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Precambrian and Paleozoic of the Caucasus (Brief Synthesis)

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With 3 figures

Project Ecostratigraphy

Schlüsselwörter
Orogene Komplexe
Paragenesen
Formationen
Kaukasus
Paläozoikum
Präkambrium

Inhalt

In connection with the studies following Project 5 "Prevariscis and variscic events of the Mediterranean belt" of the International Program of Geological Correlation, it became necessary to sum up our knowledge of Prealpian complexes of the major regions of the belt. The given paper is a generalization of the data on Premesozoic complexes of the Caucasian segment of the Mediterranean belt.

The authors have been working in the Caucasus for about 20 years, so they know all its zones. Numerous data of many researchers studying the geology of the Caucasian Prealpian complexes have been used in this work. It should be said, however, that a limited number of sheets does not allow us to give a complete list of references.

Paleozoic and Precambrian complexes of the Caucasus are located in various tectonic areas shown in Fig. 1.

In the north of the East European platform adjoins the Caucasus by the Rostov salient of the Ukrainian shield and continuation of the Donets downwarp. To the south of the old platform a young Skiphean platform is situated. Further on, there occur foredeeps and the Alpian folded area. Prealpian com-

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plexes crop out in the nucleus of meganticlinorium of the Greater Caucasus and in the zone of its southern slope within the alpine folded area. Three Hercynian zones can be distinguished in the nucleus: Bechasin zone, that of the Forerange and the Major Range.

On the south the Prealpian base is exposed in salients of the basement of the Georgian block and in anticlinal uplifts. These outcrops correspond to the Prealpian Transcaucasian massif up to the Erzindzan-Sevan ophiolitic suture.

To the south of this suture the Prealpian complexes exposed in the Alpian structures characterize the marginal part of the Paleozoic (epibaikalian) Iranian plate.

These are some terminological explanations: the terms "orogenesis", "orogenic complex" are used in accordance with ethymology of these words, like the mountain building, "complex" related to the "mountain rise", this having been adopted in Russian geological literature.

A "formation" is not a stratigraphic term. "Parageneses" (cooccurrence) of mountain rocks are meant closely related to one another by age and space. For example, there are flysch, molassa, diabase-spilitic formation.

Ophiolites are regarded as a heterochronous petrotectonic association (DICKINSON, 1971).

Stratigraphic subdivisions: the smallest of them are suites of piles corresponding to an American term "formations". These are subdivisions of the regional stratigraphic scale; their age corresponds to series less frequently — to system. Groups are larger subdivisions that usually correspond to some systems.

Precambrian

The Precambrian complexes were recognized in the Hercynian basement of the Skiphean plate and meganticlinorium of the Greater Caucasus, in the Transcaucasian massif and the basement of the Iranian plate. These are thick groups of metamorphic rocks, usually of the sialic or intermediate type; much less frequent are melanocratic deposits occurring as tectonic detached masses in the

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Fig. 1: Scheme of Paleozoic distribution in the Caucasus. I — Rostov salient of the Ukrainian shield; II — Donbas continuation; III — Skiphean platform; a — foredeeps and intermontane depressions.

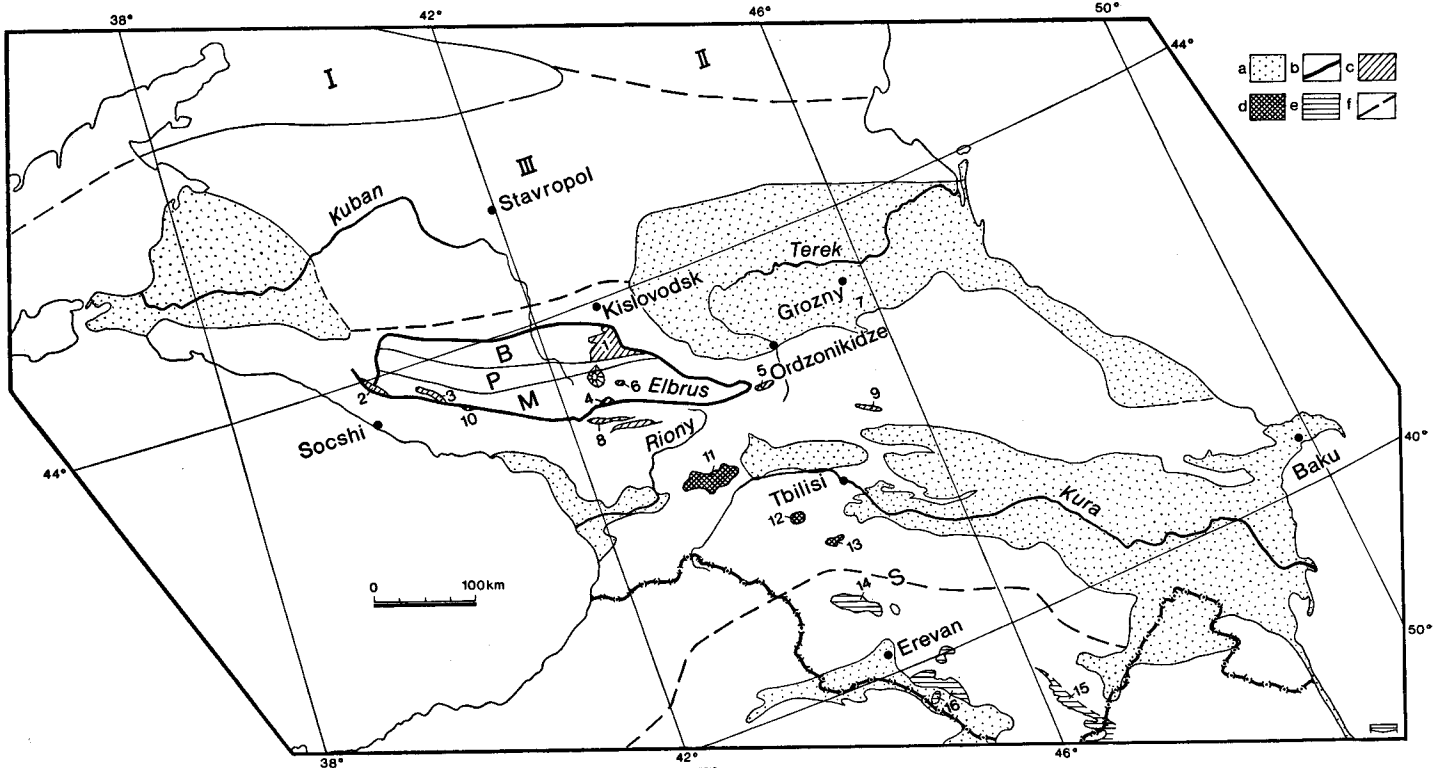
Alpine folded area:

Greater Caucasus; b — boundary of the Precambrian-Paleozoic nucleus (in places with a thin Mesozoic-Genozoic cover); c — localitets.

