

L. LYARSKAYA

## A CLASSIFICATION OF DEVONIAN VERTEBRATE LOCALITIES OF LATVIA

Two main types of Devonian fossil fish localities are distinguished by I. Efremov (1950). The first type is connected with the Old Red Sandstone facies and represented by well-known localities in Europe (in Scotland, Wales, Rhineland, Namur and Oslo regions) and North America (Acadia, Nova Scotia, Catskill, Scaumenac Bay, and others). The second type is mainly connected with typical marine deposits; here belong some of the localities in the Rhine region and many localities of North America (Utah, Onondaga, Attica Shales in Buffalo region, Huron Shales in Ohio, Cleveland Shales, etc.). The localities of the Russian platform (in Leningrad, Novgorod, Pskov areas and the Baltic Region) are considered by I. Efremov as intermediate between the two above-mentioned types. They are situated in the region of platform marine basins which were considerably remote from the mountain massifs.

The majority of the well-known Devonian fossil fishes in the East Baltic Region have been found in 500-metre-thick beds consisting of sandy-argillaceous sediments (Gross, 1942; Obruchev, Mark-Kurik, 1965; Sorokin, 1967; Lyarskaya, 1967, 1970; Vorobyeva, Lyarskaya, 1968). Their lower part corresponds to the Eifelian and Givetian, and the upper to the Lower Frasnian. That time is characterized on the Russian platform by a prevailing subsidence of the territory and by marine transgressions.

In the Eifelian time the sea covered all the Moscow syncline and reached the East Baltic Region. The latter represented a shallow water basin with abnormal salinity. Its freshening took place in the Late Eifelian time. During the Givetian the transgression had developed only in the central part of the platform. The character of sedimentation in the East Baltic Region was similar to that of the continental type. During the Frasnian time the largest Devonian transgression took place. The subsidence of the East Baltic Region started already in the Early Frasnian. On the territory of the Middle and Southern East Baltic Region a shallow marine bay was located adjacent to a coastal plain in the north. Thus, in the Middle Devonian and Early Frasnian the East Baltic territory was characterized by the presence of two main landscape elements: the epicontinental basin with abnormal salinity and a coastal plain.

At the end of the Middle Devonian the formation of fossil vertebrate localities took place under conditions of regression of the epicontinental basin: in the lagoons, in shallow parts of the basin with brackish water and on the coastal plain. During the Early Frasnian fossils accumulated under conditions of transgression: in the bays and on the alluvial plain.







The classification of the vertebrate localities of Latvia proposed by the author concerns mainly the localities of the Middle Devonian and early Late Devonian, whereas the later ones are exemplified in some cases. A number of them needs a further thorough study.

The vertebrate localities may be classified into four types according to the lithology of the enclosing rocks (see Table). The localities of the type I are associated with terrigenous and carbonate sediments, II with clays, III with silts and fine sandstones and IV with coarse sandstones and conglomerates.

The **type I** of localities, associated with terrigenous and partly with carbonaceous sediments, may be subdivided into two subtypes: A and B.

The localities of the **subtype IA** are related to argillo-carbonaceous silts and marls. They are known from the Plavinas Beds (the Lower Frasnian) on the Gauja and Abava Rivers. In these localities fish remains are rare, and benthonic invertebrates, such as *Lingula*, ostracods and phyllopods prevail. The fish assemblage consists of euryhaline forms of Arthrodira, Crossopterygii and Dipnoi. Invertebrate and fish remains do not form large accumulations, but are sporadically distributed in the enclosing rocks. Skeleton parts are not rounded and oriented. The localities may have been formed in a shallow marine environment with relatively stable flow dynamics. It must be mentioned that the localities of the subtype IA need a more detailed study.

