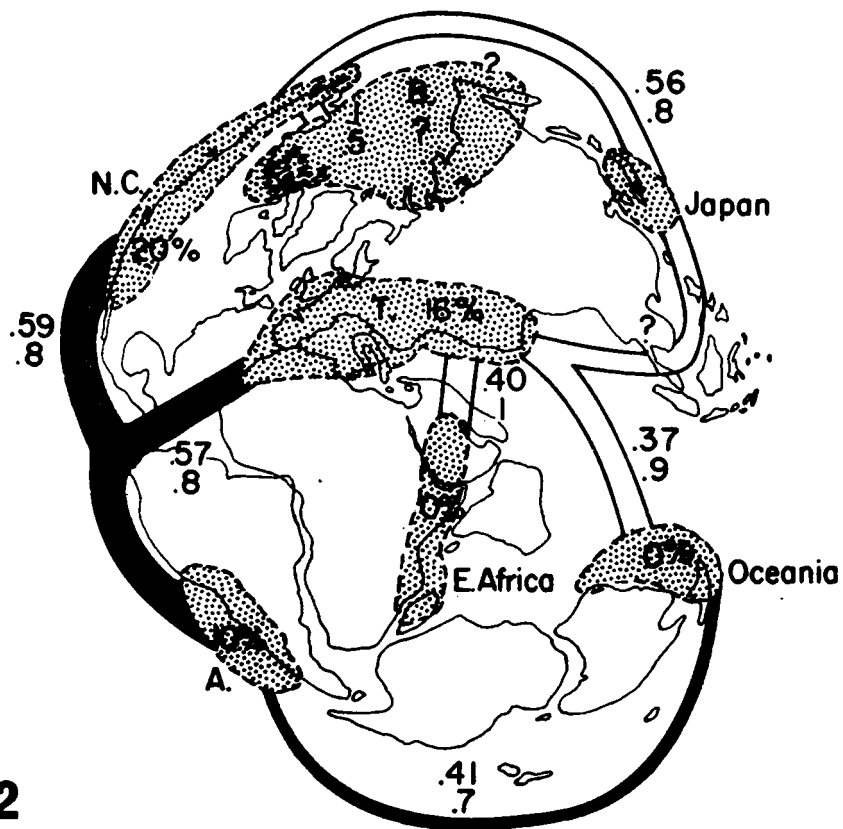
Also noteworthy is the absence of any genus or subgenus restricted to the Pacific Ocean margins.

A A L E N I A N



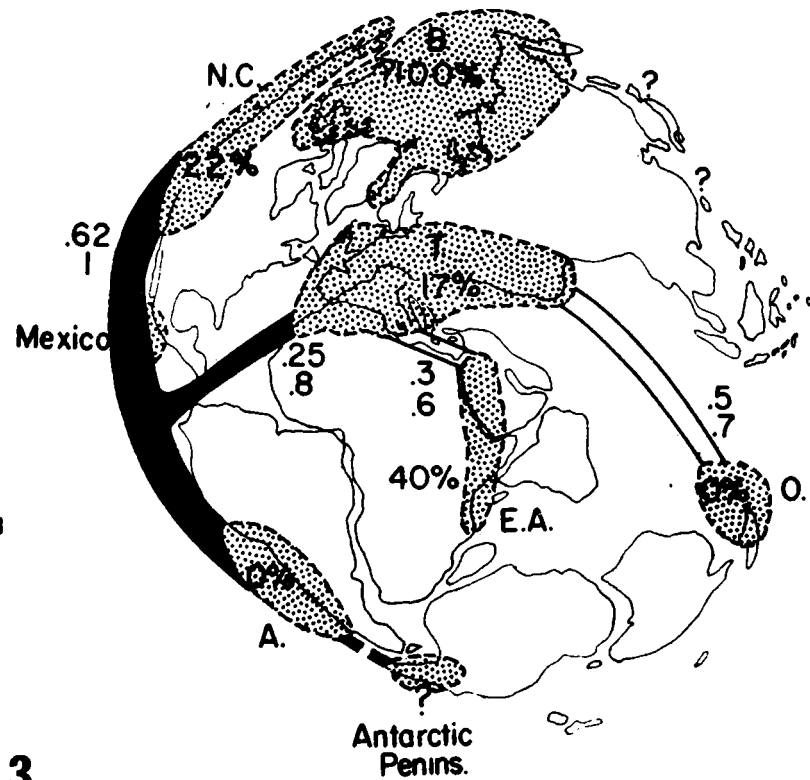
Text-figures 1-5 -- Taxonomic resemblance of Middle Jurassic Ammonitina at the generic/subgeneric level between major areas of distribution (see text). The Dice (above) and Simpson (below) Coefficients of similarity between area pairs are indicated numerically and by the relative width of the bands connecting them, with those of the Andean area in solid. No directions of dispersal or migration are implied. (Base map of the Jurassic globe adapted from Seyfert and Sirkin, 1973.)