B — Bechasin zone, I — Upper course of the Malka river, P — Forerange zone, M — Major Range zone: 2 — Khuko region, 3 — Pseashkho region, 4 — Kvishi region, 5 — North Ocetiya region, 6 — Baksan river upper course; 7 — Holes to S-E of Grozny.

Southern slope zone. 8 — Svanetiya, 9 — Kakthetiya. — Salients of the Transcausian massif basement. d — localitets. 10 — Gorab region (Mountain Abkhasiya), 11 — Dzirulsky salient, 12 — Khramsky salient, 13 — Loksky salient.

Marginal part of the Iranian (prealpine) plate. e — localitets. 14 — Miskhansky (Arzakansky and Aparansky) salient, 15 — Zangezur region, 16 — outcrops in the south of Armenia and in the Nakhichevan ASSR; g — some large faults at the boundary of the zones. S — Erzindzhan-Sevan ophiolitic suture.


38°
42°
46°
50°
44°
40°
I
II
III
Kuban
Stavropol
Terek
Kislovodsk
Grozny
Ordzonikidze
Elbrus
B
P
M
Socshi
Rion
Tbilisi
Kura
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16

Fig. 1

Alpine ophiolitic zones. This last can likely be the lower parts of the old continental crust and the underlying mantle.

Complexes correlated to those of the Ukrainian shield were penetrated by drilling in the Pre-Caucasian region, within the subsided continuation of the Rostovsky salient. The Archean complex includes rocks with the K-Ar age equal to 2000—2150 m. y. These are granites, plagiogranites, granite-gneisses, plagiogneisses, biotite-hornblende gneisses, amphibolites. Proterozoic deposits appear to be composed of granites with the K-Ar age of 1390 m. y., microgneisses, amphibole-epidotic, biotite- and sericite-chloritic, hornblende and calcareous schists resembling the Saksaganian series of the Ukrainian shield.

In the central part of the Bechasin zone the Precambrian deposits crop out from under Jurassic deposits in the deep-seated valleys of Chegem, Malka, Baksan and Kuban. Stratigraphy of these deposits is open to the question. Many of geologists distinguish two groups in them: Khasautskaya and Chegemskaya, their stratigraphic relationships being obscure. The Khasautskaya group in the section along the Malka river can be divided into three major stratigraphic units. 1) The lower unit is composed of rocks belonging to the epidote-amphibolitic facies, i. e. biotite-quartz and binary micashists, paragneisses and amphibolites, their thickness being up to 800 m. 2) Higher up the section there occur less metamorphosed tuffoids, intraformational conglomerates with pebbles of plagiogranite-porphyries, phyllites and limestones. Thickness is about 1000 m. 3) Still higher up, thin-laminated metatuffites alternating with sericite-chloritic schists appear to lie conformably. The thickness is up to 1000 m. This pile is overlain with washout and angular unconformity by Lower Cambrian (?) conglomerates and sandstones. This testifies to the Precambrian age of the Khasautskaya group, or, at least, of its considerable part.

The Chegemskaya group is exposed in more southern regions of the Bechasin zone. It is composed of various, complicated by the composition, rocks of sedimentary and volcanogenic-sedimentary genesis. Metamorphism of these rocks corresponds most frequently to the epidote-amphibolitic facies, descending sometimes down to the green schist facies. These rocks contain various amounts of quartz, albite, hornblende, biotite, epidote and calcareous schists. Some thick packets are composed of muscovite-quartz schists and quartzites associated sometimes with gematitic schists. In addition to, there is a pile of porphyroblastic chlorite- and muscovite-quartz-albitic schists that composes independent tectonic sheets overthrusting other piles with slightly pronounced albitization. Some parts of the section of the Chegemskaya group can be correlated to the Khasautskaya group. The Rb-Sr age of the porphyroblastic micaschist from the region of the Daut river is 870 m. y.

Within the tectonic zone of the Forerange, a thick (about 3500 m) complex of amphibolites, garnet and micaceous plagiogneisses and albitized muscovitic schists exposed in the basins of the Malaya and Bolshaya Laba rivers, is attribeted by some authors to the Precambrian. Amphibolites are developed below; in the upper part of the section metapelitic schists are

predominant. In its middle part there are lenses of eclogites and disthenic schists that a likely to evidence of existing here an old tectonic surface. It is assumed that the contact of the given complex with the overlying slightly metamorphosed Devonian deposits is tectonic every where. However, some geologists find here gradual transitions and asign the rocks of higher degrees of metamorphism to the Paleozoic as well. The known the absolute age datings of crystalline schists and gneisses do not contradict this assumption.

The presence of Precambrian metamorphites in the tectonic zone of the Caucasian Major Range is an extremely debatable question. Some of geologists believe that almost all Preupper Paleozoic metamorphic rocks of this area can be attributed to the Precambrian. This point of view is most probably erroneous. There are more reasons, though not enough yet, to assume that the lower part of the section of the Major Range (Central-Caucasian complex), known under the name of the Makerskaya group is of the Precambrian age. The series has the sialic composition. It comprises paraorthogneisses, micaceous crystalline schists, migmatites and very little amphibolites. Two stratigraphic units can be distinguished in many regions of the section. In the lower unit the micaceous paragneisses are predominant over micaceous crystalline schists. As a rule, more or less intensely developed migmatization can be recorded at this level. Higher up the section one can observe a thin horizon of amphibolites associated with marble. Sometimes there occur lenses of serpentinites that testify to probability of existing the discontinuity surface. The upper unit (Arkasarskaya suite) is composed of muscovitic and binary crystalline micaschists that usually contain sillimanite, andalusite and garnet, graphite being sometimes in abundance. There are interbeds of plagiogneisses, locally developed quartzites. The thickness of the suite is not less than 1000 m. G. I. BARANOV thinks that each of the above units is twice repeated in the section of the Central-Caucasian complex (i. e. BARANOV distinguished four stratigraphic units). But this assumption has not yet been confirmed by mapping.

Regional metamorphism of rocks of the Makerskaya group was proceeding under conditions of the amphibolitic facies at low pressures (andalusite-sillimanitic type). In some places, for instance, along the Indryuka river, in the field of distribution of rocks of the lower unit there occur outcrops of rocks of the granulitic facies in which migmatization is already of the superimposed character. Presence of granulites speaks in favour of the Precambrian age of the lower part of the Central Caucasian complex. Another argument is a high (790 m. y.) age dating of pegmatoid granite cutting the rocks of the Makerskaya group along the Gonachkhir river. However, this dating requires an additional confirmation, as numerous absolute age determinations of metamorphic rocks and granitoids of the Major Range do not usually yield the datings exceeding 360 m. y.

