Some Boreal or Subboreal Ammonites in the Japanese Barremian

(Boreale/Subboreale Ammoniten im Barreme Japans)

1988

IKUWO OBATA, Tokyo & MASAKI MATSUKAWA, Matsuyama

With 4 Text Figures and 1 Table

Obata, I. & Matsukawa, M. (1988): Some Boreal or Subboreal Ammonites in the Japanese Barremian. [Boreale/Subboreale Ammoniten im Barreme Japans.]. *In:* Wiedmann, J. & Kullmann, J. (Eds.), Cephalopods - Present and Past, pp. 469-476. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart.

Abstract: The marine Barremian is well distributed from Hokkaido to Kyushu, from which the Kimigahama, Ishido, and Arida Formations are better studied. They are correlated approximately with the related zones in the stratotypes. Among the Barremian species, only a few can be regarded as so-called Boreal- and Tethyan-derived Subboreal elements (i.e., *Simbirskites, Crioceratites (Paracrioceras),* and *Shasticrioceras*). The faunal resemblance between Japan and other regions is analyzed using Nomura-Simpson, Jaccard and Dice Coefficients and the number of common genera. The distribution of the Boreal or Subboreal ammonites can be explained by the presumed paleocurrent directions along a seaway across part of Siberia during a transgression. Finally, the relationship between oceanic circulation and the distribution of the Tethyan and Boreal or Subboreal representatives is compiled on the Barremian world map.

Kurzfassung: Marines Barreme ist zwischen Hokkaido und Kyushu sehr verbreitet; die Kimigahama-, Ishido- und Arida-Formationen sind die am besten bekannten. Sie können ungefähr mit den entsprechenden Zonen der Stratotypen korreliert werden. Unter den Barreme-Arten können nur wenige als sogenannte subboreale Elemente (mit Boreal- bzw. Tethys-Herkunft) betrachtet werden, z.B. *Simbirskites, Crioceratites (Paracrioceras)* und *Shasticrioceras.*

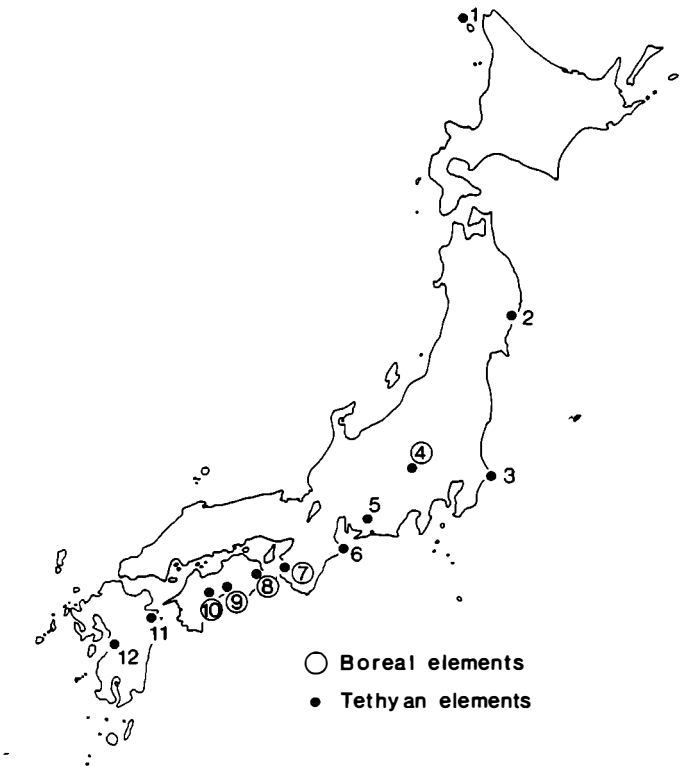
Die Faunenbeziehungen zwischen Japan und anderen Gebieten werden nach den Nomura-Simpson, Jaccard and Dice-Koeffizienten und der Zahl gemeinsamer Gattungen ermittelt.

