Since the Late Emsian the geological history of Devonian sedimentation in the South Ural Basin of Russia was associated with the evolution of volcanism responsible for vastly different facies environments over a long period of time – from the Late Emsian until the Late Famennian. Maximum manifestations of volcanism took place in the Magnitogorsk Megazone; much less masses of volcanic rocks are characteristic of the Kuragan-Sakmara zone. A significant deepening of the basin was associated with rift basaltic volcanism at the end of the costatus Conodont Zone and continued through the australis and kockelianus zones. Prolonged deepening in the Frasnian began in the punctata Zone and continued until the tectonic calm of the Late rhenana Zone. Maximum shallowing occurred at the end of the varcus zone. Faunal changes followed with the more pronounced mass extinction of different faunal groups occurring at the F/F boundary.

Key words: Devonian, South Urals, correlation, Zilair, Magnitogorsk megazones, Kuragan-Sakmara zone, conodonts, volcanic succession.


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Devonian deposits in the South Urals are presently subdivided into small stratigraphical units correlated with each other on the basis of conodont research (Antsygin et al. 1993). In keeping with the zonation for the South Urals, the western slope involves the Zilim-Zigan and West Zilair zones with shelf deposits as well as the Kuragan-Sakmara and East Zilair zones with bathyal complexes. All the other zones are situated within the eastern slope and are characterized by paleoceanic basin deposits (Fig. 1).

The western slope of the South Urals shows a domination of carbonate sediments whereas the eastern slope is distinguished by the volcanogenic character of the rock sequence. Devonian carbonate deposits are well studied and subdivided into horizons on the basis of macrofossils (brachiopods and corals). For many years the subdivision of volcanic sedimentary complexes of the Magnitogorsk Megazone was based on their composition; in most cases their age was conventionally assigned either by identification of macrofossils from extremely rare biothermal limestone bodies or by the position of the strata in the sequence. Inevitably, the stratigraphy of these volcanic sedimentary complexes was a matter of various subjective speculations and caused many debates. Any correct correlation between them and the Devonian deposits of the western slope was apparently out of the question.

The application of the conodont fauna for subdividing and determining the age of the volcanic sedimentary rocks undertaken by us since 1973 has made it possible to change the situation. At present we have a very rich collection of conodont imprints from siliceous rocks throughout the whole Devonian sequence at the eastern slope and the Kuragan-Sakmara Zone of the South Urals. The age of the local stratigraphical units has been determined, and the volcanic sedimentary complexes have been correlated with the horizons of carbonate sections of the western slope. The revised stratigraphical scheme of the Devonian deposits within the Magnitogorsk Megazone is now characterized to an unprecedented level of detail (Maslov et al. 1993; Artuyushkova & Maslov 1998, 2005; Maslov & Artuyushkova 2000, 2002).

During the last two decades, new evidence on the Devonian stratigraphy in the South Urals has been gathered in quantity either by the authors or through their cooperation with other geologists. The obtained data and detailed paleontologic studies from some problematic stratigraphic intervals now make it possible to determine and equate in time major geological events of the region, which find their reflection in the facies specific nature and response of faunal assemblages.
In Devonian time the South Ural Basin constituted a single intricately evolved water area, including a marginal sea with continental shelf, slope and rise zones and an “oceanic sector” within the Magnitogorsk Arc (Zonenshain et al. 1984, Ivanov et al. 1986, Korinevsky 1988, Puchkov 2000).

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**Stratigraphy and the main regional events**

In Devonian time the South Ural Basin constituted a single intricately evolved water area, including a marginal sea with continental shelf, slope and rise zones and an “oceanic sector” within the Magnitogorsk Arc (Zonenshain et al. 1984, Ivanov et al. 1986, Korinevsky 1988, Puchkov 2000).