There are no analogues of Precambrian molassoid deposits in the Major Range, and the structural metamorphic history of the predominant part of the Makerskaya group is the same as that of metamorphosed Paleozoic deposits of the Forerange. This allows to think that metamorphism, deformation and, per-

haps, sedimentation of this group took place in the Paleozoic time. However, it is quite probable that the Makerskaya group is structurally heterogenous and comprises remobilized blocks that are older than Paleozoic.

On the southern slope of the Greater Caucasus the Precambrian age can be ascribed to amphibolites, hornblendites (monomineral amphibolites) and chloritic diaphthorites cropping out in small erosive windows from under the cover of Jurassic deposits to the south of the Gorabsky granitic massif in Mountain Abkhazia. These rocks are likely to be the base of the northern margin of the Transcaucasian massif. More extensive areas are occupied by the rocks of this base towards the south, in the Dzirulsky, Khramsky and Loksky salients. These are migmatized binary micaceous, biotitic and biotite-garnet metapelitic crystalline schists with interbeds of amphibolites and hornblende gneisses, i. e. the products of transformation of basic volcanites and gabbroids. Plagiogranitegneisses are of great importance in the composition of a complex. A progressive stage of regional metamorphism of these rocks was proceeding under conditions of the amphibolitic facies, and, to a lesser extent, in the Khramsky and Loksky massifs, in the epidote-amphibolitic facies. The Precambrian age of this complex is assumed due to the fact that slightly metamorphosed deposits containing organic remains of the Lower Cambrian are in a direct contact with the complex. There are also conglomerates with pebbles of plagiogranite-gneisses, the K-Ar age of which is 500 m. y. Finally, fragments of crystalline schists supplied from the south, from the region of the Transcaucasian massif, were recognized in Middle Devonian deposits of the southern slope zone of the Greater Caucasus.

In Armenia in the Miskhansky (Arzakansky) salient a metamorphic complex attributed apparently to the Precambrian has been singled out. V. A AGAMALYAN considers it to consists of two groups. The lower group was metamorphosed under conditions of the almandine-amphibolitic facies and underwent diaphthoresis of the chlorite-muscovite subfacies. The group is divided into three suites. The lower one is composed of quartz-andalusite-binary micaschists with interbeds of crystalline dolomites. Higher up the section there occurs a suite composed of muscovitic quartzites, and, to a lesser extent, dolomitic and calcitic marbles. The third suite is composed of graphitic garnet-quartz-binary micaschists and contains a horizon of marbles in its upper part. The total thickness of the lower group is about 1200 m.

The rocks of the upper group underwent metamorphism of the green schist facies only. V. A. AGAMALYAN distinguished below a suite of metaarkosic phillites containing detrital material of the lower series. The next suite had been formed at the expense of volcanites of the basaltic composition that was transformed into green schists of the albite-epidote-chlorite-actinolitic composition. Higher up the section there occur quartz-albitic porphyroids — a product of transformation of volcanic and subvolcanic rocks of the acid composition. The section ends with a suite of carbonate rocks that is likely to occur on porphyroids with a certain washout. The suite is composed mainly of calcitic marbles

with subordinate interbeds of green schists. The total thickness of the group is about 1600 m.

The Dzoraglukhskaya suite of apogabbroid amphibolites cut by plagiogranites with K-Ar age of 255 m. y. was distinguished in the Aparan region. The K-Ar age of metamorphic rocks of the Arzakan massif is not older than Middle Jurassic. The oldest deposits that are in a stratigraphic contact with metamorphic rocks belong to the Upper Cretaceous. Thus, the attributing of the Miskhan salient to the Precambrian is based on general considerations only.

Quite different is the group of metamorphic rocks in the south of the Lesser Caucasus in Zangezur (BELOV, 1968). The group is composed of intercalating phyllites and chloritic (metavolcanic, in part) shales, metasiltstones, metasandstones and shales of grey, sometimes red colour, crystalline dolomites, and less frequently limestones. The visible thickness of the stratum is 1100 m, the age being Premiddle Devonian, when judged by stratigraphic relationships; by the composition it can be correlated to Upper Precambrian-Cambrian deposits of North Iran.

A part of metamorphic and magmatic rocks known as tectonic inclusions in a serpentinitic melange of the Lesser Caucasian ophiolitic zones can be asigned to the Precambrian. The pegmatitic gabbro of the Sevano-Akerinskaya zone has the K-Ar age of 583 $\pm$ 30 m. y. Gabbro, together with associated amphibolites and plagiogranites, form the old melanocratic basement of the Alpian eugeosynclinal zone of the Lesser Caucasus. The composition of metamorphic rocks of the inclusions is extremely diverse by the lithological composition and degree of metamorphism. There are amphibolites, eclogite-like and carbonate rocks, micaceous-garnet, feldspar-biotitic and various green schists and quartzites. The K-Ar age of micaceous schists is not over 160 m. y. These figures, however, do not appear to correspond to the real age of metamorphic rocks.

Paleozoic

Paleozoic deposits are widely distributed in the Caucasus. They are presented most fully and differently in the Greater Caucasus: in the Bechasin zone, in the zones of the Forerange and Major Range, and in the zone of the Southern slope. Northwards, in the Transcaucasian region and on the continuation of the Donetsk Basin, within the Karpinsky swell these deposits were studied through data obtained from bore-holes.

In the Transcaucasian region the Paleozoic deposits have been known within Dzirulsky, Khramsky, Loksky salients of the Prealpian folded basement and in small nuclei of anticlinical uplifts in various zones of the Lesser Caucasian meganticlinorium.

System and series of the Paleozoic erathema are distinguished in the area of the Caucasus. In many places piles can be subdivided into stages, sometimes into more detailed subdivisions of the universal stratigraphic scale. At the same time the units of local regional subdivisions are widely used, i. e. suites, piles. At present all the Paleozoic systems (except for the Ordovician one) have been paleontologically proved in the Caucasus.

Lower and Middle Paleozoic

Lower- and Middle Paleozoic deposits of the Caucasus from the margin of the East-European platform up to the northern boundary of the Transcaucasian massif are attributed to different geosynclinal formations, a part of them being strongly metamorphosed. As to some Paleozoic strata of the Transcaucasian massif, it remains still difficult to determine their formational type and age interval.

Paleozoic platform deposits are distributed to the south of the Sevan-Akerinsky suture.

In the basement of the Skiphean plate of the Precaucasian region the Middle Paleozoic undivided deposits form a geosynclinal folded and metamorphosed complex of rocks including Devonian and Carboniferous deposits (Fig. 2, I). It is composed of various sedimentary, and less frequently volcanic, rocks sometimes metamorphosed to green schists and phyllites. Besides widely distributed dark clay shales, there occur sandy-silty rocks, chloritic, sericitic and coaly shales, seldom conglomerates, cherts, limestones and dolomites. In places, near granitoid intrusions they had undergone contact metamorphism. Among volcanogenic rocks recovered in the Precaucasian region, there are tuffs, tufosandstones, quartz porphyres, dacitic and andesitic porphyrites, greenstony diabases.

