63. Ordovician Cephalopods of Yangtze and Neighbouring Areas

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In the Ochcheon trough in South Korea the oldest cephalopods are ellesmeroceroid gen. et sp. indet. and two endoceroids in the late Tremadocian *Protopliomerops* zone of the Tomkol (i.e. Dumgol) shale (1935). It is overlain by the Chikong limestone in which *Manchuroceras*, *Polydesmia* (?) and *Sigmorthoceras* occur in three horizons. The Chikunsan shale is intercalated between this limestone and the Tsuibon limestone and contains some 90 species of graptolites, machaerids, brachiopods, pelecypods, gastropods, cephalopods, ostracods and trilobites among which a half belong to cephalopods. *Kotoceras* and *Cycloceras* each includes 7 species, *Sactorthoceras* 5, *Sactoceras* 4 and *Michelinoceras* 3. Other genera are *Robsonoceras* (?), *Endoceras*, *Vaginoceras*, *Cyrtovaginoceras*, *Kawasakiceras*, *Geisonoceras*, *Sigmorthoceras*, *Spyroceras*, *Centrocyrtoceras*, *Stereoplasmoceras* (?), *Ormoceras* and *Cyrtactinoceras* (?). The Chikunsan fauna is Llandeilian in age (1934). The Tsuibon limestone yields various fossils about 45 species in which gastropods are richest. Cephalopods are 5 species of *Ormoceras*, 2 spp. of *Armenoceras*, and *Paravaginoceras*, *Cycloceras*, *Tofangoceras* and *Selkirkoceras* one species in each (1977). The Tsuibon fauna is closely related to the late Machiakou fauna of the Hwangho basin.

The Okcheon trough was separated from the Pacific ocean by the Yeongnam landmass from which clastic sediments were supplied to the basal Jangsan quartzite, Myobong and Seison slates, Dongjeom quartzite, Dumgol and Chikunsan shales during the Cambrian and Ordovician periods. All of these quartzites, slates and shales wedge out northwesterly. The basal quartzite contains boulders evidently derived from the metamorphosed Precambrian rocks of the Yeongnam land extending southwesterly toward Fukien, China (1953). Thus it is certain that the Yangtze basin was limited by this land on its east side.

Primarily I have compared the Tsinling-Seoul line to the "Caledonische Schwelle", but what kind of a barrier it was is still a question. At any rate it is certain that an important biogeographic boundary has run from Tsinlingshan to Huaiyangshan. In further east, however, any connection was maintained between its two sides, because the Cambrian Machari facies along the axis of the Okcheon trough runs into Southeast China across the Lower Yangtze region.

In the lower Yangtze area i.e. the so-called Shankiang basin (1984) the Wolungian and Toufangian faunas are represented by manchuroceroids, *Polydesmia*, armenoceroids and others. *Sigmorthoceras* and *Kotoceras* are two Chikunsan genera. Little is known of basal Ordovician cephalopods, but late Upper Cambrian ones exist, although the siphuncular bulb is undeveloped like basal Ordovician ones (Chen *et al.*, 1980). *Manchuroceras* and *Coreanoceras* occur in the Hunghuayuan formation, *Protocycloceras*, *Dideroceras* and *Chisiloceras* are common members in the Dawan formation and *Sinoceras* and *Lituites* are in higher horizons in Anhui and Nanking Hills (Qi, 1980; Pan, 1986). While cephalopods constitute the dominant group in the Hwangho basin (1987), the

trilobites and graptolites are contained in many horizons in the Yangtze basin.

The Yangtze cephalopod sequence is best represented in Szechuan, Kueichou and Hupeh around the gorges. The basal Ordovician Sanyoudong group of Yichang, Hupeh yields cephalopods abundantly. The *Pseudoectenolites-Xiadongoceras* assemblage containing *Dakeoceras*, *Anguloceras* and *Clarkoceras* is Gasconadian (Xu and Lai, 1983). *Manchuroceras* and *Coreanoceras* are in the Hung-huayuan formation in Hupeh and Szechuan. The Dawan fauna comprises *Protocycloceras*, *Chisiloceras*, *Cochlioceras*, *Bathomoceras*, *Michelinoceras* and so forth among which *Kotoceras typicum* from Szechuan is a Chikunsan species. *Meitanoceras* shows Maruyaman affinity.

Sinoceras rudum is the key cephalopod to the Kuniutan formation. So is *S. chinense* to the Pagoda (Baota) limestone. In the Miaopa-Daitianba formation between them there is the *Lituities* zone. In the Meijiang-Linhsiang formation above them there is *Richardosonoceras-Eurasiaticoceras* (i.e. *Discoceras eurasiaticum*) zone. These Llandeilian-Caradocian and latter cephalopods are quite different from the Toufangian fauna. The Pagoda fauna with *Michelinoceras*, *Lituities* and *Sinoceras chinense* is distributed northerly in the Tapashan range (Lee *et al.*, 1975). Ordovician actinoceroids are rare in Central and Southwest China, but *Oromoceras* together with *Meitanoceras* are reported from the Kuniutan formation Kueichou and Yunnan (Yang, 1980).

In the Yangtze basin long orthocones with subcentral narrow siphuncles and without deposits in siphuncle as well as camerae constitute the dominant group to which cytocones and nautilicones are associated. Their shells are light and probably capable of swimming and floating in clear seas in the Middle Ordovician age.

As stated in my preceding article, the northern and southern cephalopods were coexisted in the Kilianshan region, Mt. Altun area and Xijiang, Northwest China. Early in 1934 Gortani has described ten species of cephalopods belonging to *Vaginoceras*, *Dideroceras*, *Chisiloceras*, "*Orthoceras*", *Protocycloceras* (?) and *Cycloceras* including *C. cf. mantalense*, a Korean species from Karakorum. Recently *Thylacoceras*, *Michelinoceras*, *Troedssonella*, and *Lituities* were added to them, and some Hwangho and Yangtze species of *Dideroceras*, *Chisilocera* and *Michelinoceras* found also (Liu Zhang and Chen, 1986). The Pagoda fauna including *Lituities*, *Discoceras* and *Sinoceras chinense* was discovered at Xainza, 300 km to the northwest of Lhasa (Lai, 1982). In South Xizang (Tibet) four cephalopod zones are distinguished (Chen, 1984) as follows:

4. *Michelinoceras-Sinoceras* zone—Pagoda age (Caradocian)
3. *Meitanoceras-Dideroceras* zone —Maruyaman (Whiterockian)
2. *Ordosoceras-Wutinoceras* zone
1. *Manchuroceras-Hopeiceras* zone—Wolungian (late Canadian).

Thus in Tibet the early fauna (1) is related to the Hwangho fauna, while the later one (4) is typical of the Yangtze fauna. Beyond Karakorum, however, only sparse records are known to me in North Iran, South France, Spain and Morocco. Ordovician cephalopods were probably an insignificant member in the faunas of Western Asia and the Mediterranean region.

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