

Discovery of the Middle Triassic ammonoid *Balatonites* in the Quy Lang Formation, Thanh Hoa Province, Central Vietnam

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Abstract. The discovery of *Balatonites* sp. in the lower part of the Quy Lang Formation in the Lang Nuoc area, Thanh Hoa Province, Central Vietnam establishes that this portion of the formation is of late Middle Anisian age. This ammonoid's cooccurrence with *Costatoria goldfussi mansuyi* and *Trigonodus tonkinensis* suggests that this widely distributed bivalve assemblage in Asian shallow marine facies is at least partly of late Middle Anisian age, and its discovery may provide an important key for the establishment of a precise biostratigraphic framework for the Middle Triassic of Asia.

Key words: Anisian, *Balatonites*, Quy Lang Formation, Triassic, Vietnam

Introduction

The Superfamily Ceratitoidea is very characteristic of Middle Triassic ammonoid faunas, and it includes strongly ornamented or tuberculate taxa, most of which show a narrow or restricted stratigraphic range and a relatively broad geographical distribution. For this reason, they are regarded as ideal taxa for precise biostratigraphic correlation of the Middle Triassic (Tozer, 1971, 1981b).

Middle Triassic deposits in the Sam Nua Basin are widely distributed in Central Vietnam and northern Laos (Dang, 2006). However, the rarity of ammonoids in these deposits has precluded the establishment of a precise biostratigraphic correlation for the Middle Triassic of this area. We have recently discovered a specimen referable to *Balatonites* in the Lang Nuoc area, Thanh Hoa Province, Central Vietnam. The specimen is described herein and we discuss its importance for biostratigraphic correlation.

Notes on stratigraphy

Middle Triassic deposits are widely distributed in the Thanh Hoa and Nghe An provinces of Central Vietnam as well as in northern Laos. They are divided into three formations, the Dong Trau, Hoang Mai, and Quy Lang formations in ascending order (Dang, 2006). The 1,000 to 3,000 m-thick Dong Trau Formation, which is composed mainly of rhyolitic volcanic and siliciclastic rocks, contains the Middle Anisian ammonoids *Balatonites balatonicus* (Mojsisovics), *Balatonites* sp. and *Acrochordiceras* sp. in a sandstone and mudstone facies. Calcareous rocks are dominant in the overlying 200 to 500-m-thick Hoang Mai Formation, and they contain abundant bivalves as well as an Anisian foraminifer assemblage.

The 400 to 1,200-m-thick Quy Lang Formation consists mainly of mudstone, sandstone, conglomerate and calcareous rocks. Its lower part is composed of very fine- to fine-grained sandstone and thick mudstone, which intercalate with limestone and marl beds. An ammonoid assignable to *Bala-*