The age of the rocks from two holes was determined by means of foraminiferal remains as Tournaisian and Viséan. In some places the palynological data testify to the Middle- and Late Devonian and Early Carboniferous; Lipidophloios sp., dated as the Namur-Bashkirian was identified in the core of a hole. Older Paleozoic deposits can be assumed in the lower part of the complex not penetrated by the holes.

Fig. 2: Correlation of the summarized stratigraphic colomns of Paleozoic deposits of the main zones of the Caucasus. I — Precaucasian; II — V — the Greater Caucasus nucleus: II — Bechasin zone, III — Forerange zone, autochthone, III — A — Allochthone. IV — Major Range zone, V — Southern slope zone (Svanetiya); VI — Transcaucasian massif. VII — Iranian plate.

Names of the rock-suites: A Urlesh, B Karabekskaya, C Teberdinskaya, D Bakhmutkinskaya, E Kizilkolskaya, F Kardzhurtskaya, G Aksautskaya, H Kinyrchatskaya, I Gimaldykskaya, J Shantatsarskaya, K Srednebeskesskaya, L Makerskaya, M Arkasazskaya, N Mamkhurtsevskaya, O Damkhurtsevskaya, P Lashtrakskaya, Q Adzharskaya, R Kvanskaya, S Uturskaya, T Kirarskaya, U Bakyldskaya, V Lailinskaya, W Chelshurinskaya, X Gvadarashskaya.

Symbols:

1 — claystones, clay shales, phyllites; 2 — siltstones; 3 — sandstones; 4 — conglomerates and gritstones; 5 — conglomerate-breccias; 6 — marls; 7 — limestone and marble; 8 — limestone bioherms; 9 — dolomites ; 10 — silicites (siliceous shale, jasper, phtanite); 11 — coals; 12 — tuff-sandstones; 13 — basic effusives; 14 — tuffs of the basic composition; 15 — lavabreccias of the basic composition; 16 — median effusives; 17 — tuffs of the median composition; 18 — acid effusives; 19 — tuffs of the acid composition; 20 — tufobreccias of the acid composition; 21 — acid and median subalkaline effusives; 22 — gabbro; 23 — serpentinized ultrabasites; 24 — green schists; 25 — crystalline schists and gneisses; 26 — micaceous metapelitic crystalline schists; 27 — amphibolites; 28 — plagiogneisses; 29 — plagiogneisses-porphyroids (apoeffusive); 30 — metaconglomerate; 31 — quartzites; 32 — boundary of tectonic covers separating assemblages, stratigraphic relationships of which remain obscure.

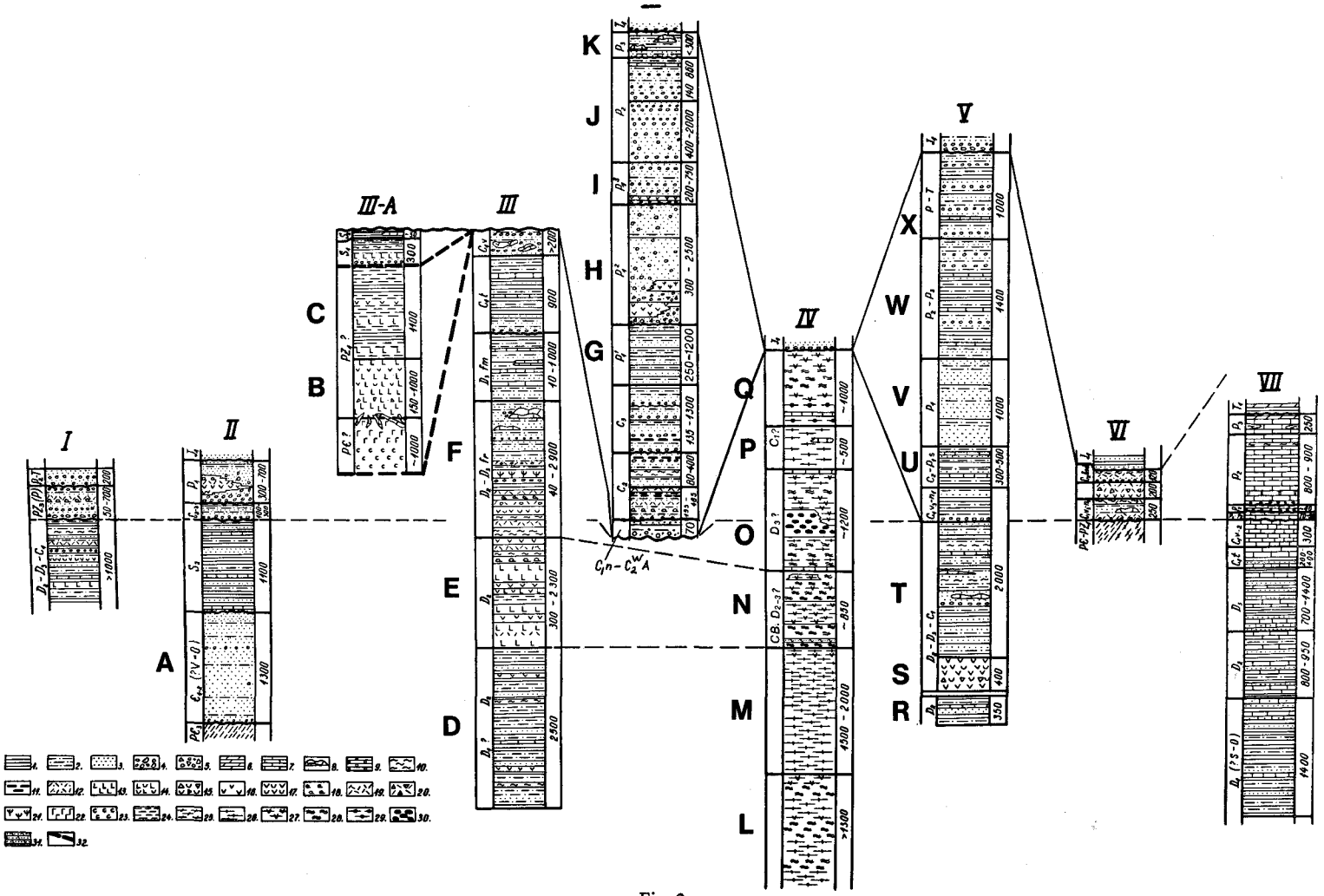

Fig. 2

In the Bechasin zone a thick (about 1300 m) Urlesh suite of the molassoid type composed of variegated quartz-albitic sandstones with interbeds of bricky-red siltstones and sandstones of the quartzy and polymictic composition belongs to the Cambrian. At the base there occur basal conglomerates. This suite with well pronounced unconformity overlies the rocks of the Khasautskaya-group. Its age was established by means of numerous remains of trilobites of the upper part of the MiddleCambrian recovered in limestone fragments; the latter, together with peculiar sandstones of the Urlesh suite are in intraformational conglomerates of the Silurian (Potapenko, Momot, 1965). As just the upper part of the suite was subjected to erosion, its lower part may be already of the Vendian age.