Die Verteilung von borealen und subborealen Ammoniten wird mit möglichen Paläoströmungen entlang einer Meeresverbindung über Sibirien — während einer Transgression — erklärt. Die sich ergebende Beziehung zwischen der Verbreitung borealer, subborealer und tethydischer Vertreter und Meeresströmungen wird schließlich in einer Weltkarte des Barreme zusammengestellt.

Authors' addresses: Dr. I. Obata, Department of Geology, National Science Museum, 3-23-1 Hyakunincho, Shinjuku-ku, Tokyo 160, Japan. - Dr. M. Matsukawa, Department of Earth Sciences, Ehime University, Bunkyo-cho, Matsuyama 790, Japan.

Introduction

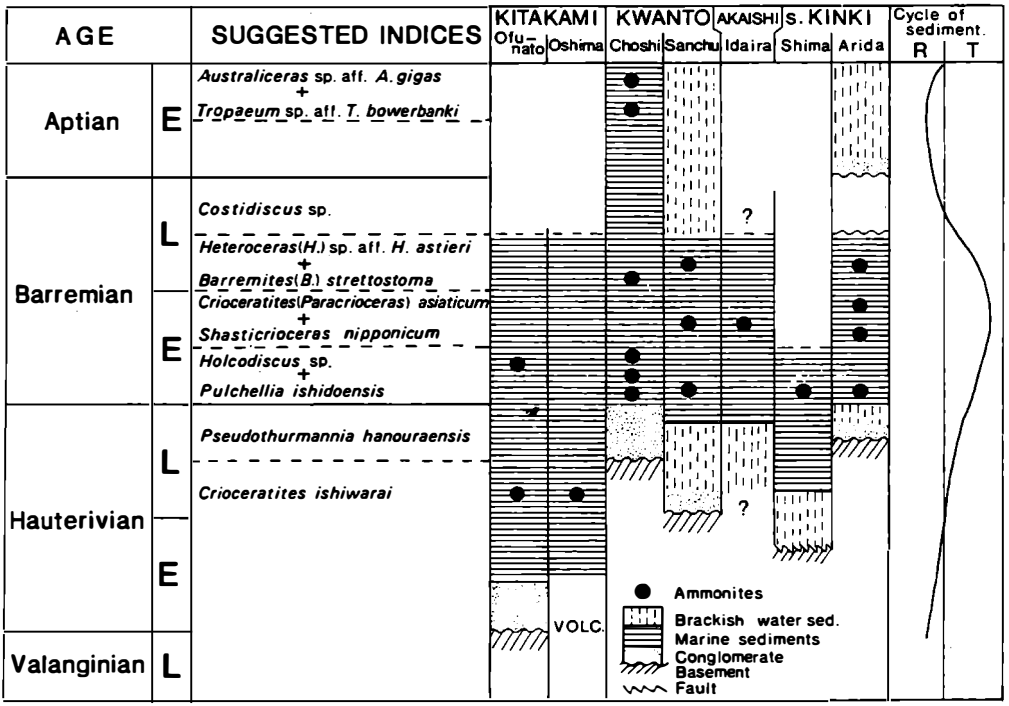
The Lower Cretaceous faunas in Japan are mostly of Tethyan or Submediterranean affinity, but Boreal elements are occasionally intermingled. Among them we know Barremian ammonites from twelve localities in Japan (Text Fig. 1). The marine



1: Rebun, 2: Kitakami, 3: Choshi, 4: Sanchu, 5: Idaira, 6: Shima, 7: Arida, 8: Katsuuragawa, 9: Monobe-Ryoseki, 10: Kochi, 11: Ohita, 12: Yatsushiro

Text Fig. 1. Occurrences of Barremian ammonites in Japan.

Barremian is well distributed from Hokkaido to Kyushu, from which the Kimigahama (Choshi), Ishido (Sanchu), and Arida Formations are better studied (Obata & Ogawa 1976, Obata et al. 1982, Matsukawa 1983). So far 65 ammonite species have been identified, of which 18 are already described (Yabe et al. 1926, Shimizu 1931, Matsumoto 1947, Obata et al. 1976, 1984, Obata & Matsukawa 1984, Matsukawa 1987a, 1987b). A bed with *Pulchellia ishidoensis* - *Barremites difficile*, one with *Shasticrioceras nipponicum* - *Crioceratites (Paracrioceras) asiaticum,* and one with *Heteroceras* aff. *H. astieri* - *Barremites strettostoma* (in ascending order) are correlated approximately with related zones in the stratotypes of Europe, although better palaeontologic descriptions are necessary (Text Fig. 2).