L. BAJOCIAN



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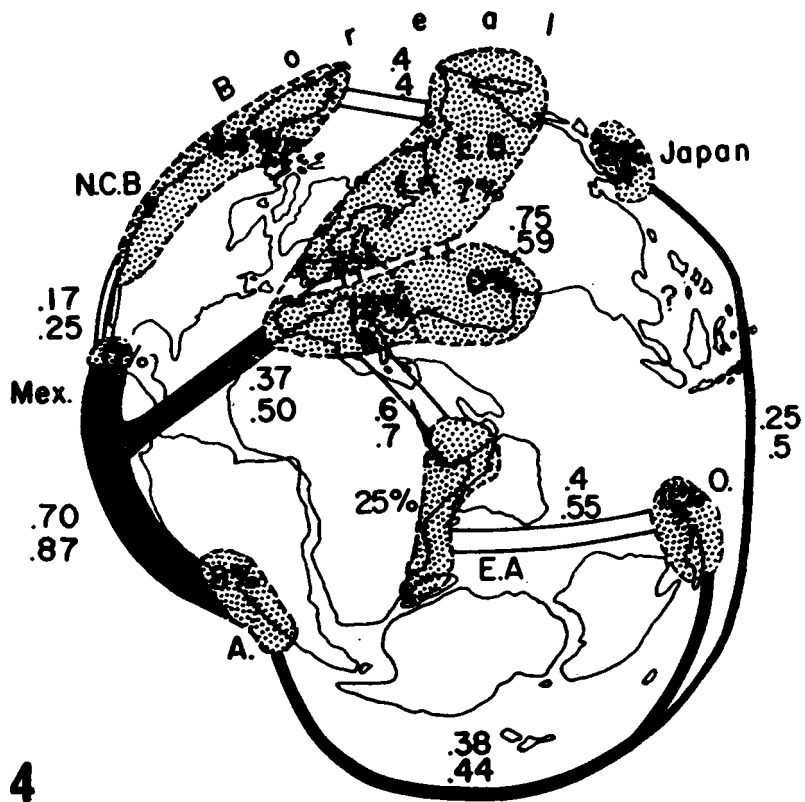
U. BAJOCIAN



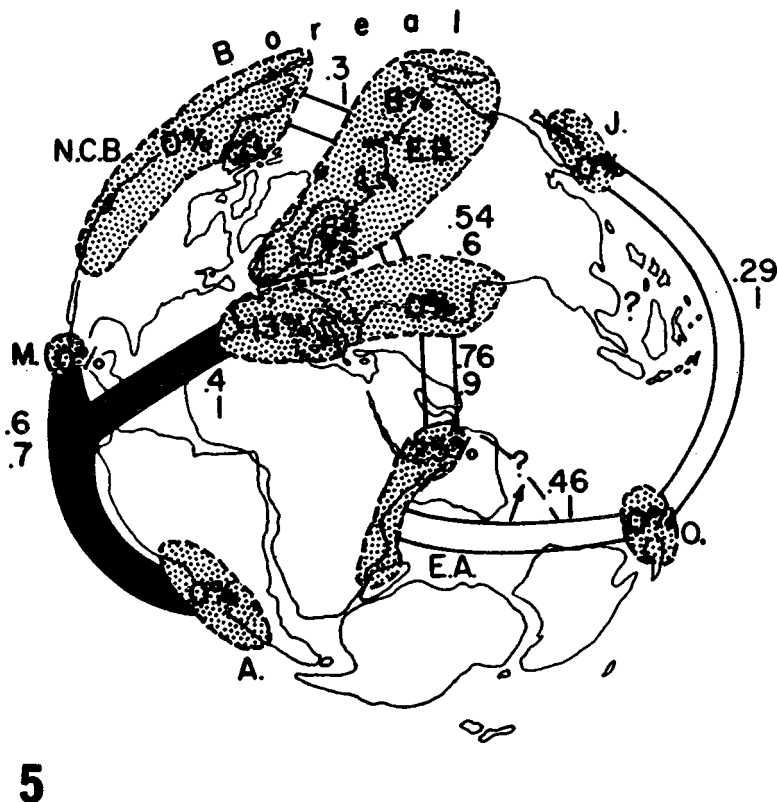
3

(11)

L. CALLOVIAN



L./M. CALLOVIAN



(12)