The Urlesh suite is overlain by Upper Silurian deposits with a stratigraphic gap, but without unconformity (Fig. 2, II). They are presented by argillaceous and sericite-chloritic shales. In its lower part there occur a sequence (170 m) of limestones and carbonate shales. Fossils of corals, brachiopods, pelecypods, orthoceratides and crinoids enable us to date deposits as the Ludlow stage (horizon E_2 Barrandien). Presence of *Spirifer superstes* Barr. testify to layers transitional to Devonian. The Silurian deposits are overlain unconformably by the Jurassic ones.

Cambrian deposits resting on the Dzirulsky salient of the Transcaucasian massif are of a quite different, typically geosynclinal, character. They are presented by limestones with remains of archaeocyatheans and catagraphs of the Lower Cambrian. The limestones form lenses among slightly metamorphosed and strongly tectonized rocks presented mostly by phyllites and, to a lesser extent, chlorite-sericitic, graphitic schists, polymictic and greywacke metasandstones with rare interbeds of altered tuffs and dikes of the basic composition. Cataclasites, mylonites are widely distributed in the pile, its outcrops making up a narrow tectonic edge with serpentinites on the contact among Upper Paleozoic granites and heavily metamorphosed plagiogneisses. Similar rocks have been also known within the Loksky and Khramsky salients and on the southern margin of the Transcaucasian massif, where the K-Ar age of rocks is equal to 235 and 224 m. y.

Geosynclinal Paleozoic deposits of the Forerange were recorded in the allochthonous and authochthonous (paraautochthonous) occurrence. The Upper Paleozoic seals the overlapped structure forming the neoautochthone.

The allochthone is composed of Lower Paleozoic (?) and Silurian undifferentiated deposits (Fig. 2, III-A). The former are divided into two suites — Karabekskaya and Teberdinskaya. The lower Karabekskaya suite of basic volcanites is associated by close intertransitions with gabbroids and gabbrodiabases composing the ophiolitic association of rocks. As to stratigraphy, higher up the section it passes gradually into green schists of the Teberdinskaya suite. The upper contact of the latter is tectonic everywhere (Grekov et al., 1974; Belov, Omelchenko, 1976).

The Karabekskaya suite is presented by greenstone diabases, basaltic and andesite-basaltic porphyrites with interbeds of tuffs of the andesitic composition,

sometimes lava-breccias, spilites, and sometimes by quartz albitophyres. Pillow-lavas were frequently recognized.

The Teberdinskaya suite is composed of sericite-chloritic, chloritic, chloritic-actionolitic, frequently with epidote, schists (apopelitic, aposilty-sandy, apotufaceous, and apoeffusive of the basic and less frequently acid dacitic and plagioliparitic composition), phyllites, sometimes with interbeds of white marbled limestones.

The age of the both suites is not grounded paleontologically. The suites were attributed to the Lower Paleozoic due to pebbles of the ophiolitic association rocks found in conglomerates of the Llandoverian.

Silurian deposits form separate covering plates. The lower series is presented by variegated siltstones, quartz-feldspar sandstones, clay shales with interbeds of conglomerates, siliceous conglomerate — and gritstone-breccias, limestones, black flints and siliceous shales (1—5 m thick) and phtanites. There are interbeds of tuffs and bedded bodies of effusives (globular lavas, spilites, variolites) of the andesite-basaltic and trachybasaltic composition (up to 15—20 m thick). Graptolites enable to attribute them to the Middle and Upper Llandoverian and Lower Wenlock stage (CHEGODAEV, SAVCHENKO, 1975).

Upper Silurian deposits are presented by phyllites with lenticular interbeds of marbled limestones. Remains of graptolites are peculiar to the Lower Ludlow (DYSSA, KIZEWALTER, 1972; GREKOV et al., 1974).

The Paleozoic autochthone (para-autochthone?) of the Forerange is presented by Devonian and Lower Carboniferous deposits (Fig. 2, III). They can be subdivided from below upwards into the Bakhmutkinskaya, Kizilkolskaya, Kardzhurtskaya suites, Famenian and Tournaisian. All these stratigraphic subdivisions overlie successively each other. The basement of the entire column is not know, the lower contact being usually tectonic.

The Bakhmutkinskaya suite is presented by clay shales and phyllites with subordinate interbeds of siltstones and sandstones, rhythmicity of lamination being sometimes observed. Fine-pebbled conglomerates and gritstones were sometimes recovered. In the lowermost parts there are lenses of crinoid limestones (5—6 m thick) and small bun-shaped bodies of coral bioherms. Siliceous shales, dark banded jaspers (up to 3—5 m thick) and nodular scones with the cone-in-cone texture were found too. Greenstone tuffs and effusives can be sometimes recognized in the lower part of the suite and in its uppermost parts.

Fossils of corals, foraminifers, algae, spores and pollen are attributed to the Eifelian and Givetian stages (KRUTJ et al., 1963). There is the flora puculiar to the Middle Devonian of Bohemia (POTAPENKO et al., 1974, GREKOV et al., 1974). The Lower Devonian age may be possible for the lower part of the suite.

The Kizilkolskaya suite is conformable with over- and underlying deposits, and is asigned to the Middle Devonian as to its stratigraphic position. It is composed of various effusives. These contain diabases (frequently containing quartz), diabase porphyrites, spilites, quartz albitophyries. Less frequent were pyroclastic and effusive-pyroclastic varieties of the same rocks. Still less frequently were observed sedimentary rocks, siliceous (including jaspers with radio-

larians) and siliceous-hematitic rocks and small lenses of limestones being recognized among them. The limestones contain remains of corals, brachiopods, tentaculites, ostracods, Devonian crinoids that could not be identified in details.

The suite consists of various deposits and dikes of subvolcanic rocks. Its section is very variable. Amygdaloidal, cushioned and variolitic effusives of the basic composition, effusives of the median and acid composition, effusive-explosive piles, tuffs become rapidly thinner, pinch out, or replace facially each other. On the whole, the pile has a complicated megalens-shaped bedding. The thickness of some lenses is up to 100—1300 m. The total thickness of the suite varies from 300 to 2300 m, being sometimes 30—40 m only.

When judged by the features of structure and chemical and petrographic composition, the effusives of the Kizilkolskaya suite can be regarded as an island arc volcanic association of rocks. They include the well-known chalcopyritic deposits of the North Caucasus.