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**Early Devonian**

The Early Devonian period shows evident ‘heritability’ of the main facies zones from Late Silurian time. Deposits of the Siyak Horizon (*Cladopora actuosa, Neomphyma origi nata, Lanceomyonia borealiformis Zone*) established at the base of the Lochkovian Stage are represented by gray bedded limestones with lens-shaped interbeds of clay shales. They make a gradual transition from underlying Silurian deposits. This level is marked by the appearance of the Devonian brachiopod genera *Neomphyma, Ivdelinia* and corals *Riphaeolites, Pachyfavosities, and Acanthophyllum*. There is also a drastic impoverishment of the Silurian fauna with only infrequent specimens of *Lissatrypa kuschevensis* (Tschern.) (Tyazheva et al. 1976). The very few conodonts are represented by *Icriodus woschmidti*. The Siyak Horizon is 45 to 70 m thick. From the Late Lochkovian to the Early Pragian (the Sherlubai and during the whole Kulamat time), reef limestones, up to 1000 m thick, formed a well-exposed continuous belt of 250 km length, fringing the Bashkirian Upland along the eastern latitudinal length of the Belaya and in the basin of the Bolshoi and Maly Ik Rivers (Krauze & Maslov 1961). Reef fragments found in the Beloretsk and Tirlyan synforms allow a reconstruction of their borders with the assumption of the existence of a barrier reef. The lowland area was supposed to be located in the west within the Bashkirian Upland and in the form of local elevations in the East-European Platform. Transreefal facies were probably eroded because of a pre-Emsian (pre-Takata) break. Terrigenous rocks are preserved locally as sandstones of the Khelebodarovo Formation (Tchibrikova 1977). At the continental slope and rise situa ted more to the south and east, within the Kurgan-Sakmara and East-Zilair zones as well as the Pre-Sakmara-Voznesenska Subzone, there accumulated siliceous-clayey, siliceous and silico-clastic deposits, sometimes with detached masses of biogenic limestones (upper Sakmara, Akchurino and Mazovo formations). In all probability, these organogenous limestones, spread widely in the sections of the Magnitogorsk Megazone between the latitude of Magnitogorsk and that of the town of Miass, were generated at elevated areas of the continental rise in the form of biohermal structures. It is possible that in the Early Devonian these structures constituted a carbonate platform. During that time interval the basin depths varied within the limits of the calcium carbonate compensation depth (CCD). No dated manifestations of volcanism can be found at that time in the South Urals (Figs 2, 3).

In Early Emsian time the sedimentation pattern changed to an essential degree. Facies environments became increasingly diverse both in the shelf zone and in the paleoceanic sector of the basin. Faunal assemblages underwent a rapid transformation accompanied by total extinction of Pragian taxa. Transgression that began during Takata time significantly enlarged the basin area. An important influence on the processes of sedimentation was also exerted by early manifestations of pre-arc Devonian volcanism (alkaline basalts of the Chanchar and Mostostroevsky complexes). The terrigenous composition of the Takata Formation (West-Zilair Zone) consisting mainly of different grain-sized quartz sandstones, some-
times of gravel size, unsorted clastic material, peculiar oblique bedding and absence of faunal remains, does not provide an unambiguous answer to the question of their origin. Sharing the opinion of Domrachev (1952), Nalivkin (1952), Adrianova & Spassky (1953, unpublished), we are inclined to think that the facies environments were formed in shallow sea waters with a markedly moving coastline. Clastic material was supplied mainly from the Bashkirian Upland. In the eastward direction to the open sea, sandstones were facially replaced by shallow-water bedded dark-colored limestones with *Favosites regularissimus* Yanet, which contain lens-shaped interbeds of quartz sandstones (Irgizla Formation, up to 80 m thick). Still further to the east there also appear bathyal complexes of the continental slope consisting of siliceous siltstones, cherts, sometimes monomictic clastites of different sizes (Khutorskaya Series in the East-Zilair Zone, upper Akchurino Series in the southern Kuragan-Sakmara Zone, and Mazovo Formation in the Pre-Sakmara-Voznesenska Subzone). Silicocterrigenous rocks with organogenous limestones found in a number of sections (Ryskuzhino, Uskul, Iltibanovo and Turgoyak series) along the marginal part of the West-Magnitogorsk Zone might have been deposited in a compartmented trough with elevated seafloor areas, where biothermal structures were formed. To the north of the zone the basin depths were less than the CCD; perhaps, the floor underwent slow subsidence, so that sandy-siliceous deposits were spread there together with abundant organogenous sandstones in the form of relatively thick bioherms. As a whole, the Early Devonian interval, including the lowermost *serotinus* Zone, is characterized by a brief transgression (Vanyashkino Formation) that is most probably synchronous with the beginning of the Baimak-Buribai volcanism (Fig. 3) in the Magnitogorsk Megazone (Baimak-Buribai and Kiembai formations).