TABLE 1: AALENIAN							TABLE 2: LOWER BAJOCIAN									
genus / subgenus		Andes	N. Cord.	Boreal	Eurafr.	S.W. Asia	E. Asia	genus / subgenus		Andes	N. Cord.	Eurafr.	S.W. Asia	Indo-E. Afr.	Oceania	E. Asia
Tmetoceras		+	+	+	+	+	+	Zurcheria		+		+	+			
Leioceras								Haplopleuroceras						?		
Costileioceras		+						Eudmetoceras		+	+	+	+			
Staufenia								Euaptetoceras		+	+	+	+			
Cyclicoceras								Puchenquia		+						
Ludwigia								Podagrosiceras		+						
Graphoceras			+					Praestrigites				+	+			
Brasilia								Sonninia		+	?	+				
Oedania								Fissiloboceras		+		+				
Geyerina								Euhoploceras		+	+	+				+
Hyperlioceras								Papilliceras		+	+	+				
Pseudolioceras								Shirbuirnia				+				
Hosoureites				+				Mitchellia		+	+	+	+	+	+	+
Planammatoceras		+	?	+		+		Dorsetensia		+	+	+	+	+		
Pseudammatoceras		?						Guhsania				+				
Spinammatoceras								Fontansesia		?	+	+				+
Bredyia		+						Alaskoceras				+				
Hammatoc. gen. nov.		+						Asthenoceras				+	+			
Erycites		+	+	+		+		Strigoceras				+	+	+		
Erycitoides				+		+		Hebetoxyites				+	+			
Abbasites				+		+		Poecilomorphus				+	+	+		
TABLE 3: UPPER BAJOCIAN																
genus / subgenus		Andes	Mexico	N. Cord.	Boreal	Eurafr.	S.W. Asia	Indo-E. Afr.	Oceania							
Trimarginia										Lissoceras		+	+	+		
Oecotraustes										Toxamblytes			+			
Cadomites		+	+	?						Bradfordia		+	+	+	+	
Liroxyites				+						Oppelia		+	+	+	+	+
Ermoceras										Praeoppelia			+	+		
Telermoceras										Stegoxytes				+		
Kosmermoceras										Doxidoceras			+	+	+	
Thamboceras										Pseudocidoceras		+	+			
Sohlites				+						Emileia		+	+	+	+	
Leptosphinctes		+	+	+						'E. giebeli'		+	+			
Prorsisphinctes				?						Pseudotoites		+	+			+
Strenoceras		?								Zemistephanus			+			
Garantiana										Labyrinthoceras			+	+		
Hlawiceras										Chondroceras		+	+	+		+
Orthogarantiana										Schmidtoceras				+		
Torrensia								?		Parabigotites			+			
Hemigarantiana										Stephanoceras		+	+	+	+	?
Parkinsonia										Kumatostephanus			+	+	+	
Durotrigensia										Skirroceras		+	+	+	+	+
Caumontisphinctes										Stematoceras		?	+	+	+	+
Parastrenoceras			+							Teloceras		+	+	+		+
Dimorphinites										Skolekostephanus				+		
'Boreiocephalites'										Alfeldites				+		
Spiroceras		+	?	+						Arkelloceras			+			
Sphaeroceras				+						Lupherites			+			
Megasphaeroceras		+		+												
Parachondroceras				+												
Praetulites																+
Cranocephalites																

TABLE 4: LOWER CALLOVIAN											TABLE 5: LATE LOWER-MIDDLE CALLOVIAN										
genus / subgenus	Areas										genus / subgenus	Areas									
	Andes	Mexico	N. Cord.	Boreal	Eurafr.	S.W. Asia	INDO- E. Afr.	Oceania	Japan	Andes		Mexico	N. Cord.	Boreal	Eurafr.	S.W. Asia	INDO- E. Afr.	Oceania	Japan		
Parapatoceras		+		+							Bonarellites								+		
Oxycerites	+	?	+								Ankobites								?		
Prohecticoceras	?										Putealicerias								+		
Chanasia	+										Hecticoceras	+							+		
Paralcidia	+	+									Lunuloceras								+		
Eulumulites											Brightia								+		
Lorioloceras											Kheraites								+		
Pseudoclydoniceras											Sindeites								+		
Pseudomicromphalites											"Bonarellia"								+		
Aneraiceras	+	+									Phlycticeras								+		
Macrocephalites											Eucycloceras								+		
Indocephalites											Idiocycloceras								+		
Lurycephalites											Subkossmatia								+		
Xenocephalites	+	+	+								Erymoceras								+		
Lilloettia	+	+	+								Kosmoceras		+						+		
Chinitnites											Guilielmites								+		
Iniskinites											Zugokosmokers								+		
Imlayoceras		+	+								Epicosmoceras								+		
Warrenoceras	+	+	+								Stenocadoceras								+		
?Buckmaniceras											Longaeviceras								+		
"I." gertzi	+										Reineckella		+	?					+		
"Cad." shoshonense											Kellawaysites		+	+					+		
Notocephalites											Rehmannia		+						+		
Kepplerites											Kinkoliniceras								+		
Seymourites											Obtusicosites								+		
Gowericeras											Sivajiceras								+		
Sigaloceras											Binatisphinctes								+		
Catasigaloceras											Fiabellisphinctes								+		
Cadoceras																			+		
Paracadoceras																			+		
Chamousetia																			+		
Epimorphoceras	?																		+		
Parareineckella																			+		
Egabrensiceras																			+		
Neuquenoceras	+	?																	+		
Proplanulites																			+		
?Cutcnisphinctes																			+		
Choffatia	+	?	+	+	+	+	+	+	?										+		
Parachoffatia																			+		
Indosphinctes		?																	+		
Subgrossouvria	+	+	?	+	+	+	+	+	+										+		
Irianites																			+		

