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Devonian Volcanism and Conodont Biodiversity in the South Urals

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In the Devonian history of the South Urals volcanic activity was the strongest factor that determined the basinal sedimentation and biodiversity of the inhabiting faunas. In general, volcanism was of unstable character with both explosive eruptions of the island-arc type and fissure ones peculiar to rift systems. There were also geodynamically quiet periods of different duration, when volcanic eruptions if any were episodic, momentary and had very insignificant environmental impacts. The main feature of volcanic activity in the South Urals was its submarine occurrence at great depths (below Calcium-carbonate-compensation depth – CCD).

At present there exists a well-developed Devonian stratigraphy for the eastern slope of the South Urals, whose section is represented mainly by volcanogenic or volcano-sedimentary units. It is totally built upon conodonts (more exactly on their imprints). It is precisely these fossils distributed in different types of rocks (sometimes in limestones, but mostly in cherts and others) that made possible subdivision and correlation of volcanites. We succeeded to establish practically complete continuous sequence of the Devonian section (ARTYUSHKOVA 2009, MASLOV & ARTYUSHKOVA 2010) and recognize faunistically rich, poor and utterly barren intervals.

In the Early Devonian (pre-Emsian time) conodonts are extremely rare in spite of the fact that the section consists exclusively of sedimentary siliceous and carbonate rocks. Nevertheless, the Upper Lochkovian interval is noted for taxonomically and quantitatively rich assemblages of conodonts typical for the *delta-pesavis* Zones. Radiolarians are always found in siliceous rocks together with conodonts. In the Sakmara Zone conodont faunal assemblages are accompanied by graptolites. Carbonate deposits of the western slope also show a distinct presence of diversified nektonic and benthic faunas.

The very first short-duration and local occurrences of the Devonian fissure-type volcanic activity (Mostostroevisky volcanic complex) are known in the Early Emsian (*kitabicus-excavatus-nothoperbonus* Zones). Probably, the transgression onset on the western slope is associated with this phenomenon. As a consequence, these processes caused essential biotic changes in all paleo-basinal areas. Conodont assemblages with zonal species are found in heterogeneous facies sections, primarily within deep-water bathyal deposits.

The Late Emsian is characterized by intense prolonged island-arc volcanism (Baimak-Buribai volcanism) occurring at great depths. There is no evidence to support the existence of long hiatuses in volcanic activity marked in the section by sedimentary rock members with faunal remains. As volcanism terminates at the end of the Emsian, there occurs accumulation of cherry-red jaspers of the Sagitovo Formation containing a great deal of radiolarian and conodont materials. The cosmopolitan species *Polygnathus serotinus* TELF. is dominant in the conodont assemblages and usually represented by a large number of specimens. The species *Pol. linguiformis bultyncki* WEDD. is found in the same amount while *Pol. costatus patulus* KLAPP. is less frequent.

The beginning of the Eifelian age (*partitus-costatus* Zones) marks the new onset of volcanism (Irendyk volcanism). Its intense explosive character with very short inactive periods was not conducive to preserving conodonts in the sediments. Only after volcanism termination bioherms and shoals built up by brachiopods, corals and crinoids begin to evolve on elevated parts of submarine ridges. Conodonts are rare in them.

At the boundary between the *costatus* and *australis* Zones and also in the *kockelianus* Zone volcanism (Karamalytash volcanism) takes on another character. Fissure effusions that resulted from spreading and changed hydrochemical and temperature regimes were responsible for basin deepening over the vast territory of the South Urals. Accordingly, these factors provided conditions

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favourable for the development of benthic and nektonic faunas in all basinal areas. Karamalytash volcanism was discontinuous as demonstrated by frequent interbeds of cherry-red jaspers between basalt layers. The jaspers are rich in conodonts and radiolarians. The species composition of conodont assemblages is diverse with quantitatively prevailing *Pol. linguiformis linguiformis* HINDE. Deposits of the distance-related facies coeval with volcanites are represented by sedimentary rocks. These are black cherts and cherry-red jaspers containing many conodonts as well.