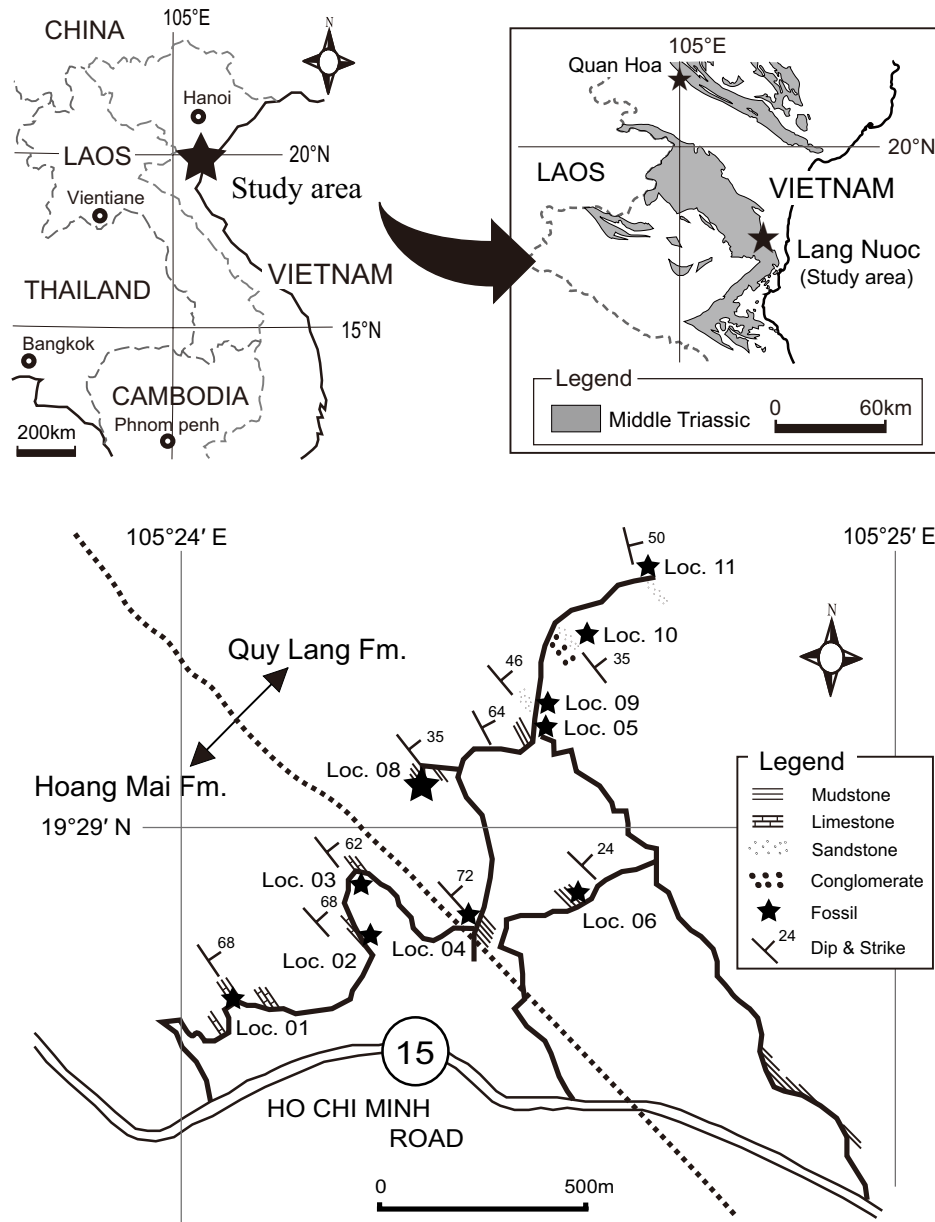


Figure 1. Index maps showing the locality from which *Balatonites* sp. was collected.

tonites sp. was obtained from the lower part of the formation at the Lang Nuoc-Bao Tre Mountain Section in southern Thanh Hoa Province (hypostratotype as reported by Dang in 2006) (Figure 1). This horizon also yields abundant bivalves such as *Costatoria goldfussi mansuyi* (Hsü), *C. ngeanensis* Vu Khuc, *C. quinquicostata* Kobayashi and Tamura, *C. paucicostata* (Vu Khuc), *Trigonodus tonkinensis* (Mansuy), *Entolium tridentini* Bittner, *Langsonella minima* Vu Khuc, *Hoernesia magnissima* Vu Khuc and Trinh Tho and *Pteria* sp. (Figure 2).

Paleontological description

Morphological terms in the systematic description are those used in the Treatise on Invertebrate Paleontology (Moore, 1957). Quantifiers used to describe the shape of ammonoid shell replicate those proposed by Matsumoto (1954, p. 246) and modified by Haggart (1989, table 8.1).

Abbreviations for shell dimensions.—D = shell diameter; U = umbilical diameter; H = whorl height; W = whorl width.