The subsequent history of Devonian sedimentation in the South Uralian Basin was associated with the evolution of volcanism responsible for vastly different facies environments over the long time span from the Late Emsian to Late Famennian. The bathymetry of the basin offered great
contacts. Maximum manifestations of volcanism took place in the Magnitogorsk Megazone. Much less mass of volcanic rocks are characteristic of the Kuragan-Sakmara Zone (Seravkin et al. 1992).

During the Late Emsian, from serotinus time on, the shelf-occupied area (western slope of the South Urals) remained virtually constant; horizons of Koiva quartz sandstones occurring in this region mark the beginning of a new transgressive cycle. Accumulation of silicicites and manifestation of “early island-arc volcanism” (Seravkin et al. 1992) (Utyagulovo Formation in the Kuragan-Sakmara Zone) mark basin deepening and suggest that sedimentation took place in the continental slope environments. Early island-arc volcanites of the Baimak-Buribai and Kienbai formations were formed in the Magnitogorsk Megazone over a considerable area covered with rift-like units (Seravkin et al. 1992). Contrasting rhyolite-basaltic volcanism showed itself in deep-water settings, below CCD, as evidenced by the complete absence of limestones and the development of jaspers (Fig. 3B).

During the Late–Early Eifelian (patulus–coptatus zones), the basin moved westward under conditions of compensated subsidence. Reef limestones of the Biya Horizon (patulus–partitus zones) accumulated on the shelf, and in the beginning of the costatus Zone they gave way to black and dark-gray bituminous limestones, siliceous and clay shales of the Afonino Horizon. Andesite-basaltic volcanism characteristic of primitive island arcs (Utyagulovo and Irendyk Formations) continued in the Kuragan-Sakmara and West-Magnitogorsk zones (Seravkin et al. 1992). This stage is associated with the generation of the thick Irendyk submarine volcanic ridge, which is about 400 km long, as seen in the present-day structure. The end of volcanism is marked in the costatus Zone by shoals of shell deposits and bioherms accumulated on the crests of the Irendyk ridge and comprising brachiopods, corals and crinoids (Gadilevo Series).

Middle Devonian

From the beginning of the costatus Zone till the very beginning of the Domänik time, pelagic sediments (the condensed siliceous section of the Aktau Formation) accumulated westward from the Irendyk Arc within the fore-arc basin below the CCD.

Such a dramatic change of sedimentation pattern at the boundary between the partitus–coptatus zones was evidently induced by a sudden increase of sea level, resulting in the development of anoxic facies (Afonino Horizon) and biohermal growth in the elevated areas of the volcanic ridge (Fig. 3). In all probability, the distinct local deepening can be correlated with the Choteč Event (Walliser 1996).

Diffuse spreading that began from the australis Zone showing itself in the Kuragan-Sakmara and Kraka zones, with its maximum in the Magnitogorsk Megazone, promoted faster subsidence of the basin floor. During australis–kockelanism time there evolved thick volcanic units of the jasper-basaltic association: the Karamalytash and Gumbeika formations and synchronous jaspers of the Yarlykapaovo Series in the Magnitogorsk Megazone; the Ishmuratovo Formation in the Kuragan-Sakmara Zone; and thick jasper-like radiolarian cherts in the Sukhteli and Kochkar-Adamovka zones. Siliceous-clayey-carbonate sediments of the Afonino Formation (infra-Domanik) accumulated within the shelf. This time interval is marked by one of the greatest stages of silica accumulation in the Devonian of the South Ural Basin. The faunal association changes drastically, with a major increase in diversity of conodonts, tentaculites and radiolarians.