BIBLIOGRAPHY

- AGRAWAL, S.K. 1956. Contribution a l'étude Stratigraphique et Paléontologique du Jurassique du Kutch (Inde). Ann. Centre Doc. Paléont. 19, 188 pp., 12 pl.
- ANDAL, D.R., ESGUERRA, J.S., HASHIMOTO, W., REYES, B.P. and SATO, T. 1968. The Jurassic Mansalay Formation, Southern Mindoro, Philippines. Geol. Pal. SE Asia IV:179-197, pl. 28-30.
- ARKELL, W.J. 1956. Jurassic Geology of the World: pp. xv + 804, 46 pl. Oliver and Boyd Ltd, Edinburgh & London.
- ARKELL, W.J., KUHMEL, B. and WRIGHT, C.W. 1957. Mesozoic Ammonoidea. In MOORE, R.C., ed., Treatise on Invertebrate Paleontology L4:L80-L437, figs. 124-555. University of Kansas Press.
- ASSERETO, R., BARNARD, P.D.W. and FANTINI SESTINI, N. 1968. Jurassic Stratigraphy of the Central Elburz (Iran). Riv. Ital. Paleont. 74(1):3-21.
- BASOV, V.A., VELIKZHANINA, L.S., DGINORIDZE, N.M., MELEDINA, S.V. and NALNJAIEVA, T.I. 1967. New Data on Stratigraphy of Jurassic deposits of the Lens-Anabar region. In Problems of Substantiation of Detailed Mesozoic Stratigraphy of Siberia and the Far East of U.S.S.R., Akad. "NAUKA", pp. 74-94.
- BIRKELUND, T., HAKANSSON, E. and SURLYK, F. 1971. New finds of Bathonian, Callovian and Oxfordian Ammonites in Northern Jameson Land, East Greenland. Geol. Soc. Denmark Bull. 20:240-259, pls. 1-2.
- BOUCOT, A.J. 1975. Evolution and Extinction Rate Controls: pp. xv + 427. Scientific Publ. Co., Amsterdam.
- BOURQUIN, J. and CONTINI, D. 1968. Données nouvelles sur la stratigraphie et la Paléogéographie du Callovien du Jura Franc-Comtois. Soc. Géol. Fr. Bull. Ser. 7, X: 362-369.
- BOURQUIN, J. 1969. Découverte d'une espèce boréale Cadoceras (Stenocadoceras) nikitini Sokolev, dans le Callovien moyen du Jura. Féd. Soc. Hist. Nat. Franche-Comté Bull. CXXI, NS 2:38-40.
- BREMER, H. 1966. Ammoniten aus dem unteren Bajocium und unteren Bathonien in der Umgebung von Ankara (Türkei). N. Jb. Geol. Paläont., Abh. 125:155-169, pls. 15-18.
- BUSNARDO, R., ELMI, S. and MANGOLD, C. 1964. Ammonites Calloviennes de Cabra, (Andalousie, Espagne). Lab. Géol. Fac. Sci. Lyon Trav. NS 11:49-94, 6 pls.
- CALLONUM, J.H. 1959. The Ammonite Zones of the Middle Jurassic Beds of East Greenland. Geol. Mag. XCVI (6):503-513, pls. 17-18.