Institution abbreviations.—KMSF = Faculty of Science,

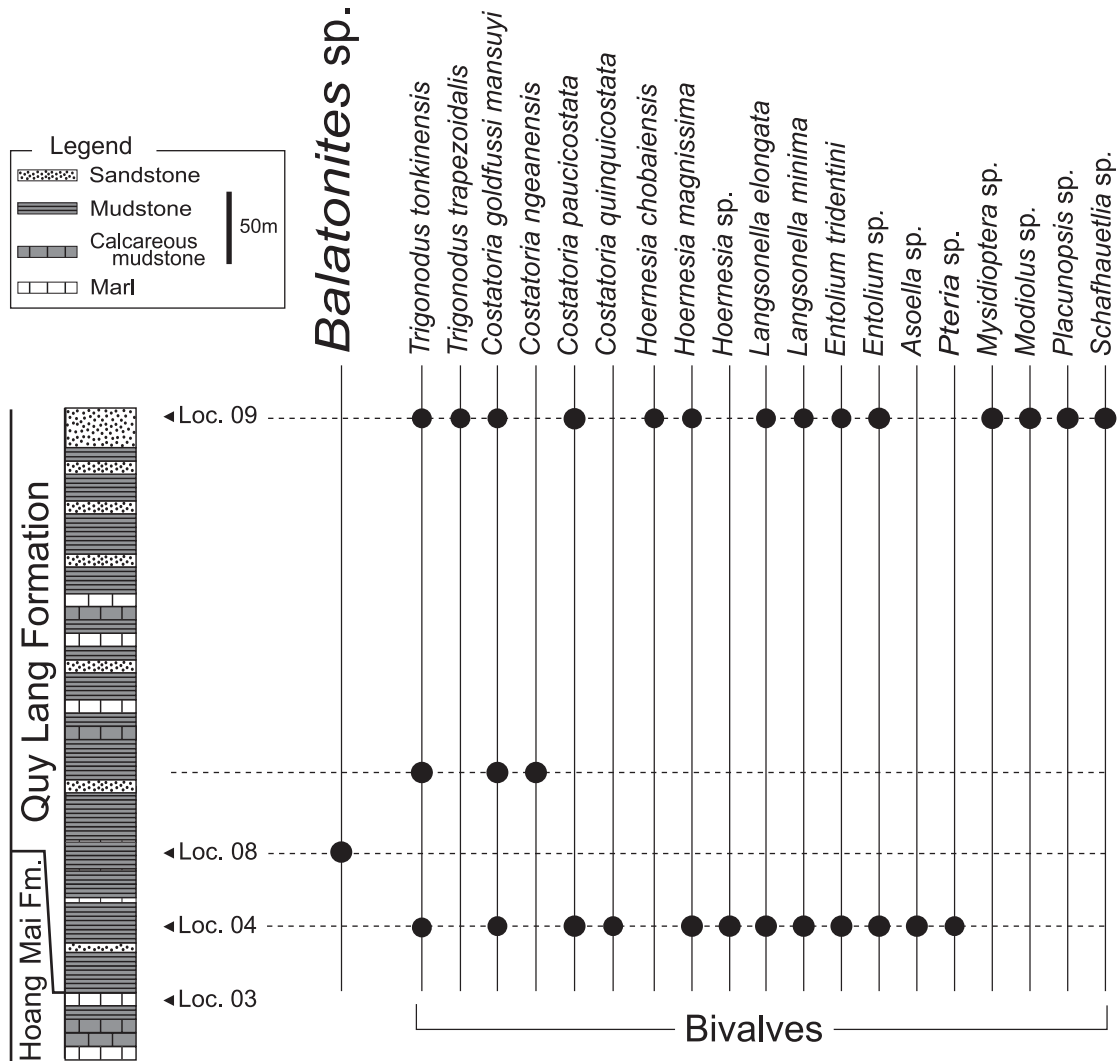


Figure 2. Columnar section of the Quy Lang Formation in the Lang Nuoc area, Thanh Hoa Province, Central Vietnam, showing stratigraphic occurrences of bivalves and *Balatonites* sp.

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Order Ceratitida Hyatt, 1884
 Superfamily Ceratitoidea Mojsisovics, 1879
 Family Balatonitidae Spath, 1951
 Genus *Balatonites* Mojsisovics, 1879

Type species.—*Trachyceras balatonicum* Mojsisovics, 1873.

Discussion.—In excess of 40 species have been assigned to the taxon *Balatonites* since it was first erected (Mojsisovics, 1873). This excessively large number of names reflects the typological species concept, which is based on minimal morphological differences. Morphometric studies by Hohenegger and Tatzreiter (1992) revealed that *Bala-*

tonites from Austria and Hungary exhibit a wide variation in shell morphology and ornamentation, and they pointed out that the more than 10 species described by Arthaber (1896) must be regarded as synonymous with *Balatonites egregius* Arthaber, 1896. However, the intraspecific variation of *Balatonites* described from other regions has not been fully studied, and, likewise, the validity of the various species assigned to it has not been fully addressed.