Text Fig. 2. Suggested indices of Barremian ammonites and their occurrences at selected areas in Japan.

Discussion

Among the 65 Japanese species only a few can be regarded as the so-called Boreal- and Tethyan-derived Subboreal elements. The first step taken in answering the question of their derivation and migration routes was to analyze the faunal relationship between Japan and other regions (Table 1). The table shows faunal resemblances in the Barremian on the basis of Nomura-Simpson, Jaccard and Dice Coefficients and the number of common genera. The result is that the Japanese fauna bear the greatest resemblance to Californian and Silesian faunas, and then to Colombian and French ones. The Californian and Colombian faunas resemble that in the French stratotype, while the faunal composition of the Pacific side of Arctic Canada greatly resembles the Boreal side. In other words, the Barremian faunas in the Circum Pacific region are interpreted here as consisting of Tethyan- and Boreal-derived elements, instead of endemic elements from the Circum Pacific region.

Simbirskites was formerly thought to represent the last perisphinctacean and to have died out at the end of the Hauterivian (Rawson 1971a, 1971b). Recently, the occurrence at Speeton of *Crioceratites (Paracrioceras) spathi* at the base of the Simbirskites variabilis Zone was interpreted as suggesting that this zone (and the

Table 1. Faunal resemblance between Japan and other regions in the Barremian.
Faunal resemblance in the Barremian on the basis of Nomura- Simpson (S_{NS}), Jaccard (S_J) and Dice (S) Coefficients and the number of common genera.

● very high degree
$S_{NS} \geq 0.700$
$S_J \geq 0.350$
$S \geq 0.450$
▲ high degree
$S_{NS} \geq 0.500$
$S_J \geq 0.300$
$S \geq 0.400$

		Number of geneta	Yorkshire	Hannover	Silesia	Stratotype	Bulgaria	N.Caucasus & Crimea	Madagascar	Arctic Canada (Boreal)	Arctic Canada (Pacific)	California	Colombia	Japan	
Yorkshire	B	4		3	0	0	1	0	0	1	2	0	0	1	Spath(1924), Rawson (1971a, b)
Hannover	B	13	●		4	1	3	1	0	2	3	3	2	6	Koenen(1902)
Silesia	T	32				19	16	13	2	1	6	10	6	17	Uhlig(1883)
Stratotype	T	29			●		16	13	2	2	7	12	7	16	Busnardo(1965)
Bulgaria	T	37			●	●		17	3	3	8	10	6	14	Dimitrova (1967)
N.Caucasus & Crimea	T	27			▲	●	●		2	1	5	6	5	11	Drushchitz & Kudryavtseva(1960)
Madagascar	I	3			▲	▲	●			0	1	2	0	0	Collignon(1962)
Arctic Canada (Boreal)	B	6					▲				5	3	1	3	Jeletzky(1971)
Arctic Canada (Pacific)	C	17	▲							●		7	2	8	Jeletzky(1971)
California	C	15			▲	●	▲			▲	▲		3	11	Murphy(1975)
Colombia	C	13				▲								7	Bürgl(1954)
Japan	C	37			●	▲						●	▲		This study