The Givetian is marked by a gradual decrease in the basin depths, with a maximum fall of sea level during the Pashiya Formation time (Fig. 3A). At least two transgressive-regressive cycles are evident in the shelf zone, with their boundaries running in the lowermost Chusovaya and Pashiya formations. At that time the Kuragan-Sakmara Zone constituted a deep-water region, with mainly siliceous sediments. In the East-Magnitogorsk Zone there was an island arc, which supplied sedimentary material westward for the Ulutau Formation. The extinct Irendyk Arc then served as a barrier against clastic transport to the west. The explosive character of the Givetian volcanism favoured the generation of submarine elevations and temporary islands, formed by corals, stromatoporoids, brachiopods, with locally growing bioherms.

The end of the varcus Zone was characterized by shallow-water conditions on the shelf. At that time massive indistinctly-bedded stromatopore-coral limestones of the Cheslava Horizon were generated with Stringocephalus buritii. By the beginning of the Pashiya time continued shoaling reached its maximum; at that stage the basin can certainly be identified as that of ‘super-shallow’ type. Indeed, over a vast territory the sedimentary environments were almost similar to littoral ones. Everywhere in the sections of the Pashiya Horizon (several metres to 40 m thick) one can find quartz sandstones and frequently ferruginous sandy-clays containing plant remains. The maximum depth of the break is observed in sections further to the west, where Pashiya sandstones are seen to overlie Emsian Biya limestones. By the beginning of Pashiya time the Stringocephalus fauna, Givetian corals and ostracodes became extinct, and Frasnian miospores of the optius–krestovnikovi Zone make their first appearance (Avchimovich et al. 1993). The Pashiya Horizon is a distinct marker showing large regional shoaling comparable most probably to the Taghanik Event (Johnson & Sandberg 1988). Terrigenous deposits of the Pashiya Horizon mark the beginning of a new sedimentation cycle. In Kyn (Timan)
time, which terminates the Givetian, slow basin deepening takes place, and clay limestones, marls and clays are deposited. The Kyn Horizon is only insufficiently correlated with the international conodont scale. The horizon varies in thickness from 0.25 to 15 m (Abramova 1999). Faunistically, it is poorly characterized, with only rare finds of the brachiopod *Uchtospirifer murchisonianus* (Vern.) and ostracodes.

The overlying deposits of the Sargaevo Horizon (Late falsiiovalis-transitans zones) begin the Frasnian Stage (Fig. 2). Here, deep-water black and dark-gray bituminous limestones make their appearance; the fauna becomes much more diverse; ostracodes, tentaculites, goniatites and conodonts play an increasingly important part, alongside brachiopods, corals and stromatoporoids.

In Domanik time (*punctata-jamiae* zones), the basin deepening reached its maximum and covers the whole territory of the South Uralian Basin in question. An increase in depth was due to general stabilization of geodynamic conditions in the South Urals. The complete suppression of volcanism occurred in the Magnitogorsk Megazone. Most likely the basin floor underwent an irregular uncompensated subsidence at that time. The shelf zone extended westward as far as the East-European Platform and is characterized by a relatively intricate floor relief with isolated wide depressions and elevated areas. During that time interval, the black siliceous-clayey shales and bituminous limestones of the Domanik Formation were formed on the western slope of the South Urals, being rich in deep-water faunal remains of *Radiolaria*, *Styliolina* shells, goniatites and conodonts. The accumulation of these deposits still continued in Mendym time (Early rhenana Zone). The base of the Early rhenana Zone is associated with the onset of the goniatite *Manticoceras intumescense* Beyr. (Abramova 1999). Siliceous and siliceous-clayey sediments of the Ibragimovo Formation were accumulated further eastward within the continental slope. In and outside the Magnitogorsk Megazone, along the fringe of the