The localities of the **subtype IB** are connected with silty-sandy sediments. This subtype, exemplified by the locality Kuķe on the Gauja River (Fig. 1) is typical of the Late Devonian Amata Beds on the Perse River and Abava River near Kandava, as well as of Voronezh Beds on the Amula, Imula and Abava Rivers. The enclosing rocks contain mainly fish remains, while invertebrates are of a markedly subordinate significance. The fish assemblage is various, with antiarchs predominating. The accumulations are lenticular and generally elongated in submeridional direction. They were apparently situated parallel to the shoreline of the basin. The extent strike of some hundred metres and a small dip width (up to 20 m) are characteristic of these lenses. They have the form of a "puff", in which interlayers of intact and crushed bones alternate. The fish remains are generally sorted in respect to weight and shape. The accumulations are considered to have been formed in a shallow water zone with unstable flow dynamics.

The **type II** is confined to lenses of refractory clays, occurring in sandstones. This type is so far known only by one Late Devonian locality (that of the Gauja Beds) in the Lode quarry near Cēsis (Fig. 2). The locality is characterized by extraordinarily well preserved fossil fishes and plant remains. The fish assemblage is limited, consisting of one antiarch species (*Asterolepis ornata* Eichw.) and two crossopterygians (*Panderichthys rhombolepis* Gross and *Laccognathus panderi* Gross). *Asterolepis* predominates in this assemblage. The plant remains belong to *Rhacophyton*. The locality is of medium extension, and the thickness of a complex containing three layers of fossil-bearing beds is 3 m on the average. The fish skeletons are articulated, the posterior portion of the trunks and tails covered with scales being perfectly preserved. The skeletons are only slightly deformed and often found in a position with their dorsal sides upward, clinging close to each other. They belong to adult individuals of nearly the same size. The orientation of the specimens is various, the long axis arrangements tend to be submeridional. The formation of such a locality seems to have taken place in a closed or semiclosed basin with relatively deep stagnant water and at a high rate of sedimentation. At