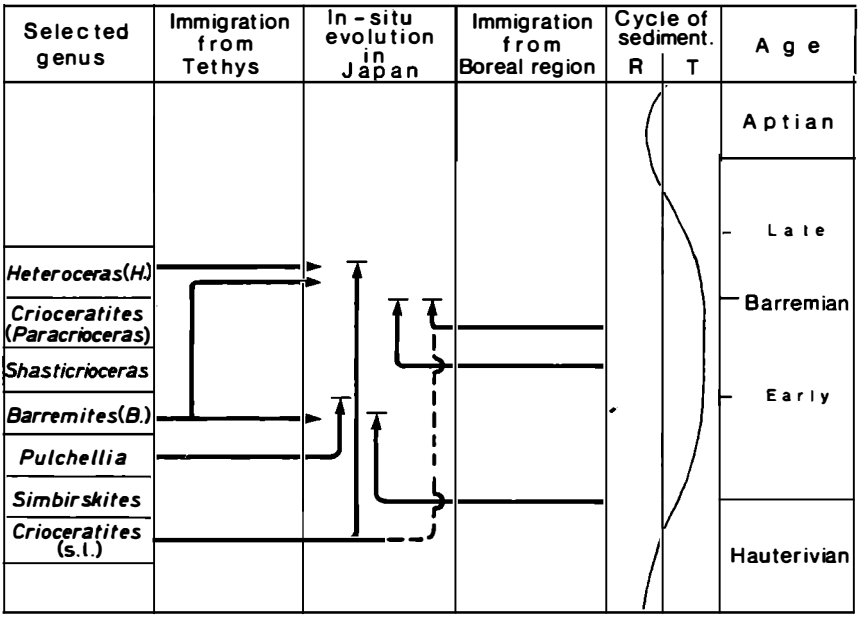
B Boreal region; T Tethyan region; I Indo-Madagascar region; C Circum Pacific region

upper part of the German Discofalcatus Zone) is already from the earliest Barremian, since *P. spathi* has the characteristic looped ribs of "*Emericiceras*" from the lowest Barremian of the Tethys (Kemper et al. 1981). Furthermore, faunal mixing in northwestern Europe shows that the base of the Tethyan Upper Hauterivian correlates with the upper part of the Simbirskites (Speetoniceras) inversum Zone (Kemper et al. 1981, Rawson 1983). On the other hand, the Japanese *Simbirskites (Milanowskia)* sp. is associated with *Pulchellia ishidoensis* at the same locality (Obata et al. 1984). According to Matsukawa (1987b), *Simbirskites (Milanowskia)* sp. is considered an example of the latest surviving relicts from the Hauterivian, which possibly migrated from the Boreal Sea via northeastern Siberia. It is essential for us to seek more specimens. *Crioceratites (Paracrioceras)* and *Shasticrioceras* occur rather frequently in the Barremian of southwestern Japan (e.g., Obata & Ogawa 1976), and they may represent other examples of Subboreal elements, which existed on a southern shelf sea extension from the so-called Boreal Sea. *Crioceratites (Paracrioceras)* is known from Speeton and northern Germany. *Shasticrioceras* occurs from California and Arctic Canada to Bulgaria, even if we exclude (as Murphy [1975] suggests) *S. anglicum* from the Lower Hauterivian at Speeton (Doyle 1963).

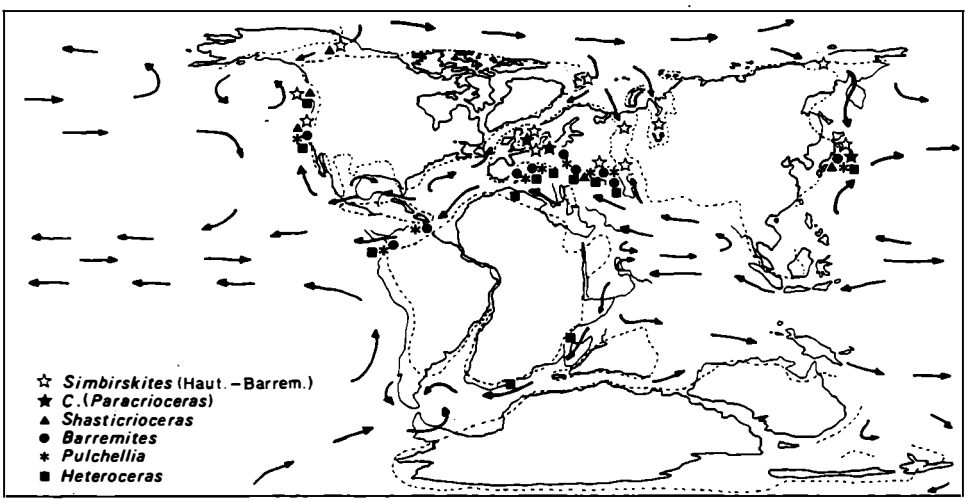
In the Early Cretaceous, the Arctic Ocean was larger than it is now, and its cool water presumably circulated in a counter-clockwise direction around the North Pole