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**Figure 3.** A – Correlation of the sea-level curve for the Devonian in the Middle and East Europe: 1 – on the West slope of the South Urals; 2 – on the Central area of the Russian Platform (Karaulov & Gretschischnikova 1997); 3 – on the southeastern Russian Platform (Yunusov *et al.* 1997); 4 – in the Czech Republic (Chlupáč 1988). • B – sea depth changes curve and volcanism intensity curve for the Devonian of the South Urals (Magnitogorsk megazone). a – rift basalts, b – volcano ark deposits, c – deposits without volcanites, CCD – Calcium carbonate compensation depth.
East-Uralian Upland (Sukhteli and western part of the Kochkar-Adamovka Zones) silica accumulation encompassed a vast region and continued into Askynian time, including the Late *rhenana* Zone. This stage is related to the generation of condensed siliceous sequences of the Mukasovo Formation as well as the Babaryk, Arsy and Solonchakta series. The silica accumulation process was periodically disrupted by volcano-telligenous material brought by turbid flows and entrapped in the deepest basin reservoirs. It is best seen within the Kyzil-Urtazym Syncline of the West-Magnitogorsk Zone (Maslov & Artyushkova 2002). Available evidence suggests that the Irendyk and Ural-Tau ridges were submerged and overlapped with siliceous deposits during the *punctata-rhenana* zones time. This time interval represents the greatest and longest stage of silica accumulation in the South Uralian Basin; in the shelf zone it is marked by hypoxic shales of the Domank Formation. Contemporaneous rocks on the western and eastern slopes of the South Urals are comparable in their thicknesses and vary from 20 to 150 m. The Domank Event is clearly traced over a considerable territory of the East-European Platform; the associated deposits have been well studied in the sections of the South Timan (House et al. 2000). In the North American continent it is correlated with the New York Middlesex and Rhinestreet black shales (House et al. 2000, fig. 12).

Differentiation of the basin started in Mendym time (Early *rhenana* Zone) and is associated with a gradual uprising of the ocean floor, which becomes more pronounced during Askyn time (Late *rhenana* Zone); facies environments become much more diverse and find their reflection in the composition of the deposits and faunal assemblages. The shelf zone showed an alternation of relatively deep-water uncompensated depressions, with the accumulating Domank-like facies, and shallow areas, in which psammitic and clay sediments were deposited and locally colonized by amphipores and stromatopoids (Orlovka and Ust'-Katav formations). The transition zones between were occupied by reef-like structures ‘‘with indistinctly separated bioherms’’ (Chuvashov 1968). During Askyn time (possibly earlier in the Frasnian) of the East-European Platform, the Kama-Kinel system of depressions came into existence, individual branches of which can be traced as far as the western slope of the Urals. These depressions accumulated deep-water deposits throughout the whole Late Devonian.

Frasnian/Famennian boundary interval

The Late Askyn and Barma (*linguiformis* and Early-Middle *triangularis* zones, respectively) are important time intervals in the development of the South Uralian Basin. Shoaling that begins in the Late *rhenana* Zone is marked by the absence of any deposits of this stratigraphical interval in many sections and in some regions the duration of the break ranges into the *marginifera* Zone. In continuous sections, the Askyn reef-like limestones are overlapped by Barmian brachiopod-shell deposits (Abramova 1999, Abramova & Artyushkova 2004). In depression sections, well-exemplified by the Lemezinsky section, the *linguiformis* Zone contains thin-bedded black bituminous limestones rich in diverse faunas, primarily in goniatites of the genus *Manticoceras* and numerous conodonts (Abramova 1999, Abramova & Artyushkova 2004). By early Barma time, the richest and most diverse conodont assemblage of the *linguiformis* Zone almost entirely disappears. Brachiopods of the genera *Gypidula, Hypothyridina, Theodossia, Pseudoatrypa, Spinatrypa, Warrenella* and *Thomasaaria*, which formed the basis for the Askyn association, suffer complete extinction. Different *Manticoceras* species that constitute the main part of the Frasnian goniatite associations in the deep-water sequences (Abramova 1999, Abramova & Artyushkova 2004) also become extinct.