During the Givetian age active explosive volcanism (Ulutau volcanism) took place over a prolonged length of time (conodont *hemiansatus-varcus* Zones) within the East Magnitogorsk Zone. It served as a supplier of huge masses of volcanic clastics carried by turbidity flows at avalanche speed (FAZLIAKHMETOV 2011). That is the probable reason why we have no conodont findings in the accumulated thick layers of the Ulutau Formation. The time interval corresponding to the ?*hermanni-cristatus* – *disparilis* Zones is characterized by decreased depths in the basin. The maximum Pashiya regression clearly marked in the shelf sections by a deep washout manifested itself in the paleo-oceanic zone by widespread occurrence of large biohermic structures with benthic stromatoporates, corals, brachiopods and ostracods. Conodonts are extremely rare and can be found only as solitary specimens.

The volcanism finally stops acting in the *falsiovalis* Zone, and in the *transitans* Zone there occurs an acute change in the sedimentation scenario associated with increased depths. High organic content plays a noticeable role in the sediments. Rocks are dark-grey and black in colour. In the *punctata* Zone depths reach their maximum all over the South Ural region. The time interval corresponding to the *punctata* – *hassi-jamieae* – Late *rhenana* Zones is the period of prolonged geodynamically quiet conditions on the eastern slope without volcanic effusions. At that time thin-layered siliceous and siliceous-clayey deposits (Mukasovo Formation) are accumulated for the most part all over the territory of the South Urals (with bituminous limestones on the western slope in addition). Benthic faunas are rarely found. Nektonic faunas, i.e., tentaculites, ammonoids and conodonts, have a dominant role. Radiolarians are also widespread. Conodont assemblages from these deposits are diversified both with regard to species content and quantity. If conodont assemblages of the *punctata* Zone that occur in cherts involve 8-10 species belonging to the genera *Ancyrodella*, *Mesotaxis* and *Palmatolepis*, those of the Late *rhenana* Subzone contain 17 species of the genus *Palmatolepis*. The number of specimens in each species varies from 15-20 to 50-70 respectively.

Last explosion-type volcanic eruptions take place in the *linguiformis* – Early-Middle *triangularis* Zones. The area of volcanic activity reduces. Eruptions supply enormous masses of volcano-sedimentary material, including mixtites. Conodonts preserve higher diversity in the *linguiformis* Zone. Representative of the genus *Palmatolepis* are also dominant. Some species of the genus *Ancyrodella* are practically always present in the assemblages whereas the *Ancyrognathus* species are sporadic. The assemblages of the Early-Middle *triangularis* Subzones are characterized by an extremely poor species composition that involves only four species.

Beginning with the Late *triangularis* Subzone up to the end of the Famennian time volcanic activity in the South Urals covers a limited area within the East Magnitogorsk Zone. Thick flysch units (Zilair Formation) evolve within the West Magnitogorsk Zone. At that time interval an increase in conodont species diversity and number is noted in the Late *triangularis* and *crepida* Zones. In the *marginifera* Zone the conodont association is distinguished for a considerable species diversity with more than 20 taxa. In the *expansa* Zone there occur pronounced taxonomic changes at the genus level. The genera *Bispathodus*, *Neopolygnathus* and *Pseudopolygnathus* make their first appearance alongside the genus *Palmatolepis*.

Thus, the conodont distribution analysis for the Devonian section of the eastern slope of the South Urals shows a certain dependence on the type and duration of volcanic processes. Fissure volcanism accompanied by gas emanations definitely had a strong influence on chemical composition and temperature of seawater. It is evident that during hiatuses planktonic growth tended to increase nektonic faunas first of all. Explosion-type volcanism contributed to accumulation and transport of great masses of sedimentary material formed quickly in the hydrodynamically active setting. Water body was probably saturated with suspended small particles responsible for turbidity. These factors could adversely affect the composition and biotic diversity. In contrast, very long non-volcanic phases of stable and quiet sediment genesis under deepwater conditions in the absence of flows were

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accompanied by gradual equivalent accumulation of biomass (both nutritional components and consumers).