under the influence of westerly winds at those latitudes (Gordon 1973). Communication between the Arctic Ocean and the tropical seaway was restricted for much of the Early Cretaceous. In Europe, ammonites in eastern England and northern Germany show a connection in Neocomian time between these areas and the Arctic Ocean, as was already mentioned. There is more evidence of a link between the Arctic Ocean and the Tethys during the Hauterivian in the Crimea and Caucasus regions. According to Jeletzky (1970), a strait situated along the Alaska-Yukon border connected the Arctic Ocean with the Pacific from the Berriasian to the Barremian. There was a shallow seaway, via the Anyuy synclinal zone, which connected the Arctic with the Pacific before the Albian (Matsumoto 1978). The current direction along this seaway (crossing northeastern Siberia) was presumably southward. Cool water from the Arctic Ocean would presumably have moved south wherever a suitable channel was available (Gordon 1973), being deflected to the right due to the coriolis force. Thus, the distribution of Boreal or Subboreal ammonites in the Barremian in southwestern Japan can be explained by the presumed paleocurrent directions.

The zonal sequences for the northwestern Pacific (Text Fig. 2) are based on a group of genera which dominated the faunas at successive periods of time: the change from one genus to another is sometimes an evolutionary progression but is usually a sharp break reflecting immigration. The majority of genera are of Tethyan origin, but some are derived from the Boreal Sea. The probable origin of the selected genera is shown in Text Fig. 3. In the earliest Barremian, *Simbirskites* species, a Boreal element, is found in southwestern Japan as small, short-lived populations which are probably related to the beginning of a transgression. The main part of the Valanginian and Lower Hauterivian are free from ammonites and are generally represented by non-marine beds or by an unconformity (Matsumoto et al. 1985). *Crioceratites (Paracrioceras)* suddenly expanded in number in both northwestern Europe and Japan, while *Shasticrioceras* increased in Japan and California. Both genera (or subgenera) represent Subboreal elements, and their distribution in southwestern Japan is related to the maximum transgression in the Middle Barremian. The replacement of Tethyan genera by Subboreal forms reflects the probability that environmental conditions there suited Subboreal faunas more than Tethyan ones. In conclusion, the distribution of some Barremian ammonites is closely related to the presumed paleocurrent directions around Japan. They probably migrated via the currents as planktonic ammonitella, because the most effective stage for dispersal would have been immediately after hatching in the juvenile stage or in the nektonic or planktonic stage (Wiedmann et al. 1978, Klinger et al. 1984). Thus we are inclined to consider that during the Barremian there was Boreal or Subboreal influence in southern Japan; however, the alternative possibility is that the Japanese lineage of the *Crioceratites nolani* and *duvali* group (e.g., *Crioceratites ishiwarai*) in the mid-Hauterivian, developed into the *"Emericiceras" emerici* group in the lower Barremian, which in turn developed into the *Crioceratites (Paracrioceras) asiaticum* group via convergent development with the European lineage (Rawson 1975, Kemper et al. 1981). The Barremian basins of Japan were connected to both the Tethys to the south and the Boreal Ocean to the north. Their ammonite faunas were predominantly of tropical or subtropical



Text Fig. 3. Probable origin of the genera represented in Japan.



Oceanic circulation adapted from Gordon(1973) & Klinger et al.(1984); continental position after Smith, Hurley & Briden(1981); coastlines compiled from Harrington(1962), Jeletzky(1970), Kauffman(1973), & Ziegler(1982)

Text Fig. 4. Barremian world map which shows the relationship between oceanic circulation and the global distribution of some Tethyan and Boreal or Subboreal representatives.

Tethyan elements, but there was Boreal influence during the maximum transgression in the mid-Barremian.