1968. The Kellaways Beds and the Oxford Clay. In SYLVESTER-BRADLEY, P.C. and FORD, T.D., eds., *The Geology of the East Midlands*, pp. 264-293, Leicester Univ. Press.
1971. On the type species of *Macrocephalites* Zittel 1884 and the type specimen of *Ammonites macrocephalus* Schlothheim 1813. *Palaeontology* 14(1):114-130, pls. 15-18.
1975. Jurassic Ammonites from the Northern North Sea. *Norsk. Geologisk Tidsskrift* 55:373-386.
- CALLOMON, J.H. and COPE, J.C.W. 1971. The Stratigraphy and Ammonite Succession of the Oxford and Kimmeridge Clays in the Warrlingham Borehole. *Geol. Surv. Great Britain Bull.* 36:147-176, pls. VIII-XII.
- CARIOU, E. 1965. Essai de Corrélations stratigraphiques entre l'Ouest de l'Europe et la Province Indo-Malgache, au Callovien. *Soc. Géol. Fr. Bull.* (7)VII:537-540.
- 1974a. Unités biochronologiques nouvelles dans le Callovien du Sud-Ouest de l'Europe (Province subéthysienne). *C.R. Acad. Sc. Paris* 279:381-384.
- 1974b. La série callovienne du Nord-Ouest du bassin d'Aquitaine. *C.R. Acad. Sc. Paris* 279:307-310.
- CARIOU, E., ELMI, S., MANGOLD, C., THIERRY, J. and TINTANT, H. 1971. Zones de l'étage Callovien en France. *Soc. Géol. Fr. Bull.* (7)XIII:38-45.
- COLLIGNON, M.E. 1958. Atlas des Fossiles Caractéristiques de Madagascar. I. Lias-Bajocien; II, Bathonien-Callovien, pls. I-XXXIII. *Serv. Géol. Madagascar*.
1966. Sur quelques ammonites remarquables, nouvelles ou peu connues du Jurassique de Madagasikara. *C.R. Sem. Géol. Madagascar* 1966, pp. 21-27, pls. 7-8.
- CONTINI, D. 1969. Les Graphoceratidae du Jura Franc-Comtois. *Ann. Sci. Univ. Besançon, Ser. 3, Geol.* 7:3-93, pls. I-XXIV.
- CONTINI, D. and GIRARD-CLAUDON, F. 1966. Le Callovien de la Gare de Boujailles (Doubs). *Ann. Sci. Univ. Besançon* (3), *Geol. fasc.* 2:65-68.
- DAGIS, A.S. and ZAKHAROV, V.A., eds. 1974. *Mesozoic Palaeogeography of the North of Eurasia*. 187 pp., 4 pls., "Nauka" Siberian Branch. Novosibirsk.
- DIENI, I., MASSARI, F. and STURANI, C. 1966. Segnalazione di Ammoniti nel Giurese della Sardegna orientale. *Acad. Naz. Lincei* (8)XL:99-107, pls. I-II.
- DONOVAN, D.T. 1957. The Jurassic and Cretaceous Systems in East Greenland. *Medd. om Grøn.* 155(4):3-214, pls. 1-3.
- EKMAN, S. 1953. *Zoogeography of the Sea*: pp. xiv + 417. Sidgwick & Jackson, London.
- ELMI, S. 1963. Les Hammatoceratinae (Ammonitina) dans le Dogger Inferieur du Bassin Rhodanien. *Lab. Géol. Fac. Sci. Lyon Trav.* NS 10:7-121, pls. I-XI.
1967. Le Lias supérieur et le Jurassique Moyen de l'Ardèche. *Lab. Géol. Fac. Sci. Lyon Doc.* 19:845 pp., 15 pls.
1971. Les zones d'Ammonites dans la série Bajocien supérieur-Callovien de l'Oranie (Ouest algérien). *Soc. Géol. Fr. Bull.* (7)XIII:1-2, pp. 28-37.