Occurrence.—Late Middle Anisian in the Alps and adjacent regions (Mojsisovics, 1873; Arthaber, 1896; Hohenegger and Tatzreiter, 1992), Nevada, U.S.A. (Hyatt and Smith, 1905; Bucher, 1992; Monnet and Bucher, 2005), South Primorye (Kiparisova, 1961; Zakharov, 1968), northern Japan (Mojsisovics, 1888, Diener, 1915; Shimizu, 1930; Bando, 1964), Yunnan, China (Patte, 1922), Thailand (Kummel,

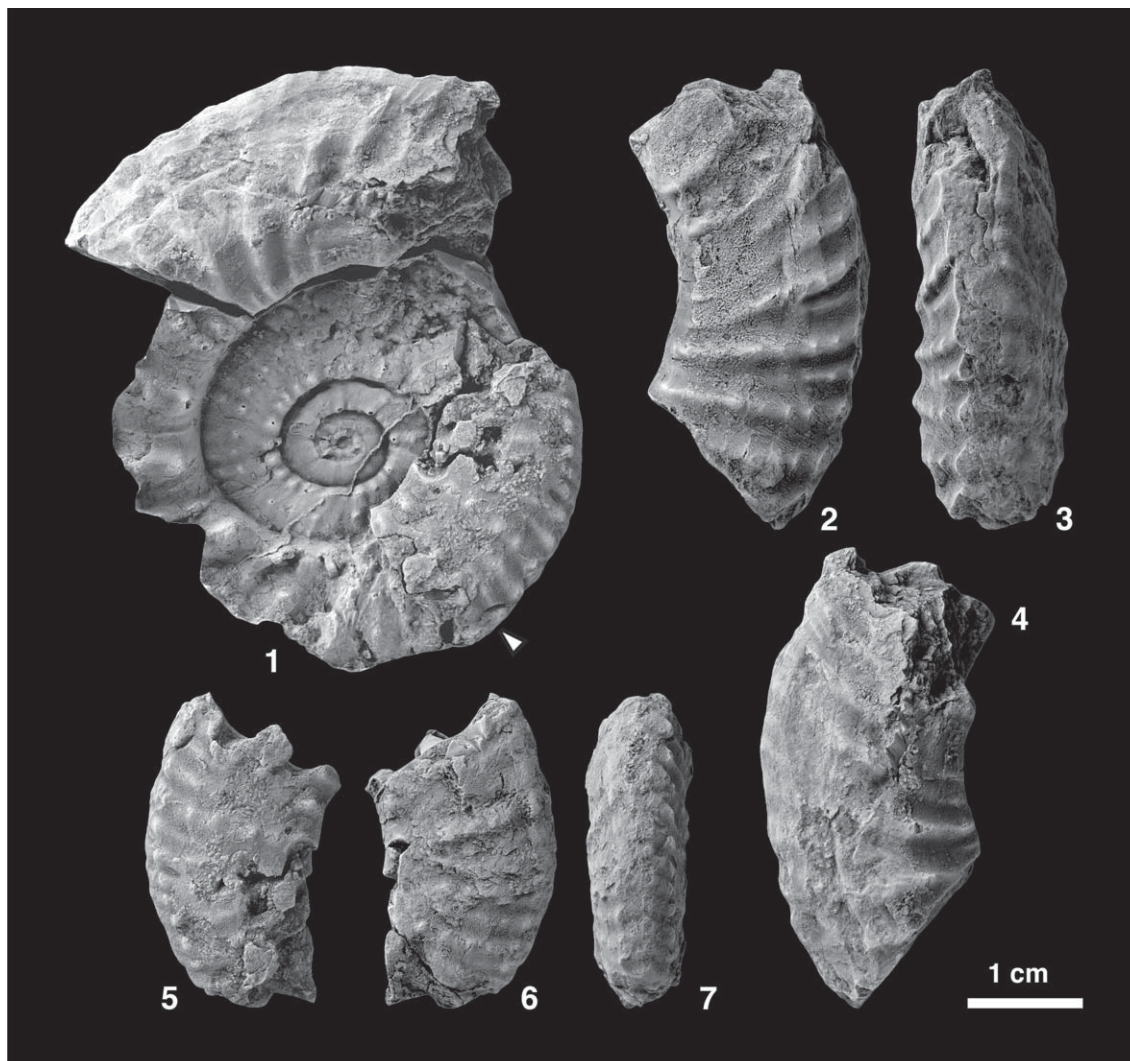


Figure 3. *Balatonites* sp. 1–7. KMS5100, from loc. 08 in the Lang Nuoc area, Thanh Hoa Province, Central Vietnam. The rear part of the body chamber and most of the inner whorls were made with a silicon rubber cast of the outer mold. White arrow indicates position of last septum.

1960), and Vietnam (Mansuy, 1913; Dang, 2006).

***Balatonites* sp.**

Figures 3, 4

Material examined.—KMS5100 was collected from mudstone in the lower part of the Quy Lang Formation at Loc. 08 in the Lang Nuoc area, Thanh Hoa Province, Central Vietnam (19°29'10"N, 105°24'20"E). The specimen consists of the phragmocone and a part of the body chamber. Its inner whorls and the inner flank part of the rear portion of its body chamber are preserved only as an outer mold.

Description.—Very evolute, fairly compressed shell with fastigate venter and slightly convex flanks with maximum thickness at mid-flank. Umbilicus moderately shallow with

low, oblique wall and rounded shoulders. Whorls of last part of phragmocone (35 to 40 mm diameter) ornamented with prorsiradiate major and intercalatory ribs. Each rib has spinose ventrolateral and clavate ventral tubercles, while the major ribs possess an additional four rows of tubercles located at the umbilical shoulder, slightly below mid-flank, mid-flank, and slightly above mid-flank. Preserved portion of body chamber represents about 240° in spiral length. Ribs on body chamber become more distant, with small, numerous tubercles on outer flank. Suture ceratitic. First lateral lobe deep, wide with three strong denticulations at base. Second lateral lobe shallower than first lobe.