The Kartdzhutskaya suite has also conformable boundaries and is characterized by abrupt changes of facies and thicknesses. The suite is composed of various tuffs, tuff-sandstones, tuff-siltstones and tuff-conglomerates. Less frequent are clay- and siliceous shales, sandstones, limestones and effusives (plagioliparitic porphyries, quartz keratorphyres). The tuffs are of the acid composition. In tuff-conglomerates the pebbles are presented by effusives of the Kizylkolskaya suite, plagiogranites, granophyres and micropegmatites, limestones.

At the basement of the suite there occurs a horizon of siliceous and siliceous-hematitic slates, its thickness being 50—150 m.

The Kartdzhurskaya suite is frequently divided into two subsuites — tufogene and terrigene ones. The lower subsuite is composed of tuffs of various composition, acid effusives, siliceous shales, jaspers, claystones, less frequently effusives of the basic and median composition and lenses of limestones being frequently revorded as well. The upper subsuite is a rhythmic alternation of sandstones, tuff-sandstones, tuff-conglomerates, siltstones and clay shales. The conglomerates, siltstones and clay shales. The conglomerates are characterized by presence of fragments, large blocks and lenticular bodies of limestone bioherms.

Rare findings of fossil remains of corals, brachiopods etc., enable a tentative dating of the Kartdzhurskaya suite, i. e. the uppermost parts of the Middle Devonian — the Frasnian stage.

Famennian deposits are presented by terrigenous rocks and limestones. In a most complete section on the Pastukhov mountain, D. S. KIZEWALTER singled out five horizons of limestones alternating with particoloured sandstones and siltstones. Facies changes are expressed in replacement of terrigenous rocks by carbonate ones. Fossil remains of corals, algae, brachiopods and foraminifers from the upper part of the pile testify to the Famennian stage and Etroeungt.

The Tournaisian stage rests conformably with slight washout on the Famennian. One can frequently distinguished at the base a horizon (10—20, seldom 50 m thick) of fine-pebbled quartzy conglomerates, gritstones and sandstones.

This horizon contains pebbles of limestones Upper Famenian with microfaunistic remains. The pile is presented by alternation of sandstones (fine-grained quartz-feldspar), siltstones, clay shales, limestones and calcareous shales. The age is determined by means of fossil foraminiferal remains found in the lower part of the pile (Geology of the USSR ..... 1968).

In the eastern part of the Forerange there is a pile, its structural and stratigraphic position has not been determined yet. By the character it reminds olistostromes. In limestone blocks of this pile Upper Famennian and Lower Tournaisian foraminiferal remains were found (data by I. I. GREKOV and YU. YA. POTAPENKO). The age of this pile may prove synchronous with the epoch of nappe formation, i. e. somewhere within the Viséan age.

In the zone of the Major Range of the Greater Caucasus (IV) the Labino-Buulgenskaya group is assumed to be of the Middle Paleozoic age. It is exposed with a gap in a narrow pass belt of the range from the Belaya river in the west till the Ardon river in the east. In the west (the Belaya and Damkhurts rivers) in the section of the series four suites have been distinguished (SOMIN, 1971). The lower Mamkhurtsevskaya suite is composed of biotitic, hornblende and leucocratic apovolcanogenic plagiogneisses, amphibolites to a lesser extent. It also contains strongly subordinate interbeds of micaceous and quartzitic schists below, and conglomerate-shaped rocks above. The Damkhurtsevskaya suite below is presented by the horizon of marbles, higher up the section — by a member of intercalating hornblende plagiogneisses and garnet-micaceous schists, metaconglomerates and quartz-micaceous schists that are overlain by amphibolites and amphibole plagiogneisses and a horizon of marble. The Lashtrakskaya suite is composed of metapelitic quartz-micaceous schists, frequently with graphite and garnet- sometimes with staurolite and disthen, and contains marble lenses. The Adzharskaya suite is presented by marble and leucocratic hornblende orthogneisses. The stratigraphic position of this suite is not quite clear. Carbonate rocks of the Lashtrokskaya and Adzharskaya suites contain fossils — crinoids of the Postcambrian age. By the lithological composition and succession the two lower suites are correlated to the Middle-Upper Devonian of the Forerange zone. The two upper suites are assumed to be Lower Carboniferous.

In the east, in the Kodori river basin the group consists of three suites. The Gwandrinskaya suite is composed of biotic and quartz schists and paragneisses, the participation of hornblende schists and amphibolites being subordinate. The Klychskaya suite consists mostly of amphibolites of volcanogenic genesis. The Dombaiskaya suite abounds in biotitic and binary micaceous plagioparagneisses. The Klychskaya suite appears to correspond to the middle part of the Mamkhurtsevskaya suite of the western sections of the Labino-Buulgenskaya group.

The most eastern outcrops of the Labino-Buulgenskaya group are known in North Osetiya and are presented by the Kassarskaya and Chanchakhskaya suites. The first of them is composed mostly of alternating quartz-biotites and hornblende schists, biotitic quartzites, and contains marble lenses in the top. The Chanchakhskaya suite consits of metamorphosed tuffs of the albitophyric com-

position, quarts-albitic, epidote-quartzy and micaceous schists. Regional metamorphism of this suite corresponds to the greens schist and epigote-amphibolitic facies, whereas the Kassarskaya suite — to the epidote,amphibolitic one. The remaining piles of the above group were subjected to transformation under conditions of the amphibolitic facies of regional metamorphism. In places the level of metamorphism rises up to the level where migmatites are formed.

The relationships between the Labino-Buulgenskaya and Makerskaya (Pcm?) groups of the Major Range are interpreted by various authors differently. It is certain that no jump in the metamorphism level and the history of metamorphism and its character has been observed. The history of the structural evolution did not show any principal differences as well. Therefore, despite the local presence of cataclasites in the contact zone of groups, one can believe that there is no structura-metamorphic unconformity between them. This enables us to suggest that at least the upper part of the Makerskaya group is of the Paleozoic age (Ordovician-Middle Devonian).

Middle Paleozoic deposits of the Southern slope zone are known in the region of Upper Svanetia only where they make up a part of low-metamorphosed (not deeper that the chlorite-albite-muscovite subfacies) Desskaya group (SOMIN, 1971). The Kvanskaya suite containing amphipores and corals of the Eifelian stage of the Middle Devonian is considered the oldest. The suite is presented by subarkose sandstones, phyllite-shaped clay shales and bioherm bodies of limestones. The Uturskaya suite composed of volcanigenic rocks of the andesite-basaltic composition transformed into chlorite-albite-actinolitic schists, tuffoids and porphyroids (their thickness being over 400 m) is assumed to have the higher stratigraphic position. The age of the suite is tentatively determined as the Eifelian-Givetian. The next, Kirarskaya, a about 2000 m thick suite is composed of polymictic sandstones, siltstones, clay shales, intraformational conglomerates and lenses of limestones. In the middle part of the section were found corals apparently of the Frasnian stage of the Upper Devonian. The upper part of the Kirarskaya suite, beginning from the horizon of conglomerates is of the Lower Carboniferous age, as Upper Viséan-Lower Namurian corals were recovered here.