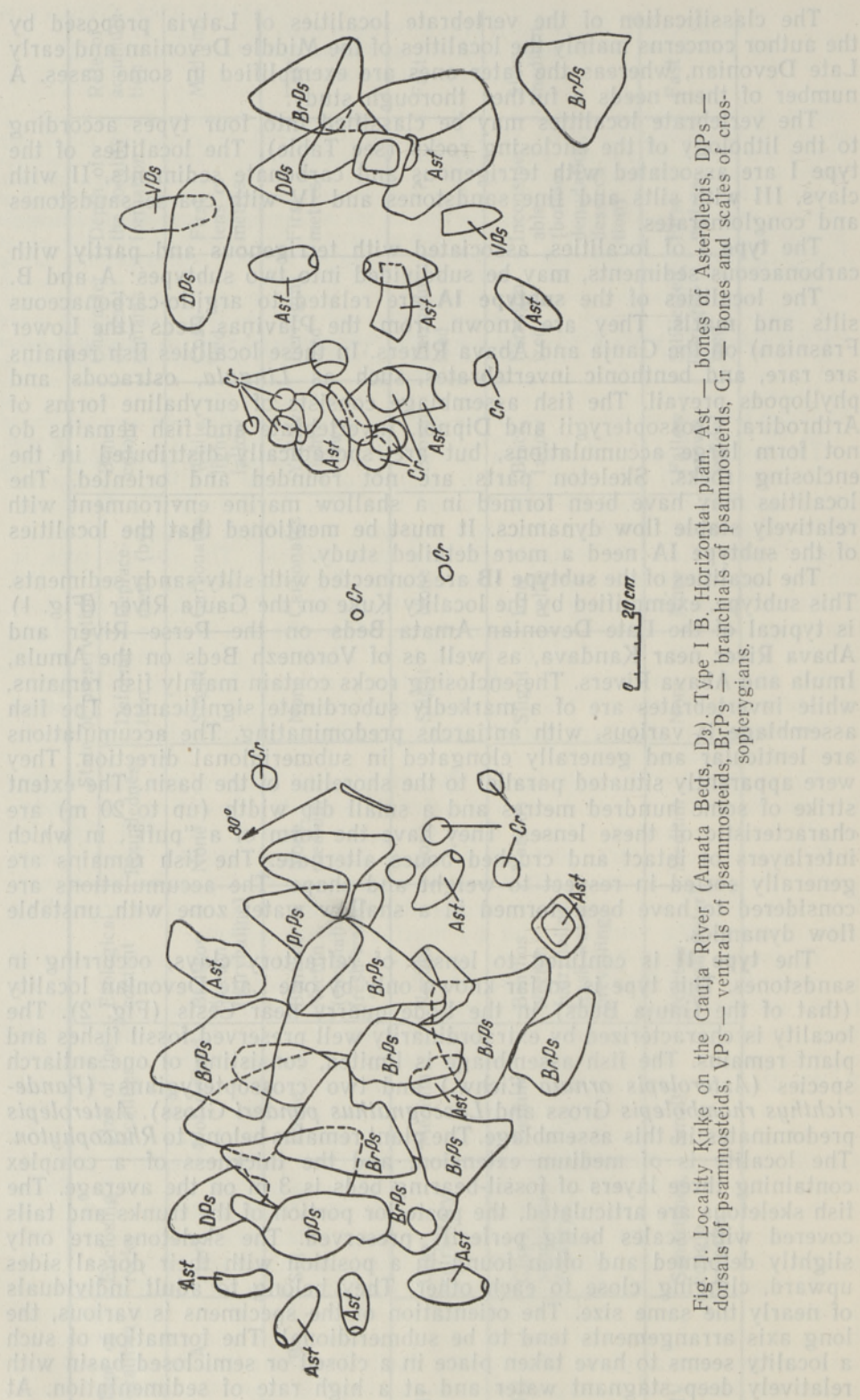


Fig. 1. Locality Kuke on the Gauja River (Amata Beds, D<sub>3</sub>). Type I B. Horizontal plan. Ast — bones of Asterolepis, DPs — dorsals of psammosteids, VPs — ventrals of psammosteids, BrDs — branchials of psammosteids, Cr — bones and scales of crinoid spongygians.