Measurements.—Taken at D = 52.5 mm of KMS5100, U = 19.8 mm, H = 18.2 mm, W = 14.0 mm, U/D = 0.38, W/H = 0.77.



Figure 4. Suture line of *Balatonites* sp. (H = 15 mm), KMSP5100, from loc. 08 in the Lang Nuoc area, Thanh Hoa Province, Central Vietnam. Arrow and broken line indicate the positions of siphuncle and umbilical shoulder, respectively.

Remarks.—Even though the present specimen is fragmental, its distinctive features enable us to assign it with reasonable confidence to the genus *Balatonites*. Our specimen is close to *Balatonites* sp. 1 described by Kummel (1960, p. 692) from Thailand, and it is also somewhat similar to the specimen described as *B. egregius* by Hohenegger and Tatzreiter (1992, Fig. 19-12, 13), which also has numerous small tubercles on its outer flank. However, we decline to make a definitive species assignment because we lack the large number of specimens required to adequately demonstrate variation in shell form and ornamentation.

Discussion

The Quy Lang Formation yields abundant shallow marine bivalves such as *Costatoria goldfussi mansuyi* and *Trigonodus tonkinensis*. These same bivalve species also occur abundantly in the Na Khuat Formation of Ladinian age in northern Vietnam. Based on this evidence, Dang (2006) and Dang *et al.* (2008) considered the Quy Lang Formation to also be of Ladinian age.

Since *Balatonites* is one of the more important low-paleolatitude age-diagnostic genera of the late Middle Anisian (Tozer, 1971, 1981a), its occurrence in the lower part of the Quy Lang Formation in the Lang Nuoc area demonstrates that this particular horizon is late Middle Anisian age. Late Middle Anisian ammonoids have also been reported from the Dong Trau Formation in the Quan Hoa area of northwestern Thanh Hoa Province (Vu Khuc, 1984, 1991). Although this formation is below the Quy Lang and Hoang Mai Formations, the distance between each area is about 120 km. These lines of evidence suggest that both late Middle Anisian ammonoid-bearing horizons are contemporaneous.