In the Lesser Caucasus the section of Middle Paleozoic deposits begins with organogene limestones, claystones and quartzy sandstones. Redeposited Lower Devonian fossils were found here. It is not excluded that the lower part of this thick (1400 m) pile is of the Siluian age. Higher up the section there occur limestones and multicoloured sandstones, claystones and siltstones with a rich fauna of Eifelian and Givetian brachiopods. Frasnian and Famennian stages are arenaceous limestones, sandstones, clay shales, and sometimes phtanites; interbeds of phosphorites were recognized in the Famennian. The total thickness of the Devonian continous section is about 3000 m (ARAKELYAN, 1964).

Lower Carboniferous deposits rest conformably on Devonian ones. These are also marine terrigenous and carbonate sediments. The limestones are frequently bituminous, or organogene-detrital, sometimes oölitic, rich in remains of

foraminifers, corals and brachiopods of the Etroeungt — Viséan middle substage. Higher up the eroded surface of the Devonian deposits is overlain by Permian and younger beds.

Upper Paleozoic

In the Caucasus the Upper Paleozoic is composed of Upper Viséan, Namurian, Middle-Upper Carboniferous and Permian deposits. When judged from the historico-tectonic position, it will be expedient to assign the Lower Triassic to the same complex. Upper Paleozoic deposits of the Caucasus can be subdivided into some types differing in formations.

In the eastern continuation of the Donets Basin and the southern slope of the Greater Caucasus these are mostly terrigene marine deposits closely related to Middle Paleozoic ones and similar to them by the composition. In the rest of the Precaucasus and in the Forerange of the North Caucasus they form a typical Hercynian orogenic complex of continental molassa and volcanic rocks.

In the Major Caucasian range there are both the continental and marine deposits. The Upper Paleozoic of the Transcaucasian massif is also composed of orogenic, terrigene and volcanic sediments of marine and continental genesis. Quite different, mostly carbonate deposits of the platform type are distributed in the south of the Lesser Caucasus (Armenia and the Nakhichevan ASSR).

In the Precaucasian region the Upper Paleozoic deposits presented by red terrigene (conglomerates, sandstones, siltstones and claystones) and volcanogenic (tuffs, tuff-sandstones, andesite-dacitic porphyrites, acid lavabreccias and ignibrites) rocks are distributed sporadically, frequently filling separate superimposed depressions. They rest on the Middle Paleozoic deposits with unconformity and a large stratigraphical gap and are usually not metamorphosed and slightly dislocated, forming often one complex with Triassic rocks.

In addition to, in the west of the Precaucasian region A. I. LETAVIN (1972) singled out one more complex — marine Upper Paleozoic rocks that have been very poorly studied. Its relationships with the Middle Paleozoic are not known yet. These are carbonatesiliceous, coaly-carbonate, carbonate-clay shales, red marls, claystones, sandstones with sporadic interbeds of limestones containing fragments of brachiopods, Bryozoans, gastropods, columnals, echinoid spines, remains of corals and ostracods. An assemblage of foraminifers recognized among them belongs, on the whole, to the Upper Paleozoic.

In the southern part of the Bechasin zone (Fig. 2, II) continental upper Paleozoic deposits are distributed sporadically. They form some small basins or erosional relics, occur unconformably on Precambrian crystalline complexes. The piles of grey, slightly molassic deposits belong to the uppermost parts of the Middle- and Upper Carboniferous, as to remains of the flora. Red coarse-detrital deposits and land effusives are attributed to the Lower Permian according to comparison with analogous deposits of the Forerange zone.

The Upper Paleozoic complex of the Forerange zone rest unconformably on the Middle Paleozoic one and is unconformably overlain by Lower Jurassic deposits of the marginal part of the Alpine geosynclinal system of the

Geater Caucasus. Triassic deposits occupy an intermediate position. Lower Triassic molassas in the eastern part of the zone continue, in fact the Late Paleozoic development, whereas Upper Permian and Triassic marine deposits, known in the western part of the Forerange, form a quasiplatform cover.

A pile of sandstones, siltstones, claystones and fine-pebbled conglomerates was recognized at the base of the Upper Paleozoic section (Fig. 2, III). The pile contains remains of Namur A, Namur C and Westphalian A of the West-European scheme, this corresponding to the Serpukhovian stage of the Lower Carboniferous and the lower part of the Bashkirian stage of the Middle Carboniferous USSR (ANISIMOVA, CHEGODAEV, 1976).

The overlying Middle Carboniferous deposits are subdivided into two piles. The lower one is composed of sandstones, siltstones, claystones, conglomerates, tuffs, and less frequently effusives of quartzy-porphyries, as well as of tuffites and tuff-sandstones. Among them there occur rare interbeds of coal, reaching sometimes thickness up to 2—4 m. The pile is characterized by three assemblages of fossil floras dated as the Early Bashkirian, Late Bashkirian transitional to the Early Moscovian, and the Early Moscovian age, or the Westphalian A — Early Westphalian B- Westphalian B — the lowermost parts of the Westphalian C and the Westphalian C respectively. The thickness of this part of the section is 155—465 m.

Contrary to the previous pile the upper one is characterized by disappearance of effusives and appearance of great numbers of ashy-siliceous interbeds. The upper part of the pile abounds in conglomerates and sandstones; thin, not persistent coal beds can be observed too. Pebbles of microcline-containing granites widely distributed in the Major Caucasian Range appear in conglomerates for the first time. The fossil flora enables us to date the upper pile as the Moscovian stage or the Westphalian C and D.

Upper Carboniferous deposits rest on the Middle Carboniferous mostly conformably, but in some places the lower part of the Carboniferous falls out, and the upper one overlies with angular unconformity Middle Carboniferous deposits. Marginal unconformity with a transgressive transition over Middle Paleozoic deposits can be observed in places.

The Upper Carboniferous begins in some places with boulder conglomerates with pebbles of quartzy porphyries and their tuffs from the middle Carboniferous.

Upper Carboniferous deposits are subdivided according to rhythmicity of alternation of rocks into three large rhythms of the first order formed by conglomerates (pebbles of crystalline rocks, granites, quartzy porphyries and quartz), gritstones, variegated sandstones, siltstones and claystones. In places there are some lenticular interbeds of coal, andesitic porphyrites.

Abundant assemblages of the fossil flora enable to date the Kassimovian and Gzhelian stage and to correlate the deposits to suites $C_3^1 - C_3^2$ and $C_3^2 - C_3^3$ of the Donets Basin.