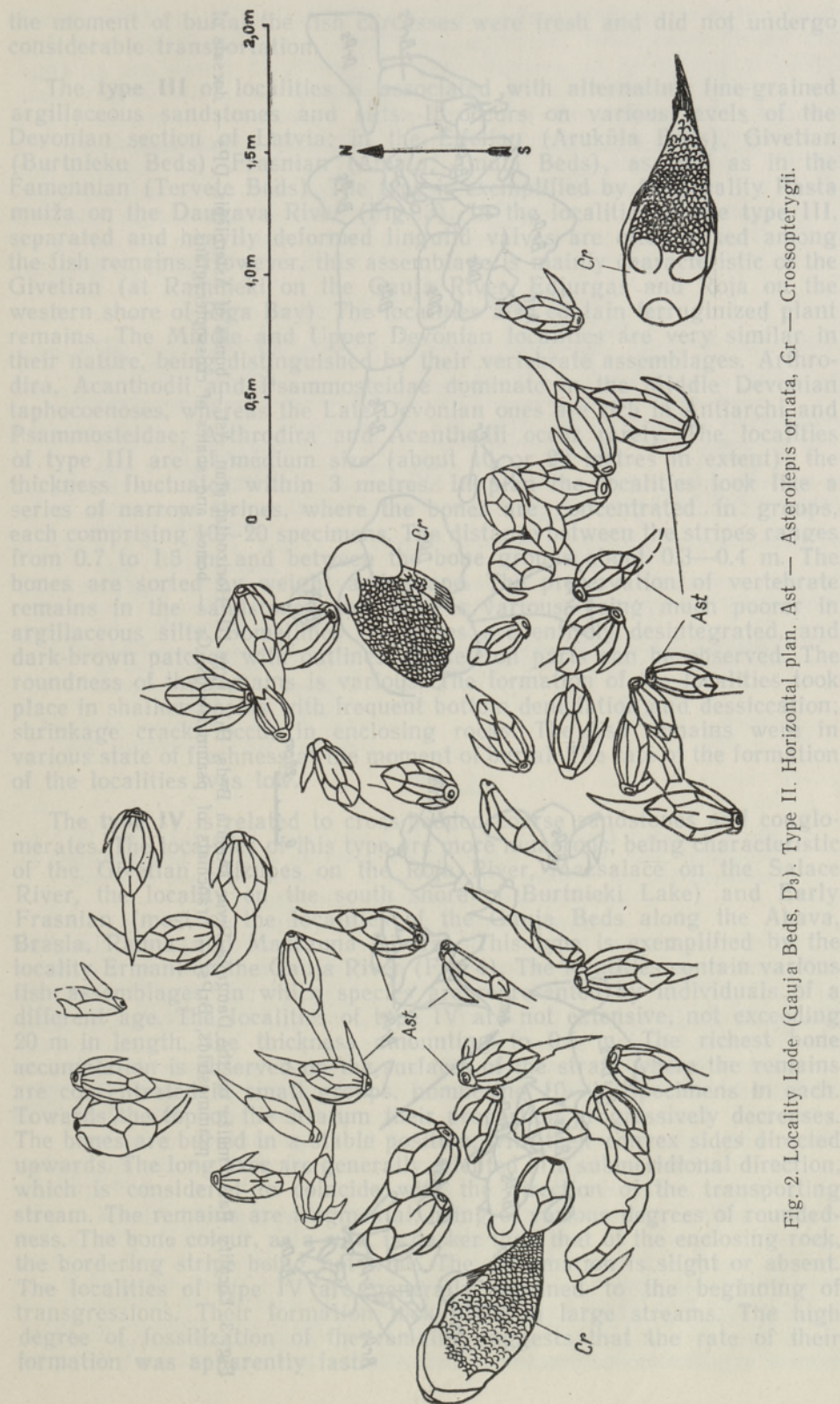


Fig. 2. Locality Lode (Gauja Beds, D<sub>3</sub>). Type II. Horizontal plan. Ast — *Asterolepis ornata*, Cr — *Crossopterygii*.



