Concentrations of Silurian nautiloid cephalopods from Russia and Kazakhstan

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Silurian cephalopod limestones known from northern Asia are usually singular beds or horizons of nodules. They range in their taphonomic character from the Mojero river type, with postmortem concentration from rich living populations by relatively gentle bottom currents into a submarine low, to that of the Karabutak Formation of the South Urals, where there has been concentration by strong wave or current action.

Key words: Nautiloid cephalopods, concentrations, Silurian, Russia, Kazakhstan.

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Introduction

A recent review of concentrations of Ordovician to Devonian nautiloid cephalopods from various parts of the world (Holland *et al.* 1994) concluded that they are found largely in limestones of relatively shallow water origin and had frequently been more or less orientated by waves or currents. The examples included ones from the Kunda Regional Stage (Ordovician) of Estonia and the St. Petersburg region of Russia (Khabakov 1964), and from the Silurian of Uzbekistan and the South Urals. This paper adds and discusses further less easily accessible examples from the Silurian of the territory of the former Soviet Union.

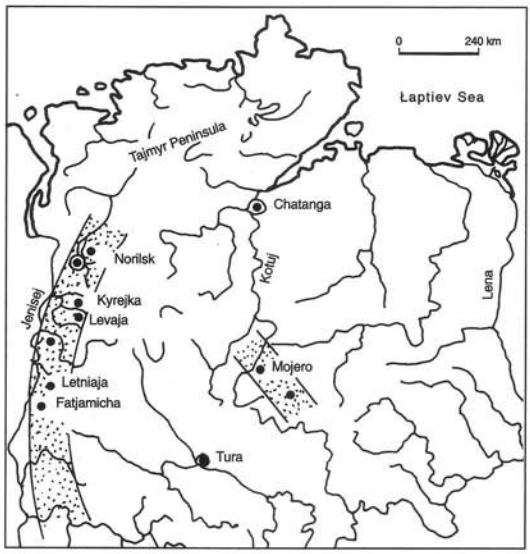

Fig. 1. Map of the Siberian Platform showing distribution of the cephalopod limestone facies.

Mojero River region of Siberia

Silurian (Mojerokan Formation, Llandovery) cephalopod limestones in Siberia (Fig. 1) are known from sections along the Mojero, Letniaja, Levaja Tanda, and Kyrejka rivers; from boreholes on the Fatjanicha river; and from the Norilsk region (Miagkova 1967; Bogolepova & Kříž in press). They are represented by black bituminous limestones of total thickness from 15 cm to 5 m with numerous cephalopods, conodonts, rare brachiopods, gastropods, bivalves, and trilobites.

The most striking example is from the Mojero river section (Figs 1, 2). The cephalopod limestone here is exposed over an area of 100 × 300 m. The bed, 30 cm thick, contains numerous cephalopods. They are diverse taxonomically, vary in size, and include juvenile to adult forms. The cephalopods include representatives of the Orthocerida, Discosorida, and Oncocerida. These are presently attributed to 14 genera and 17 species, though these are undergoing further systematic revision (by OKB). They are accompanied by conodonts, a few bivalves, and by brachiopods, gastropods, and trilobites of small size.

The accumulation of black bituminous shales and black bituminous limestones here was connected with transgression which began in the east Siberian Basin in the early Silurian. The cephalopod facies relates to the western and eastern marginal parts of this basin. The concentrations of cephalopods and other fossils record a short but biologically very productive event, when there was high organic productivity of pelagic fauna probably connecting with upwelling. The cephalopods show no signs of strong waves or currents; there is no telescoping of the shells; thin-shelled long orthocones are found in a good state of preservation. Some of the