- ERBEN, H.K. 1956. El Jurásico Medio y el Caloviano de México. *XX Congr. Geol. Inter. Proc.*, 140 pp., 19 láms, 5 mapas.
- FREBOLD, H. 1957. The Jurassic Fernie Group in the Canadian Rocky Mountains and Foothills. *Geol. Surv. Canada Mem.* 287:1-103, pls. I-XLIV.
1958. Fauna, Age and Correlation of the Jurassic rocks of Prince Patrick Island. *Geol. Surv. Canada Bull.* 41:1-32, pls. I-XVIII.
1960. The Jurassic Faunas of the Canadian Arctic. Lower Jurassic and Lowermost Middle Jurassic Ammonites. *Geol. Surv. Canada Bull.* 59:1-33, pls. I-XV.
1961. The Jurassic Faunas of the Canadian Arctic. Middle and Upper Jurassic Ammonites. *Geol. Surv. Canada Bull.* 74:1-43, pls. I-XXI.
1963. Ammonite Faunas of the Upper Middle Jurassic Beds of the Fernie Group in Western Canada. *Geol. Surv. Canada Bull.* 93:1-33, pls. I-XIV.
- 1964a. The Jurassic Faunas of the Canadian Arctic. *Geol. Surv. Canada Bull.* 119:1-27, pls. I-XX.
- 1964b. Lower Jurassic and Bajocian Ammonoid Faunas of Northwestern British Columbia and Southern Yukon. *Geol. Surv. Canada Bull.* 116:1-31, pl. I-VIII.
- FREBOLD, H. and TIPPER, H.W. 1967. Middle Callovian Sedimentary Rocks and Guide Ammonites from Southwestern British Columbia. *Geol. Surv. Canada Paper* 67-21:1-22, pls. I-III.
- FREBOLD, H., TIPPER, H.W. and COATES, J.A. 1969. Toarcian and Bajocian Rocks and guide Ammonites from Southwestern British Columbia. *Geol. Surv. Canada Paper* 67-10:1-41, pls. I-VI.
- GE CZY, B. 1967. Ammonoïdes Jurassiques de Csernye, Montagne Bakony, Hongrie. Pt. II (excl. Hammatoceratidae). *Geol. Hung., Ser. Palaeont.* 35:5-282, pls. I-LXV.
- GEISTER, J. and GEYER, O.F. 1968. Beiträge zur Stratigraphie und Paläontologie des Jura von Ostspanien. *N. Jb. Geol. Paläont. Abh.* 131(3):310-336.
- GEKTI, H. 1965. Ammoniten des mittleren und oberen Jura und der Mitesten Kreide vom Nordabhang des Schneegebirges in Neu Guinea. *N. Jb. Geol. Paläont. Abh.* 121(3):209-218, taf. 18.
- HALLAM, A. 1969. Faunal Realms and facies in the Jurassic. *Palaeontology* 12(1):1-18.
- HALLAM, A., ed. 1973. *Atlas of Palaeobiogeography*: pp. 1-531. Elsevier Scientific Publ. Co., Amsterdam.
- HILLEBRANDT, A. von. 1970. Zur Biostratigraphie und Ammoniten-Fauna des südamerikanischen Jura (insbes. Chile). *N. Jb. Geol. Paläont. Abh.* 136(2):166-211.
- HUF, W. 1968. Über Sonninien und Dorsetensien aus dem Bajocium von Nordwestdeutschland. *Beih. Geol. Jb.* 64:1-126, 51 pls.
- HUGHES, C.P. 1973. Analysis of Past Faunal Distributions. In TARLING, D.H. and RUNCORN, S.K., eds., *Implications of Continental Drift to the Earth Sciences*, vol. I, pp. 221-230. Academic Press, London & New York.