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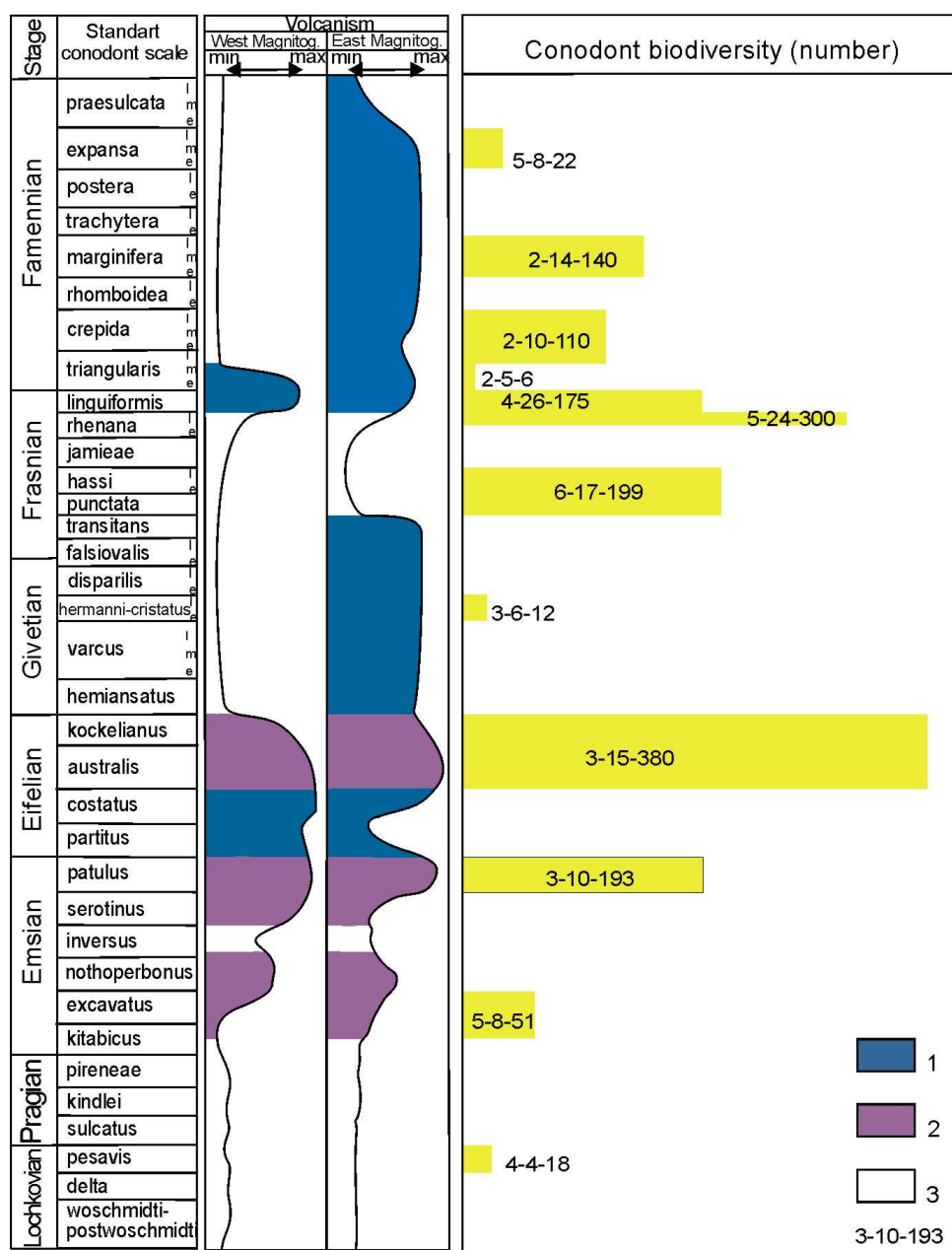


Fig. 1: Volcanism intensity curve in the Devonian of the Eastern South Urals (Magnitogorsk megazone) and Conodont Biodiversity. 1 – rift basalts, 2 – volcano-ark deposits, 3 – deposits without volcanites. The numerals designate content of conodonts: the first is the number of genera, the second is the number of species and the third is the number of specimens.

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