Within the West-Zilair Zone, the Frasnian/Famennian boundary interval is more clearly pronounced. The uppermost Askyn Horizon in the Yaumbaevo section, which we correlate with the *linguiformis* Zone, consists of loose crinoidal limestones. They are overlapped by polymeric flysch deposits of the Zilair Formation characterized 0.7 m above the base by conodonts of the Late *triangularis* Zone (Abramova et al. 1998). In the upper meridional part of the Belaya River, a gradual transition from Frasnian to Famennian deposits is found in the sections of Kagarmanovo, Ilyukhina Glade and the Chernaya River mouth (Yakupov et al. 2002, Abramova & Artyushkova 2004). Here, gray medium-bedded goniatite limestones of the *linguiformis* Zone, 2–3 m thick, are overlapped by intricately folded finely-plated siliceous-clayey shales and siliceous siltstones, not more than 20 m thick in total. At the contact between these limestones and silico-telligenous rocks, a bed of greenish-gray ferruginous siliceous-carbonate shales, 0.1 m thick, can be seen overlapped by a stratum of variously plated cherts. The base of this cherty stratum shows thin interbeds of silicified limestones and carbonate concretions with conodonts characteristic of the *linguiformis* Zone. The upper half of the unit reveals some rare *Pa. triangularis* Sannemann, whereas the top contains a fairly rich conodont assemblage characteristic of the Late *triangularis* Zone. This assemblage dates the base of the overlying Zilair Formation. We consider the siliceous-clayey unit to be transitional between the carbonate section and the flysch Zilair Formation. In all probability, this type of stratigraphical section characterizes a relatively narrow transitional zone from shelf facies proper to a slope bathyal one.

At the continent slope within the boundary interval occur thin flysch deposits of polymeric composition simi-
lar to the rocks of the West-Magnitogorsk Zone. The same time interval coincides with the beginning of the final stage of Devonian volcanism in the Magnitogorsk Megazone. Volcanogenic facies of the matured island arc are widespread (Bugodak, Ablyazovo and Sheduivye Gory series) and reach their maximum development in the East-Magnitogorsk Zone. At some distance away from the zones of active volcanism, these volcanic complexes correlate in time with polymeric flysch, several to hundreds of metres thick, and associated with mixite complexes (the Biyagoda Olistostrome).

Available information concerning the Frasnian/Famennian boundary interval from the South Ural sections makes it possible to say that the global biotic events known as the Kellwasser Crisis (Walliser 1986), with a mass extinction of many taxa belonging to different faunal groups, is well recorded in this region. Within the territory in question it is associated with dramatic changes of the biota at the boundary between the linguiformis and Early-Middle triangularis Zones. Sedimentologically, this event as prolonged as the time interval corresponding to the linguiformis to Early-Middle triangularis Zones is evidenced by: (a) a generation of brachiopod shell deposits; (b) black bituminous limestones very rich in goniatite shells; (c) stratigraphical breaks of different duration; (d) turbidites of the flysch facies with consedimentary olistostromes; and (e) an outbreak of matured island-arc volcanism.

The Famennian Late triangularis Zone is marked by the formation of flysch greywacke sequences of the Zilair Formation accumulated over a vast region of the West-Magnitogorsk Zone and in the Zilair Synform and by infilling a huge meridionally elongated trough (Puchkov 2000). At that time the shelf outer boundary moved westward, where there appeared relatively shallow sedimentation settings with sporadically dried-up shoals (this is indicated by some stratigraphical lacunas). Depressed areas were infilled with siliceous-calcareous and clay material. Volcanism terminating the island-arc stage lasted until the end of the Famennian; this was the time when the Novoivanovka and Shumilino series were formed (Figs 2, 3).