- INLAY, R.W. 1961. New Genera and Subgenera of Jurassic (Bajocian) Ammonites from Alaska. *J. Paleont.* 35(3):467-474, pls. 63-64.
- 1962a. Jurassic (Bathonian or Early Callovian) Ammonites from Alaska and Montana. U.S. Geol. Surv. Prof. Paper 374-C:C1-C32, pls. 1-8.
- 1962b. Late Bajocian Ammonites from the Cook Inlet Region, Alaska. U.S. Geol. Surv. Prof. Paper 418-A:A1-A15, pls. 1-5.
- 1963. Jurassic Fossils from Southern California. *J. Paleont.* 37(1):97-107, pl. 14.
- 1964a. Middle Bajocian Ammonites from the Cook Inlet Region Alaska. U.S. Geol. Surv. Prof. Paper 418-B:B1-B61, pls. 1-29.
- 1964b. Upper Jurassic Mollusks from Eastern Oregon and Western Idaho. U.S. Geol. Surv. Prof. Paper 483-D:D1-D19, pls. 1-4.
- 1965. Jurassic Marine Faunal Differentiation in North America. *J. Paleont.* 39(5):1023-1038.
- 1967. Twin Creek Limestone (Jurassic) in the Western Interior of the United States. U.S. Geol. Surv. Prof. Paper 540:1-105, pls. 1-16.
- 1970. Some Jurassic Ammonites from Central Saudi Arabia. U.S. Geol. Surv. Prof. Paper 643-D:D1-D15, pls. 1-4.
- 1973. Middle Jurassic (Bajocian) Ammonites from Eastern Oregon. U.S. Geol. Surv. Prof. Paper 756:1-100, pls. 1-47.
- 1975. Stratigraphic Distribution and Zonation of Jurassic (Callovian) Ammonites in Southern Alaska. U.S. Geol. Surv. Prof. Paper 836:1-28, pls. 1-6.
- INLAY, R.W. and DETTERMAN, R.L. 1973. Jurassic Paleobiogeography of Alaska. U.S. Geol. Surv. Prof. Paper 801:1-34.
- JOHNSON, J.G. 1971. A quantitative approach to faunal province analysis. *Am. J. Sci.* 270:257-280.
- KHUDOLEY, K.M. 1974. Circum-Pacific Mesozoic Ammonoid Distribution; Relation to Hypotheses of Continental Drift, Polar Wandering, and Earth Expansion. In KAHLE, C.F., ed., *Plate Tectonics-Assessments and Reassessments*. Am. Assoc. Petr. Geol. Mem. 23:295-330.
- KRIMHOLZ, G. Yu. 1961. Ammonites of the Lower and Middle Jurassic Southern Caucasus (in Russian), pp. 1-146, pls. I-IX.
- KRIMHOLZ, G. Yu., NESEZHNIKOV, M., SACKS, V., SHULGINA, N. and VAKHRAMAYEV, V. 1968. Sur la méthode de l'élaboration des Cartes paléobiogéographiques. XXIII Int. Geol. Congr. Proc., pp. 239-256.
- KRIMHOLZ, G. Yu. and TAZYCHIN, N.N., eds. 1972. Jurassic System. In *Stratigraphy of the U.S.S.R.* X.
- LELIEVRE, T. 1960. Etude des Ammonites de l'Aalénien de deux gisements du Nord du Maroc (Prérif). *Ann. Soc. Géol. du Nord LXXX:15-52*, pls. V-VII.
- LOMINADZE, T.A. 1967. The Callovian Macrocephalitidae of Georgia and the Northern Caucasus, 199 pp., pls. I-XXII.
- 1970. Middle Callovian Erymoceras of the Northern Caucasus. *Akad. Nauk Gruz. SSSR. Ins. Paleobiol.* 57:70-97.
- 1975. Callovian Hecticoceratinae from northern Caucasus (in Russian). *Akad. Nauk Gruz. SSSR*, pp. 5-83, pls. I-IX.
- MAKRIIDIN, V.P. 1973. The Principles of Discrimination and Nomenclature of Subdivisions in the Paleozoogeographic zoning of Marine Basins. *Paleont. Jour.* 2:127-131.
- MANGOLD, C. 1970. Les Perisphinctidae (Ammonitina) du Jura Méridional au Bathonien et au Callovien. *Lab. Géol. Fac. Sci. Lyon Doc.* 41(2), 246 pp., 16 pls.
- MANGOLD, C. and ELMI, S. 1966. Flabellisphinctes et Choffatia (Ammonitina) du Callovien Moyen de l'Ardeche. *Lab. Géol. Fac. Sci. Lyon Trav.* 13:183-204.
- MARCHAND, D. and THIERRY, J. 1974. Les influences Mésogènes et Boréales dans le Callovien de Bourgogne. *Soc. Géol. Fr. Bull. Ser. 7, XVI:476-489*.
- MAUBEUGE, P.L., ed. 1964. Colloque du Jurassique a Luxembourg 1962. pp. 7-948. Luxembourg.
- MAUBEUGE, P.L. 1961-1969. Catalogue des Ammonites du Jurassique inférieur et moyen (Hettangien à Bathonien) du Musée cantonal de Bâle-Campagne. *Tätigk. Naturf. Gesells.* 22:27-164; 25:43-130; 26:13-64. Basel.
- 1974. Colloque du Jurassique a Luxembourg 1967. *Bur. Rech. Geol. Min. Mem.* 75:3-757.
- MELEDINA, S.V. 1973. Bajocian-Bathonian Ammonites and Zonal Stratigraphy of Siberia. *Akad. Nauk SSSR. Sibirsk. Otdel., Geologiya i Geofizika Trudy*, vyp. 153:153 pp., 23 pls. Novosibirsk.
- 1974. Middle Jurassic and Callovian Stratigraphy problems of the Boreal Realm. In SACHS, ed. *Biostratigraphy of the Boreal Mesozoic*. *Trans. Inst. Geol. and Geophys. Acad. Sc. U.S.S.R., Siberian Branch*, 136:83-91.
- MIDDLEMISS, F.A. and RAWSON, P.F., eds. 1971. Faunal Provinces in Space and Time. pp. 1-236. Seel House Press. Liverpool.
- MORTON, N. 1971. Some Bajocian ammonites from Western Scotland. *Palaeontology* 14(2):266-293, pls. 40-51.
- 1972. The Bajocian ammonite *Dorsetensia* in Skye, Scotland. *Palaeontology* 15(3):504-518, pls. 102-105.
- 1975. Bajocian Sonniiniidae and other ammonites from Western Scotland. *Palaeontology* 18(1):41-91, pls. 6-17.
- MOUTERDE et al. 1971. Les Zones du Jurassique en France. *C.R.S. Sci. Soc. Géol. Fr. fasc.* 6, 25 pp.
- UCHOTERLINA, H. 1963. Amonitas del Jurásico Medio y del Caloviano de México. I. *Parastrenoceras* gen. nov. *Paleont. Mexicana* 16:1-26, pls. 1-5.
- 1966. Amonitas del Jurásico Medio de México. II. *Infrapatoceras* gen. nov. *Paleont. Mexicana* 23:1-18, pls. 1-3.