Finally, we attempt to compile the relationship between Barremian oceanic circulation and the distribution of Tethyan and Boreal or Subboreal representative (Text Fig. 4). The outstanding feature of Barremian oceanic circulation was the equatorial current system flowing through the Tethys Sea and across the central Pacific Ocean in a circumglobal band of warm water, with its own characteristic fauna (Gordon 1973). In Text Fig. 4, the geographic separation and faunal distinctiveness of the Arctic and Tethys Seas during the Hauterivian and Barremian are exemplified by six groups of ammonoids. Of these, *Simbirskites* is typical of the Boreal Sea, while *Crioceratites (Paracrioceras)* and *Shasticrioceras* are representatives of the Subboreal areas; *Barremites, Pulchellia,* and *Heteroceras* typify the Tethyan region. Circulation in the northern Pacific Ocean during the Hauterivian and Barremian was dominated by a clockwise gyre, with a warm Kuroshio Current flowing north on its western margin where *Barremites, Pulchellia,* and *Heteroceras* thrived, and a cool California Current flowing south on the eastern margin where *Simbirskites* and *Shasticrioceras* were successful. There must have been a powerful, uninterrupted westward flow of warm water around the globe, and the warm Tethyan currents must have been deflected well into the Northern Hemisphere in the area of present-day Europe by the northward bulge of the Africa-Arabia landmass (Gordon 1973). This would account for the south European and north African occurrences of *Barremites, Pulchellia* and other Tethyan ammonites. A northward flow of warm water along the west coast of North America passing through the Tethys may have reached northern California, where *Barremites, Pulchellia,* and *Heteroceras* occur. The southward extension of the Tethyan Faunal Realm along the east coast of Africa during the Cretaceous is a well-known fact (Gordon 1973). Describing the Upper Barremian heteroceratid ammonites from South Africa and the Caucasus, Klinger et al. (1984) pointed out that faunal similarities between southern Africa and the Caucasian part of the Tethys are too striking to be merely coincidental and that they indicate a fully marine connection between these regions during the Upper Barremian. They also noted the faunal affinity between the heteroceratids of southern Patagonia and southern and eastern Africa, mentioning that at the generic level *Colchidites* can be traced all the way from the Tethys along the east coast of Africa down to Patagonia. Thus it appears that oceanic circulation patterns, as described by Gordon (1973), can explain the existence of some Boreal or Subboreal ammonites in the Japanese Barremian (Text Fig. 4).

Literature

Doyle, J.C. (1963): A new heteromorph ammonite from the Lower Cretaceous of Yorkshire. - *Palaeontology, 3:* 575-578.

Gordon, W.A. (1973): Marine life and ocean surface current in the Cretaceous. - *J. Geol., 81:* 269-284.

Harrington, H.J. (1962): Paleogeographic development of South America. - *Bull. Amer. Ass. Petr. Geol., 46:* 1773-1814.

Jeletzky, J.A. (1970): Cretaceous macrofaunas. *In* Douglas, R.J.W., (ed.), Geology and economic minerals of Canada. - *Canada Geol. Surv. Econ. Geol. Rept. 1:* 649-662.

Kauffman, E.G. (1973): Cretaceous bivalves. *In* Hallam, A. ed., Atlas of Paleobiogeography, 353-383, Amsterdam (Elsevier).

Kemper, E., Rawson, P.F. & Thieuloy, J.P. (1981): Ammonites of Tethyan ancestry in the early Lower Cretaceous of north-west Europe. - *Palaeontology, 24:* 251-311.

Klinger, H.C., Kakabadze, M.V. & Kennedy, W.J. (1984): Upper Barremian (Cretaceous) heteroceratid ammonites from South Africa and the Caucasus and their palaeobiogeographic significance. - *J. Moll. Stud., 50:* 43-60.

Matsukawa, M. (1983): Stratigraphy and sedimentary environments of the Sanchu Cretaceous, Japan. - *Mem. Ehime Univ., 9:* 1-50.

— (1987a): Early shell morphology of *Karsteniceras* (ancyloceratid) from the Lower Cretaceous Choshi Group, Japan and its significance to the phylogeny of Cretaceous heteromorph ammonites. - *Trans. Proc. palaeont. Soc. Japan, N.S.* (in prep.).