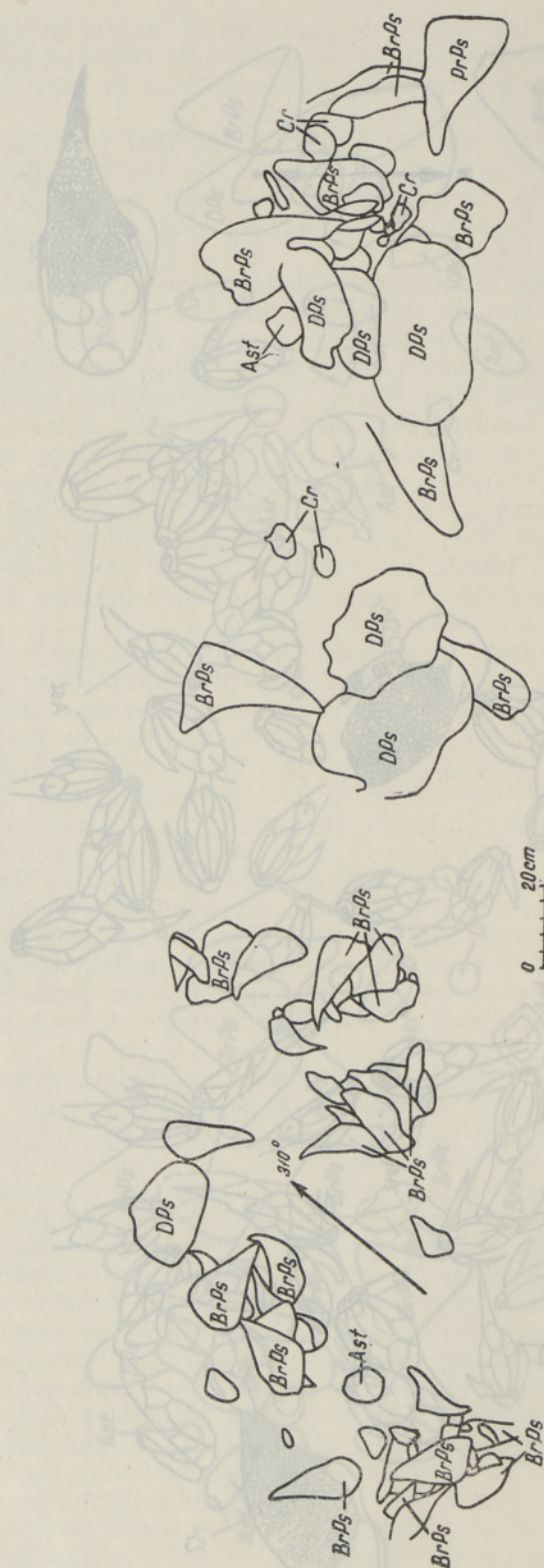


Fig. 3. Locality Pasta muiža on the Daugava River (Amata Beds, D<sub>3</sub>). Type III. Horizontal plan. Ast — bones of Asterolepis, DPs — dorsals of psammosteids, BrPs — branchials of psammosteids, Cr — bones and scales of crossopterygians.



the moment of burial the fish carcasses were fresh and did not undergo considerable transportation.

The **type III** of localities is associated with alternating fine-grained argillaceous sandstones and silts. It occurs on various levels of the Devonian section of Latvia: in the Eifelian (Arukūla Beds), Givetian (Burtnieku Beds), Frasnian (Amata, Amula Beds), as well as in the Famennian (Tervete Beds). The type is exemplified by the locality Pasta muiža on the Daugava River (Fig. 3). In the localities of the type III, separated and heavily deformed lingulid valves are often mixed among the fish remains. However, this assemblage is mainly characteristic of the Givetian (at Ramnieki on the Gauja River, Edjurgas and Roja on the western shore of Riga Bay). The localities also contain ferruginized plant remains. The Middle and Upper Devonian localities are very similar in their nature, being distinguished by their vertebrate assemblages. *Arthrodira*, *Acanthodii* and *Psammosteidae* dominate in the Middle Devonian taphocoenoses, whereas the Late Devonian ones are rich in *Antiarchi* and *Psammosteidae*; *Arthrodira* and *Acanthodii* occur rarely. The localities of type III are of medium size (about 10 or 20 metres in extent); the thickness fluctuates within 3 metres. In plan the localities look like a series of narrow stripes, where the bones are concentrated in groups, each comprising 10—20 specimens. The distance between the stripes ranges from 0.7 to 1.5 m, and between the bone groups about 0.3—0.4 m. The bones are sorted by weight and shape. The preservation of vertebrate remains in the sandstones and silts is various, being much poorer in argillaceous silts. Sometimes the bones are entirely desintegrated, and dark-brown patches with outlines of skeleton parts can be observed. The roundness of the remains is various. The formation of the localities took place in shallow basins with frequent bottom denudation and dessiccation; shrinkage cracks occur in enclosing rocks. The fish remains were in various state of freshness at the moment of burial. The rate of the formation of the localities was low.

The **type IV** is related to cross-bedded coarse sandstones and conglomerates. The localities of this type are more numerous, being characteristic of the Givetian (Aizupes on the Roja River, Mazsalace on the Salace River, the locality on the south shore of Burtnieki Lake) and Early Frasnian (most of the localities of the Gauja Beds along the Abava, Brasla, Rauna and Mazrauna Rivers). This type is exemplified by the locality Ermani on the Gauja River (Fig. 4). The localities contain various fish assemblages, in which species are represented by individuals of a different age. The localities of type IV are not extensive, not exceeding 20 m in length, the thickness amounting to 0.5 m. The richest bone accumulation is observed on the surfaces of the strata where the remains are concentrated in small groups, numbering 10—15 specimens in each. Towards the top of the stratum their proportion progressively decreases. The bones are buried in a stable position, with their convex sides directed upwards. The long axes are generally oriented in a submeridional direction, which is considered to coincide with the direction of the transporting stream. The remains are fragmental, being of various degrees of roundedness. The bone colour, as a rule, is darker than that of the enclosing rock, the bordering stripe being not wide. The deformation is slight or absent. The localities of type IV are generally confined to the beginning of transgressions. Their formation took place in large streams. The high degree of fossilization of the remains suggests that the rate of their formation was apparently fast.