- OECHSLE, E. 1958. Stratigraphie und Ammonitenfauna der Sonninien-Schichten des Filsgebiets unter besonderer Berücksichtigung der Sowerbyi-Zone (Mittlerer Dogger, Württemberg). *Palaeontographica* A11147-129, pls. 10-20.
- PAVIA, G. 1971. Ammoniti del Baiociano superiore di Digne (Francia SE, Dip. Bassos-Alpes). *Soc. Paleont. Italiana Boll.* 10(2):75-142, tav. 13-29.
- QUILTY, P.G. 1970. Jurassic Ammonites from Ellsworth Land, Antarctica. *J. Paleont.* 44(1):110-116, pl. 25.
- KIEBER, H. 1963. Ammoniten und Stratigraphie des Braunjura der Schwäbischen Alb. *Palaeontographica* 122A:1-89, pls. 1-8.
- RUGET-PERROT, C. 1961. Etudes Stratigraphiques sur le Dogger et le Malm Inférieur du Portugal au Nord du Tage. *Serv. Geol. Portugal Mem.* 7:197 pp., pls. I-XI.
- SAPUNOV, I. and NACHEV, I. 1959. Ammonite Fauna of the Jurassic in the Southern part of the Western Section of the Balkan Range. *Trav. Geol. Bulgarie, Ser. Paleont.* I
- SATO, T. 1960. A propos des courants océaniques froids prouvés par l'existence des Ammonites d'Origine Arctique dans le Jurassique Japonais. *Int. Geol. Congr. XXI, pt. XII:165-169.*
- _____ 1962. Etudes Biostratigraphiques des Ammonites du Jurassique du Japon. *Soc. Géol. Fr. Mém.* 94:5-122, pls. I-X.
- _____ 1974. A Jurassic Ammonite from near Inuyama, North of Nagoya. *Trans. Proc. Palaeont. Soc. Japan, NS* 96:427-432.
- _____ 1975. Marine Jurassic Formations and Faunas in Southeast Asia and New Guinea. *Geol. Paleont. SE Asia* XI:151-189.
- SEYED-EMANI, K. 1971. The Jurassic Badami Formation in the Kerma Region, with remarks on the Jurassic Stratigraphy of Iran. *Geol. Surv. Iran Rep.* 19:5-79, pls. 1-15.
- SEYFERT, C.K. and SIRKIN, L.A. 1973. Earth History and Plate Tectonics. pp. 1-504. Harper & Row. New York.
- STURANI, C. 1964a. La Successione delle Faune ad Ammoniti nelle Formazioni Mediogiurassiche delle Prealpi Venete Occidentali. *Ist. Geol. Min. Univ. Padova Mem.* XXIV:3-63, pls. I-VI.
- _____ 1964b. Ammoniti Mediogiurassiche del Veneto. Faune del Baiociano Terminale. *Ist. Geol. Min. Univ. Padova Mem.* XXIV:3-43, pls. I-IV.
- _____ 1971. Ammonites and Stratigraphy of the "Posidonia alpina" beds of the Venetian Alps (Middle Jurassic, mainly Bajocian). *Ist. Geol. Min. Univ. Padova Mem.* XXVIII:3-190, pls. I-XVI.
- TAKAHASHI, H. 1969. Stratigraphy and Ammonite Fauna of the Jurassic System of the Southern Kitakami Massif, North-east Honshu, Japan. *Sci. Rep. Tohoku Univ. Sendai, 2nd Ser. (Geol.)* 41(1):1-93, pls. 1-19.
- THIERRY, J. 1968. Quelques Précisions sur le Callovien de Châtillonnais. *Soc. Geol. Fr. Bull.* (7)X:334-335.
- UHLIG, V. 1911. Die marinen Reiche des Jura und der Unterkreide. *Mitt. Geol. Ges. Wien* 4:329-448.
- VALENTINE, J.W. 1968. Climatic regulation of species diversification and extinction. *Geol. Soc. Am. Bull.* 79:273-276.
- _____ 1973. Evolutionary Paleocology of the Marine Biosphere. pp. xv + 511. Prentice-Hall Inc. New Jersey.
- WATERHOUSE, J.B. and BONIAM-CARTER, G.F. 1975. Global Distribution and Character of Permian Biomes Based on Brachiopod Assemblages. *Can. J. Earth Sci.* 12:1058-1146.
- WENDT, J. 1964. Stratigraphisch-Paläontologische Untersuchungen im Dogger Westsiziliens. *Soc. Pal. Ital. Boll.* 2(1):57-145, Tav. 6-24.
- WESTERMANN, G.E.G. 1956. Monographie der Bajocien-Gattungen Sphaeroceras und Chondroceras (Ammonoidea). *Beihefte Geol. Jb.* 24:139 pp., 14 pls.
- _____ 1964a. The ammonoid fauna of the Kialagvik formation at Wide Bay, Alaska Peninsula, Part I. Lower Bajocian (Aalenian). *Bull. Am. Paleont.* 47(216):325-503, pls. 44-76.
- _____ 1964b. Occurrence and significance of the Arctic *Arkelloceras* in the Middle Bajocian of the Alberta foothills (Ammonitina, Jurassic). *J. Paleont.* 38:405-509.
- _____ 1964c. Sexual-Dimorphism bei Ammonoideen und seine Bedeutung für die Taxonomie der Ooiteidae (einschliesslich Sphaeroceratinae; Ammonitina, M. Jura). *Palaeontographica* 124A:33-73.
- _____ 1967. Middle Jurassic of Germany. In *Lexique Stratigraphique International* 5f2, p. 197.
- _____ 1969a. The ammonoid fauna of the Kialagvik Formation at Wide Bay, Alaska Peninsula. Part II, *Sonninia Sowerbyi* Zone (Bajocian). *Bull. Am. Paleont.* 57(225):225 pp., 47 pls.
- WESTERMANN, G.E.G., ed. 1969b. Sexual dimorphism in fossil Metazoa and taxonomic implications. *Intl. Union Geol. Sci., Ser. A.*, 1:251 pp.
- WESTERMANN, G.E.G. 1975a. Bajocian ammonites of Tethyan affinities from the Kambe Limestone Series of Kenya and implications to plate tectonics. *Newsl. Strat.* 4:23-48.
- _____ 1975b. *Alfeldites* nom. nov. for *Germanites* Westermann, 1954 non Schindewolf, 1929, Jurassic Ammonitina. *J. Paleont.* 49:p. 229.
- WESTERMANN, G.E.G. and GETTY, T.A. 1970. New Middle Jurassic Ammonitina from New Guinea. *Bull. Am. Paleont.* 57(256):227-321, pls. 48-62.
- WESTERMANN, G.E.G. and RICCARDI, A.C. 1972a. Middle Jurassic Ammonoid Fauna and Biochronology of the Argentine-Chilean Andes. Part I: *Hildocerataceae*. *Palaeontographica* 140A:1-116, pls. 1-31.
- _____ 1972b. Ammonites y estratigrafía del Aaleniano-Bajociano en los Andes argentino-chilenos. *Ameghiniana* 9:357-389.
- _____ 1975. Edad y taxonomía del género *Podagrosiceras* Maubeuge et Lambert (Ammonitina, Jurásico medio). *Ameghiniana* 12:242-252.
- ZEISS, A. 1956. *Hectoceras* und *Reinocera* im Mittel- und Ober-Callovien von Blumberg (Südbaden). *Bay. Ak. Wiss. Math. Nat. Kl. Abh. NF* 80:3-101, pls. 1-4.