— (1987b): Barremian ammonites from the Ishido Formation, Japan — supplements and faunal analysis. - *Ibid.* (in prep.).

Matsumoto, T. (1947): On some interesting ammonites from the Paleocretaceous of the Yuasa district, South-West Japan. - *Sci. Rep. Fac. Kyushu Univ., (Geol.) 2:* 13-18. (In Japanese).

— (1978): Japan and adjoining areas. *In* Moullade, M. & Nairn, A.E.M. (eds.), The Phanerozoic Geology of the World, II. The Mesozoic, A. Chapt. 4, p. 79-144, Amsterdam (Elsevier).

Matsumoto, T., Obata, I., & Hirano, H. (1985): Mega-fossil zonation of the Cretaceous System in Japan and correlation with the standards in Western Europe. - *Mem. geol. Soc. Japan, 26:* 29-42. (In Japanese with English abstract.)

Murphy, M.A. (1975): Paleontology and stratigraphy of the Lower Chickabally Mudstone (Barremian-Aptian) in the Ono Quadrangle, northern California. - *Univ. Calif. Publ. geol. Sci., 113:* 52 p.

Obata, I., Maiya, S., Inoue, Y. & Matsukawa, M. (1982): Integrated mega- and micro-fossil biostratigraphy of the Lower Cretaceous Choshi Group, Japan. - *Bull. natn. Sci. Mus., Tokyo, (C) 8:* 145-179.

Obata, I. & Matsukawa, M. (1984): A Barremian occurrence of an olcostephanid, a perisphinctacean ammonite, from the Choshi Group, Japan. - *Ibid., 10:* 169-180.

Obata, I., Matsukawa, M., Tanaka, K., Kanai, Y. & Watanabe, T. (1984): Cretaceous cephalopods from the Sanchu area, Japan. - *Ibid., 10:* 9-37.

Obata, I., Matsukawa, M., Tsuda, H., Futakami, M. & Ogawa, Y. (1976): Geological age of the Cretaceous Ishido Formation, Japan. - *Ibid., 2:* 121-138.

Obata, I. & Ogawa, Y. (1976): Ammonites biostratigraphy of the Cretaceous Arida Formation, Wakayama Prefecture. - *Ibid. 2:* 93-110. (In Japanese with English abstract).

Rawson, P.F. (1971a): Lower Cretaceous ammonites from north-east England; the Hauterivian genus *Simbirskites. - Bull. brit. Mus. nat. Hist., (Geol.) 5:* 27-86.

— (1971b): The Hauterivian (Lower Cretaceous) biostratigraphy of the Speeton Clay of Yorkshire, England. - *Nwesl. Stratigr., 5:* 61-75.

— (1975): The interpretation of the Lower Cretaceous heteromorph ammonite genera *Paracrioceras* and *Hoplocrioceras* Spath, 1924. - *Palaeontology, 18:* 275-283.

— (1983): The Valanginian to Aptian stages-current definitions and outstanding problems. - *Zitteliana, 10:* 493-500.

Shimizu, S. (1931): The marine Lower Cretaceous deposits of Japan, with special reference to the ammonite-bearing zones. - *Sci. Rep. Tohoku Imp. Univ., [2], 15:* 1-40.

Smith, A.G., Hurley, A.M. & Briden, J.C. (1981): Phanerozoic paleocontinental world maps. Cambridge Univ. Press. 1-102.

Wiedmann, J., Einsele, G. & Immel, H. (1978): Evidence faunistique et Sédimentologique pour un upwelling dans le Crétacé Supérieur. - *Actes 6ème Coll. afr. Micropaléontol., Tunis 1974; Ann. Mines Géol., 28/2:* 415-441.

Yabe, H., Nagao, T. & Shimizu, S. (1926): Cretaceous mollusca from the Sanchu Graben in the Kwanto Mountainland, Japan. - *Sci. Rep. Tohoku Imp. Univ., [2], 9:* 33-76.

Ziegler, P.A. (1982): Geological Atlas of western and central Europe. 130 p., 40 figs. - *Shell Intern. Petrol. Maatschap. B.V.*