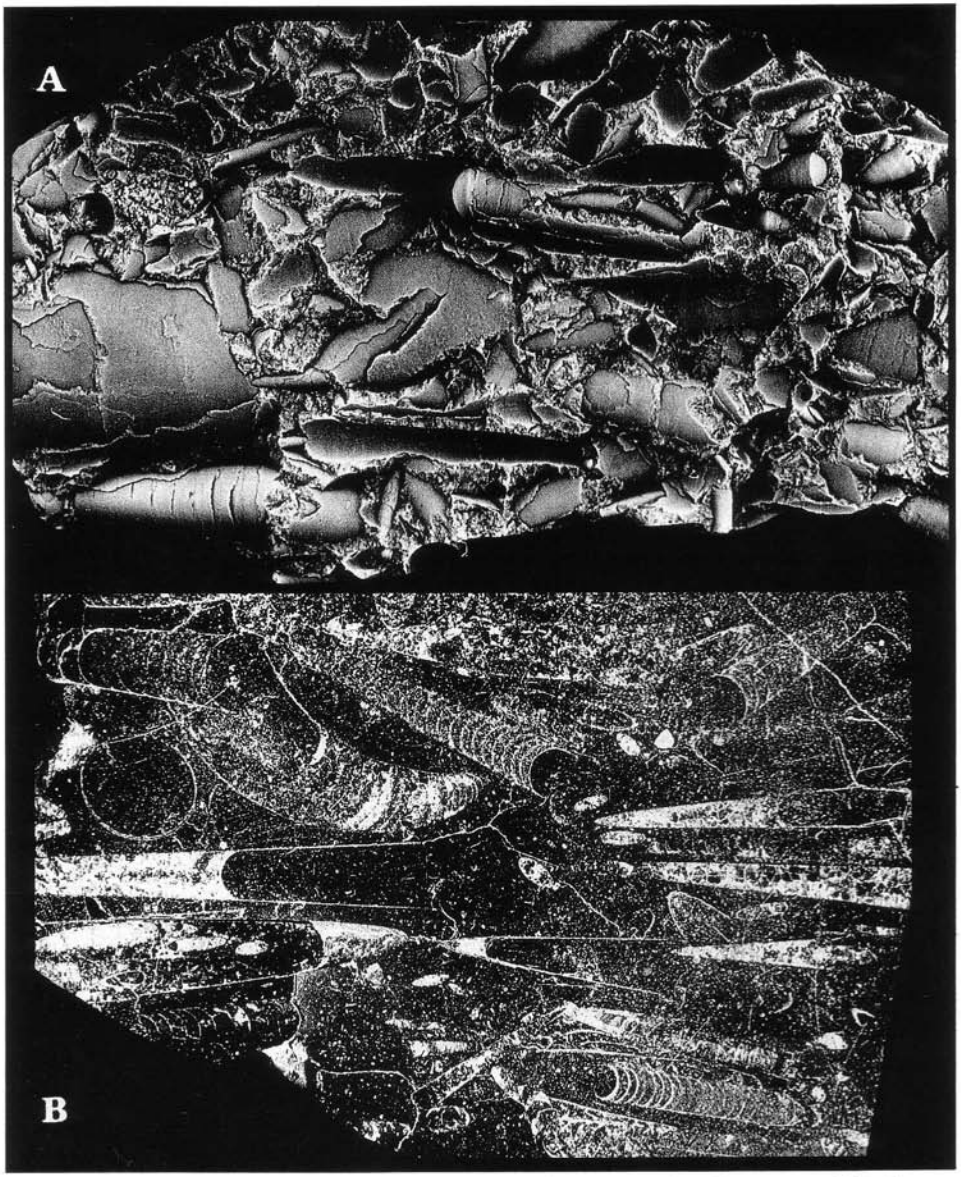

Fig. 2. Cephalopod limestone from the lower part of the Mojerokan Formation, Llandovery, Rhuddanian, Mojero River section; × 1. A. Split surface. B. Polished section.

shells show some orientation, or more particularly parallelism, and there is a neighbourhood effect. The overlying beds are black graptolitic shales. With further transgression and thus better circulation, non-bituminous clay shales with a different fauna began to accumulate.

It appears that concentration and roughly parallel arrangement have been produced here by relatively gentle currents, producing the cephalopod beds perhaps in a submarine low at the base of the basin marginal

slope. The living cephalopods must have been numerous, but the variety in size and taxonomic diversity seem to preclude the idea of a specific school or of the relationship to breeding cycles. As the concentrations are maintained through a thickness of sediment, it seems that mass mortality cannot be suggested. The occurrence suggests that there has been a postmortem concentration from already rich living populations.