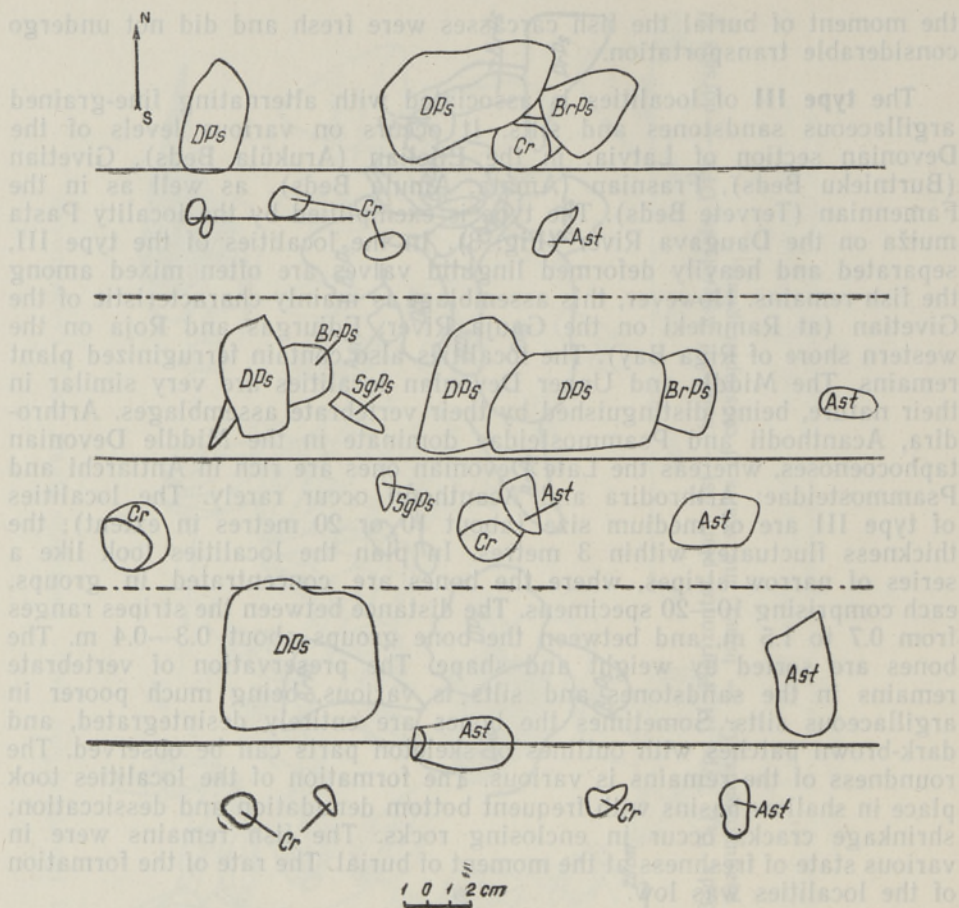


Fig. 4. Locality Ermani on the Gauja River (Gauja Beds, D<sub>3</sub>). Type IV. Horizontal plan. DPs — dorsals of psammosteids, BrPs — branchials of psammosteids, Ast — bones of Asterolepis, Cr — bones and scales of crossopterygians.

Of course, a short review of the Latvian vertebrate localities classified into four types does not exhaust all their varieties. There is a number of them with an intermediate character, such as the localities on the Amata River (Frasnian, the Amata Beds), on the Salace River (Givetian, the Burtņieku Beds), and others.

Some conclusions based on the study of the vertebrate localities of Latvia and concerning the depositional environment in the Middle Devonian and early Late Devonian can be made, and the prevailing groups of fishes and Agnatha in taphocoenoses of that age may be indicated.

The localities of type I are characteristic of shallow marine basins; the subtypes A and B reflect their different zones with stable and unstable regimes. The types II and III are typical of fresh-water closed basins (possibly lakes?) or semi-closed basins (possibly limans?) with a low rate of sedimentation. The type IV is closely connected with deposits probably belonging to the surface and underwater parts of deltas and represented by coarse-grained stream deposits.