The main source of clastic material for the Zilair flysch was restricted to the active volcanism location in the East-Magnitogorsk Zone, from which it was supplied by turbid flows. The assumption is that the East Uralian Upland uplifted in the Famennian and might have served as a main source of clastics (Smirnov & Smirnova 1961, Veimarn et al. 1998) is not supported by the evidence. Other sources of clastic material were of less importance. Within the West Zilair Zone distal parts of the turbid flows are found as roofing slates (the rise of the Zilair Formation). This proven synchonic lower boundary pattern of the lower Zilair Formation established by conodont sequence in continuous sections (Artyushkova & Maslov 2005), does not permit any alternative opinion on the existence of the two basins (to the west and east) separated from each other by the “Uraltau Cordillera” (Mizens 2002, Gorozhanina & Puchkov 2001). Indirect evidence for the viewpoint of a single basin comes from the established stratigraphical interval encompassing the marginifera Zone and consisting of interbedded cherry and green clay siltstones, sometimes with the layers of pink limestones with many conodonts. Traced in the West-Magnitogorsk, West-Zilair and Kuragan-Sakmara Zones, it undoubtedly marks a deepening of the sea.

By the end of the Famennian, the basin depths gradually decrease, with their minimum occurring early in the Carboniferous period. Submarine volcanic activity reduces, and surface or shallow-sea facies begin to occur.

Conclusions

All the most clearly pronounced sedimentological events reflected in the sedimentary sequences of the western slope in the South Ural are sufficiently well correlated with manifestations of volcanic activity in the Magnitogorsk Megazone under submerine conditions (Fig. 3B).

The grombergi-inversus zones show the very first manifestations of alkaline volcanism as in the passive continental margin (Seravkin et al. 1992). This event corresponds to the beginning of the Takata-Vanyakshkino transgression.

During the serotinus Zone, relatively vigorous volcanism begins in the submarine riftogenous structures. Volcanogenic complexes of the rhyolite-basaltic copper pyrite-bearing unit were in the process of development (Lower Utyagulovo Formation in the Kuragan-Sakmara Zone, Baimak-Buribai and Kiembai formations in the Magnitogorsk Megazone). In the shelf zone this time is indicated by the beginning of the Koiva transgression.

At the end of the costatus Zone and mainly in the australis-kockelianus Zones, a new vigorous outbreak of riftogenic rhyolite-basaltic volcanism that occurred in the Kuragan-Sakmara (Ishmuratovo Series), West-Magnitogorsk (Karamalytash Formation) and East-Magnitogorsk (Gunbeika Series) zones coincided with basin deepening; the latter reveals itself primarily in the generation of deep-water jaspers and cherts as well as black bituminous limestones and siliceous-clayey rocks of the Afonino Horizon in the shelf zone.

In the succeeding time (after the kockelianus Zone), the territory of the Magnitogorsk Megazone developed under intense island-arc volcanism. In the West-Magnitogorsk Zone volcanism stopped, whereas in the East-Magnitogorsk Zone it continued with varying intensity up to the end of the Devonian, since it was related to mature still-functioning island arcs. From the end of the Givetian to the early Frasnian, a discrete wave of volcanism probably took place; from that
time the section displays closely-spaced mixtite volcaniclastic beds with fragmented *Stringocephalus* limestones, interbeds of volcanomictic sandstones with Givetian brachiopod coquinas and limestone bioherms. In the shelf zone on the western slope of the South Urals, this time interval shows the maximum basin shoaling.

The longest time span without any volcanic activity falls within the *punctata*-Late *rhenana* zones, when the relatively shallow-water regime abruptly changed to a deep-water one. Submarine volcanic structures were then submerged below the CCD. Relatively thick siliceous beds in the Magnitogorsk Megazone and Domanik facies in the shelf area were formed under stable hydrodynamics in the absence of near-bottom flows.

After a long dormant volcanic period and sedimentation the next extensive outbreak in volcanic activity falls within the Frasnian/Famennian boundary interval. Intense explosive volcanism accompanied probably by tsunami resulted in the generation of thick creep mixtites (the chaotic complex of the Biyagoda Olistostrome) and also contributed to a distinct reduction of basin depths. At the same time limestone bioherms (at Lake Koltuban) were formed on the submarine elevations at a distance well-removed from the centers of volcanism. Brachiopod shell deposits of the Barma Formation accumulated under shallow-water conditions in the shelf zone. This was the time of an abrupt change in the sedimentation pattern. The beginning of collision tectonism and general land subsidence caused the accumulation of the flysch of the Zilair Formation in the East-Magnitogorsk Zone.

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