Tajmyr Peninsula

The section on the Nižniaja Tajmyra river (Fig. 3) was studied in the period 1954–1958 by M.N. Zlobin. From the Wenlock-Ludlow sequence near the Middendorf Cave he mentioned cephalopods and bivalves, characteristic of the middle part of the Ludlow in Central Bohemia (Zlobin 1965). There is a layer of cephalopod limestone in the lower part of the Middendorf Formation in section P-90218 (Berger *et al.* 1991) on the right bank of the river. The whole formation is 145 m thick. The grey to black cephalopod limestone bank (20 cm thick) is within a sequence of black mudstones with small nodules of clayey micritic limestone, containing the graptolites *Pristiograptus* ex gr. *dubius* and *Bohemograptus bohemicus bohemicus*. *Monograptus fritschi linearis* has been found in the black shales above the cephalopod limestone. Within the limestone itself were found rare conodonts *Ozarkodina inclinata posthamata* and *O. inclinata inclinata*, indicating the *Ancoradella ploeckensis* Biozone. Above the limestone appears for the first time the pelagic ostracode *'Entomis'* aff. *lamarmorae*. This ostracode is known from Sardinia, where it occurs in the *Cardiola docens* community of Ludlow age.

The base of the cephalopod limestone is nodular; the top bedding plane is flat. It is a dark grey, fine grained to micritic limestone with common cephalopods and bivalves, and very rare brachiopods and trilobites. The bivalves form an interesting community dominated by epibyssate forms adapted to life on the shells of the nectobenthic cephalopods, which represented a firm substrate on the muddy micritic limestone bottom (Kříž & Bogolepova in press). The situation here seems to be similar to that which obtained in the Prague Basin (referred to in Holland *et al.* 1994), where surface currents temporarily ventilated the normally anoxic sea bottom (Kříž 1991). The preservation in micritic limestone with orientated, mostly fragmental, cephalopods (Fig. 4), very rare brachiopods and trilobites, and low diversity, disarticulated bivalves (the cardiolids commonly late neanic and rarely adult) testifies the low oxygen conditions and presence of a current.

The occurrence of this upper Gorstian cephalopod limestone facies with its Bohemian type fauna is in agreement with the palaeogeographical reconstruction by Cocks & Scotese (1991). Here the Siberian Plate is in the 'upside down' position, with the Tajmyr area within reach of those surface currents which distributed the facies in the upper Gorstian and lower

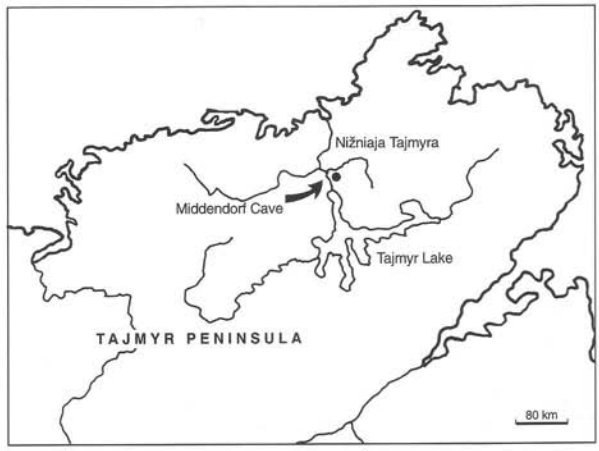

Fig. 3. Map of Tajmyr Peninsula showing location of the section P-90218, Middendorf Cave.

Ludfordian off northern Gondwana (Morocco, Algeria, Montagne Noire, Prague Basin, Carnic Alps, and Sardinia (Kříž & Bogolepova in press).

Novaya Zemlya

The Nekhvatov Formation (Ludlow) in the section along the Kuznetsova river is 1500 m thick and largely of shales (Nekhorosheva 1981). The lower 200 m are characterised by black mudstones with small lenses, concretions (diameter 10 cm), and thin interbeds (3–5 cm) of grey to black limestone. The concretions contain small orthoconic cephalopods, stromatoporoids, corals, small brachiopods, bivalves, gastropods, and ostracodes. In the thin interbeds there are accumulations of long, slender orientated cephalopods with bivalves and gastropods. On the limited available evidence here it may be reasonable to think of derivation from living schools, though mortality may again be associated with low oxygen levels.