In the Eifelian basin with relatively deep water and with an accumulation of argillaceous-carbonaceous deposits the predominant part in tapho-



coenoses belongs to the euryhaline fishes. In the coastal parts of this basin with prevailing carbonate-terrigenous sediments fresh-water fishes and Agnatha are widely distributed in taphocoenoses. In the Givetian coastal plain region within a depositional area of lacustrine silty-clayey and clayey-silty-sandy sediments large forms of Arthrodira and Agnatha prevail. Dipnoans are found, as a rule. The beginning of the Frasnian is characterized by the development of the off-shore marine and alluvial deposits. Antiarchs and agnathans are widely distributed in the Early Frasnian taphocoenoses. These vertebrates possessed a specific structure — an anchoring mechanism adapted to a bottom dwelling habit in the fast-running streams.

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All-Union Institute of Marine Geology  
and Geophysics (VNIIMORGEO)

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L. LJARSKAJA

#### LÄTI DEVONIS ESINEVATE SELGROOGSETE LEIUKOHTADE KLASSIFIKATSIOON

Artiklis esitatakse andmeid lõuatute ja kalade mattumise kohta Läti kesk- ja ülem-devoni leiukohtades. Eristatakse nelja tüüpi leiukohti. Esimene neist esineb epikontinentaalse mere terrigeen-karbonaatsetes setetes ning on jaotatud alatüüpidesse A ja B, milledest viimast illustreerib joonis 1. Teine tüüp on seotud poolsuletud basseini savisetetega, mis moodustusid vaikselt vees ning suhteliselt kiiresti (joon. 2). Kolmandat tüüpi leiukohad asuvad madalveeliste muutliku hüdrodünaamilise režiimiga basseini savikas-aleuriitsetes setetes (joon. 3) ja neljandat tüüpi leiukohad — samasuunaliste vooluvete jämedates terrigeensetes setetes (joon. 4).

Л. ЛЯРСКАЯ

#### КЛАССИФИКАЦИЯ ЗАХОРОНЕНИЙ ПОЗВОНОЧНЫХ В ДЕВОНЕ ЛАТВИИ

В настоящее время в мировой литературе известно два основных типа захоронения ископаемых рыб (Ефремов, 1950). Первый тип связан с фацией «олд ред», второй — с типично морскими образованиями. Крупнейшие местонахождения Русской платформы (Ленинградская, Новгородская, Псковская области и Прибалтика) тяготеют к типу «олд ред» и в то же время стоят несколько особно. Они расположены в области платфор-



менных морских бассейнов, удаленных от горных массивов на значительные расстояния. Изучение захоронений ископаемых рыб Прибалтики, занимающих промежуточное положение между захоронениями в «олд ред» и открытых морях, представляет значительный интерес. Большинство известных захоронений девонских рыб на территории Прибалтики приурочено к 500-метровой толще песчано-глинистых отложений, нижняя часть которых соответствует эйфельскому и живетскому ярусам, а верхняя — низам франского яруса. По приуроченности захоронений к определенным литологическим разностям пород их можно подразделить на четыре типа: I тип связан с терригенно-карбонатными породами (подразделяется на два подтипа IА и IВ; рис. 1); II тип — с тугоплавкими жирными глинами (рис. 2); III тип — с переслаивающимися алевроитовыми глинами и тонкозернистыми песчаниками (рис. 3); IV тип — с грубозернистыми песчаниками и конгломератами (рис. 4).

Захоронения I типа характерны мелководному морскому бассейну, а подтипы А и В — соответственно отдельным зонам со сравнительно устойчивым и неустойчивым гидродинамическими режимами. II и III типы характерны для замкнутых (озера) или полужамкнутых (лагуны) пресноводных или сильно опресненных бассейнов со спокойными условиями осадконакопления. IV тип связан с однопавленными потоками (русла, надводные и подводные части дельты рек). Тафаномический анализ захоронений в девонских отложениях Латвии помогает выяснить характер древних бассейнов этой территории, их эволюцию и в какой-то мере дает возможность судить об экологическом составе заселявших их организмов.