Bivalves *Costatoria goldfussi mansuyi* and *Trigonodus tonkinensis* have been regarded as significant fossils for regional correlation since they are widely distributed in Asian shallow-marine facies that rarely yield age-diagnostic ammonoid and conodont species (Gu *et al.*, 1976; Sha *et al.*, 1990; Vu Khuc, 1991; Chonglakmani and Grant-Mackie, 1993; Dang, 2006; Komatsu *et al.*, 2010). Because of the

complex tectonic setting of Vietnam, the tectonostratigraphic framework still remains unclear. However, cooccurrence of these characteristic bivalves and *Balatonites* sp. suggests that the age of this bivalve assemblage includes the late Middle Anisian, and the discovery of this ammonoid may provide an important key for the establishment of a precise biostratigraphic framework for the Middle Triassic coastal sandy facies of Asia.

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References

- Arthaber, G. v., 1896: Die Cephalopodenfauna der Reiflinger Kalke. *Beiträge zur Paläontologie und Geologie Österreich-Ungarns und des Orients*, Bd. 10, p. 1–112, 192–242.
- Bando, Y., 1964: The Triassic stratigraphy and ammonite fauna of Japan. *Science Report of the Tohoku University, 2nd Series (Geology)*, vol. 36, p. 1–137.
- Bucher, H., 1992: Ammonoids of the *Shoshonensis* Zone (Middle Anisian, Middle Triassic) from northwestern Nevada (USA). *Jahrbuch der geologischen Bundesanstalt*, Bd. 135, p. 425–465.
- Chonglakmani, C. and Grant-Mackie, J. A., 1993: Biostratigraphy and facies variation of the marine Triassic sequences in Thailand. *International Symposium on Biostratigraphy of Mainland Southeast Asia: Facies and Paleontology*, p. 97–123. Chiang Mai University, Chiang Mai.
- Dang, T. H., 2006: Mesozoic. In, Tong, D. T. and Vu Khuc eds., *Stratigraphic Units of Vietnam*, p. 245–366. Vietnam National University Publishing House, Hanoi.
- Dang, T. H., Nguyen, D. H. and Komatsu, T., 2008: Fossil zones and stratigraphic correlation of the Middle Triassic sediments of East Bac Bo. *Journal of Geology, Series A*, no. 308, p. 1–8.
- Diener, C., 1915: Japanische Triasfaunen. *Denkschriften der Akademie der Wissenschaften in Wien*, Bd. 92, p. 1–30.
- Gu, Z., Huang, B. and Chen, C., 1976: *Fossil Lamellibranchiata of China*, 522 p. Science Press, Beijing. (in Chinese)
- Haggart, J. W., 1989: New and revised ammonites from the Upper Cretaceous Nanaimo Group of British Columbia and Washington State. *Geological Survey of Canada Bulletin*, vol. 396, p. 181–221.
- Hohenegger, J. and Tatzreiter, F., 1992: Morphometric methods in determination of ammonite species, exemplified through *Balatonites* shells (Middle Triassic). *Journal of Paleontology*, vol. 66, p. 801–816.
- Hyatt, A., 1884: Genera of fossil cephalopods. *Proceedings of the Boston*