South Urals

Material of limestones from an undescribed, probably upper Ludlow formation in the South Urals, kindly provided by Professor I. Barskov (Moscow), was described by Holland *et al.* (1994). On the western slope of the South Urals, in the Sakmaro-Ilek facial zone (Ivanov & Puchkov 1984), Leonenok (1955) assigned the Ludlow rocks of the Kos-Istek area in Mugodžar to the Karabutak Formation. It consists of arkosic sandstones, conglomerates, clay and cherty slates, limestones, and volcanic rocks. Its age is determined as early Ludlow on the evidence of the rich faunas occuring in lenses and interbeds (up to one metre thick) of limestones. There are cephalopods, bivalves, gastropods, trilobites, crinoids, and rare brachiopods. The de-

Fig. 4. Cephalopod limestone from the lower part of the Middendorf Formation, Ludlow, uppermost Gorstian. Section at Middendorf Cave, Tajmyr Peninsula; × 2.

tailed list of taxa resembles that of a fauna previously found in the Caucasus (Yanishevsky 1918; Nikiforova & Obut 1965). The Karabutak Formation rests discordantly on an eroded surface of Ordovician and Lower Silurian rocks and is overlapped by Lower Devonian clastic rocks.

Khvorova and Grigoriev (1974) regarded the Silurian cephalopod limestone of the South Urals, particularly in their distinctive red and pink varieties, as in many respects similar to the Ammonitico-Rosso of the Mediterranean Area. These latter rocks are, of course, condensed pelagic deposits, in which calcareous nodules are set in dark red marl. There may be gradations between nodules and matrix. Slow sedimentation and early diagenesis were suggested in a detailed and critical discussion by Jenkyns (1974). Material from the South Urals is superficially similar in its attractive deep pink and white colours. Otherwise it is very different. Our material is a veritable coquina packed with orthocones and some brachiopods. There are patches of white calcite in the pink limestone and some of the cephalopod shells are partially or entirely replaced by calcite. The broken orthocones vary in size and are orientated chaotically. Some fragments are in the broken shells of others. Holland *et al.* (1994) described the limestone as 'a jumbled, washed in deposit'. It appears to be an excellent example of concentration of cephalopods by strong wave or current action.

North Caucasus

In Kabardino-Balkaria, along the middle reaches of the river Malka in the ravines of Ułu-Łakhran and Čeget-Łakhran, the lower part of the Łakhran

Formation (Ludlow) is grey to black limestones with interbeds of cephalopod limestone (Gerasimov 1940; Kizel'vater 1963). The fauna includes cardiolids and other bivalves, gastropods, and various orthoconic nautiloid cephalopods (Yanishevsky 1918; Azhgirej *et al.* 1976). There is direct comparison with the cephalopod limestones of Bohemia referred to already (Nikiforova & Obut 1965 and references given above).

Altaj-Sayan region

In western Tuva, on the left side of the river Ałaš, near the bridge of Akdovurak-Abaza, the road exposed Ałaš beds of Llandovery age. Their basal part is of thick beds of crinoidal and stromatoporoid-coral, red and pink limestones. These incorporate interbeds of cephalopod limestone with numerous orientated orthocones (Nikolaj P. Kulkov, personal communication 1994). The age of the beds is indicated by conodonts as of the *Pterospathodus celloni* Biozone (Kulkov *et al.* 1985). We have no additional information.

Conclusions

Silurian cephalopod limestones from Russia and Kazakhstan vary in their taphonomic character. The Mojero river type represents postmortem concentration from rich living populations by a relatively gentle bottom current into a submarine low at the base of the basin margin slope. Examples from the Tajmyr Peninsula and North Caucasus resemble those known from the Prague basin, with current orientated cephalopod shells where surface currents had temporarily ventilated the normally anoxic sea bottom. In the South Urals there are cephalopod limestones representing concentration by strong wave or current action.

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