- Society of Natural History*, vol. 22, p. 253–338.
- Hyatt, A. and Smith, J. P., 1905: The Triassic cephalopod genera of America. *Geological Survey Professional Paper*, vol. 40, p. 1–394.
- Kiparisova, L. D., 1961: Paleontologicheskoe obosnovanie stratigrafii triasovykh otlozhenij primorskogo kraja. 1. Golovonogiye molluski (Paleontological fundamentals for the stratigraphy of Triassic deposits of Primorye region. 1. Cephalopod Mollusca). *Trudy Vsesoyuznogo Nauchno-isslyedovatel'skogo Geologicheskogo Instituta (VSEGEI), Novaya Seriya*, vol. 48, p. 1–278. (in Russian)
- Komatsu, T., Dang, T. H. and Nguyen, D. H., 2010: Radiation of Middle Triassic bivalve: Bivalve assemblages characterized by infaunal and semi-infaunal burrowers in a storm- and wave-dominated shelf, An Chau Basin, North Vietnam. *Palaeogeography, Palaeoclimatology, Palaeoecology*, vol. 291, 190–204.
- Kummel, B., 1960: Triassic ammonoids from Thailand. *Journal of Paleontology*, vol. 34, p. 682–694.
- Mansuy, H., 1913: Paléontologie de l'Annam et du Tonkin. *Mémoires du Service géologique de l'Indochine*, vol. 2, p. 1–49.
- Matsumoto, T., 1954: *The Cretaceous System in the Japanese Islands*, 324 p. Japan Society for the Promotion of Science, Tokyo.
- Mojsisovics, E. v., 1873: Über einige Trias-Versteinerungen aus den Süd-Alpen. *Jahrbuch der Geologischen Reichsanstalt Wien*, Bd. 23, p. 425–438.
- Mojsisovics, E. v., 1879: Vorläufige kurze Übersicht der Ammoniten-Gattungen der mediterranen und juvavischen Trias. *Verhandlungen der geologischen Reichsanstalt Wien, Jahrgang 1879*, p. 133–143.
- Mojsisovics, E. v., 1888: Über einige japanische Trias-Fossilien. *Beiträge zur Paläontologie Österreich-Ungarns und des Orients*, Bd. 7, p. 163–178.
- Monnet, C. and Bucher, H., 2005: New Middle and Late Anisian (Middle Triassic) ammonoid faunas from northwestern Nevada (USA): taxonomy and biochronology. *Fossils and Strata*, vol. 52, p. 1–121.
- Moore, R. C., 1957: *Treatise on Invertebrate Paleontology, Part L, Mollusca 4, Cephalopoda, Ammonoidea*, 490 p. Geological Society of America, New York and University of Kansas Press, Lawrence.
- Patte, E., 1922: Fossiles du Devonien et du Trias recueillis au Yunnan par M. Fromaget. *Mémoires du Service géologique de l'Indochine*, vol. 9, p. 37–57.
- Sha, J. G., Chen, C. Z. and Qi, L. Z., 1990: Bivalves from the Middle and Late Triassic in Yushu region, Qinghai. In, Qinghai Institute of Geological Sciences, Nanjing Institute of Geology and Palaeontology, Academia Sinica ed., *Devonian-Triassic Stratigraphy and Palaeontology from Yushu Region of Qinghai, China*, p. 212–234. Nanjing University Press, Nanjing.
- Shimizu, S., 1930: On some Anisic ammonites from the *Hollandites* beds of the Kitakami Mountainland. *Science Report of the Tohoku Imperial University, 2nd Series (Geology)*, vol. 14, p. 63–74.
- Spath, L. F., 1951: *Catalogue of the Fossil Cephalopoda in the British Museum (Natural History). Part 5, The Ammonoids of the Trias (II)*, 228 p. London.
- Tozer, E. T., 1971: Triassic time and ammonoids: problems and proposals. *Canadian Journal of Earth Sciences*, vol. 8, p. 989–1031.
- Tozer, E. T., 1981a: Triassic Ammonoidea: classification, evolution and relationship with Permian and Jurassic forms. In, House, M. R. and Senior, J. R. eds., *The Ammonoidea*, p. 66–100. Academic Press, London and New York.
- Tozer, E. T., 1981b: Triassic Ammonoidea: geographic and stratigraphic distribution. In, House, M. R. and Senior, J. R. eds., *The Ammonoidea*, p. 397–431. Academic Press, London and New York.
- Vu Khuc, 1984: *Triassic Ammonoids in Vietnam*, 136 p. General Geological Department, Hanoi. (in Vietnamese with English summary)
- Vu Khuc, 1991: *Paleontological Atlas of Vietnam, Vol. 3, Mollusca*, 207 p. Science and Technics Publishing House, Hanoi.
- Zakharov, Y. D., 1968. *Biostratigrafiya i ammonoidei nizhnego triasa Yuzhnogo Primorya (Lower Triassic biostratigraphy and ammonoids of South Primorye)*, 175 p. Nauk, Moscow. (in Russian)