The Permian deposits of the Forerange are presented by thick continental red volcanogene-terrigene rocks, and in the west of the zone — by marine carbonate-

terrigene Upper Permian deposits. The red deposits are subdivided into five suites: Aksautskaya, Kinyrchatskaya, Gimaldyskaya, Shantatsarskaya and Srednebeskesskaya. The Aksautskaya suite (P_1^1) rests conformably on the Upper Carboniferous, passing in places with angular unconformity over older deposits. It is presented by lacustrine sandstones, siltstones and claystones of red-brown and dark grey colours. They contain interbeds and lenses of dolomitized limestones, ferruginous dolomites, siliceous phosphate-bearing claystones, phosphates and coaly shales. In the marginal parts of the basins there appear lenses and interbeds of conglomerates and gritstones.

Floral remains of walchia, cordaites and callipterides (?), as well as fragments of fish bones and scales of the Acanthodus genus were found in the lowermost parts of the Aksautskaya suite. Reprints of reptiles legs resembling *Amphisauroides (Auxipes) minor* (HEYLER et LESSERTISEUR) were found in the middle part of the suite (after D. S. KIZEVALTER).

The Kinyrchadskaya suite (P_1^2) overlies both conformably and with angular unconformity the Aksautskaya suite and unconformably the older deposits. This suite, as well as the three abovelying suites, are characterized by imbricate occurrences characteristic of rocks of the piedmont slopes. The suite is composed of typical red coarse-detrital molassas: conglomerates, sandstones, less frequently siltstones, claystones and volcanogenic rocks. The latter are presented by andesitic and dacitic porphyrites, quartzy trachytic porphyries and their tuffs, up to 800 m thick. The suite is not characterized faunistically and can be correlated to the Saxonian or Upper Rotligend.

The Gimaldykskaya suite (P_1^3) rests conformably on the Kinyrchadskaya suite, or is separated from it by a small angular unconformity. It is presented by alternation of sandstones, gritstones, conglomerates of the pinkish-grey colour. Horizons of amygdaloidal andesitic and trachyandesitic porphyrites, 7—15 m thick, were recognized in some places of the base of the suite.

Shantatsarskaya and Srednebeskesskaya suites lie conformably. The former is presented by irregular alternation of poorly sorted conglomerates (presence of boulder varieties being representative), gritstones and sandstones, whereas the latter is composed of conglomerates and gritstones below, and calcareous sandstones with siltstone and limestone interbeds above. Regular lamination is peculiar. The both suites are tentatavely attributed to the Middle Permian (P_2, Fig. 2, III).

Marine Permian deposits (P_3) rest either conformably with a gap on red sediments, or unconformably on older groups. They are presented by a thin facially changeable carbonate-terrigenous pile including bodies of bioherm limestones. There are abundant fossil remains of brachiopods, corals, myarians, algae, spongs, trilobites, gastropods, nautiloids, etc. Small foraminifers (*Reichelina, Codonofusiella, Colaniella, Palaeofusulina*, etc.) testify to the uppermost parts of the Permian.

Besides the above red Permian deposits, there are in the Forerange thick (from 1000 to 3000 m) red terrigenous accumulations containing in the upper part in conglomerate pebbles the limestones with foraminifers of all Permian zones of

the Tethys, including the uppermost ones. The palynological studies of the last years (data by I. I. GREKOV) confirmed the Triassic age of these red deposits. It is quite possible that they correspond to continental red conglomerates and sandstones (up to 200—600 m) recognized in the base of a faunistically grounded Triassic section of the western part of the Forerange and can be attributed to the seisian stage.

In the Major Caucasian Range the Upper Paleozoic deposits were recorded in some isolated regions (Fig. 1 and 3). They are characterized by a certain similarity in the structure of the section. Its lower part contains grey and multicoloured sandy-conglomerate piles. These occur unconformably on metamorphic complexes. The composition of the clastic material is arkose and feldspar. Rhythmicity of lamination is typical. Interbeds of tuffs of the acid and median composition were observed in the Khuko region and North Osetiya, and interbeds of coal — in the region of Khuko. The age is determined by means of the flora remainsinthe Khuko region only, where the upper part of the Westphalian is dated.

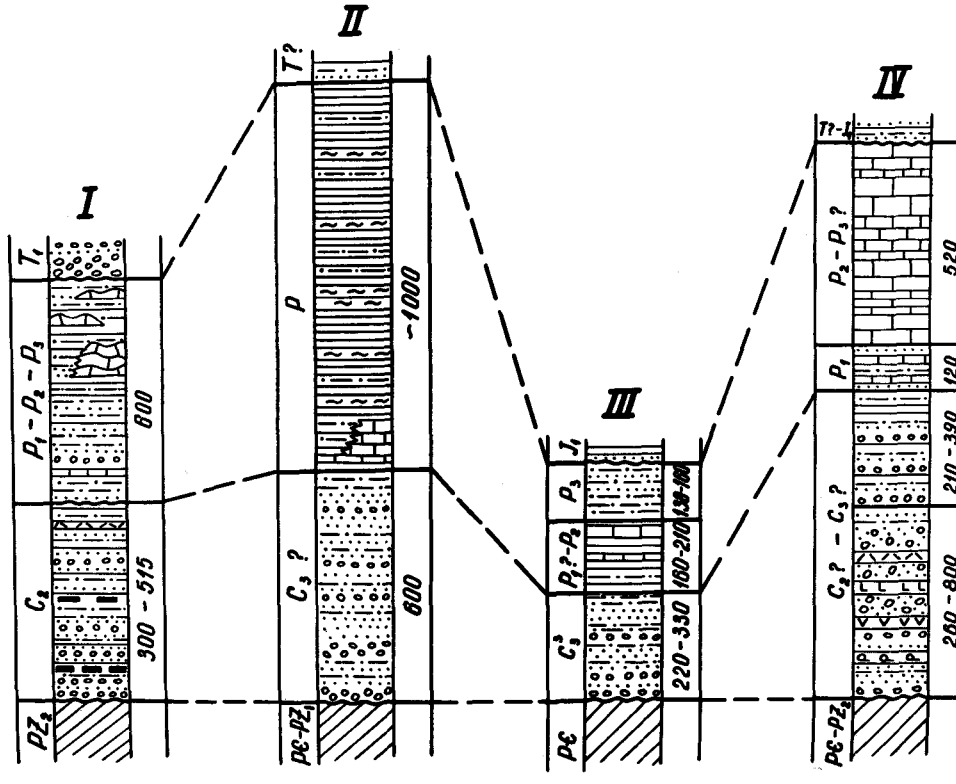

Fig. 3: Correlation of stratigraphic columns of Upper Paleozoic deposits along the zone of the Major Caucasus range. I — Khuko region; II — Pseashkho region; III — Kvishi region (Upper Svanetiya); IV — North Osetiya. Lithological symbols are similar to thos of Fig. 2.

The upper part of the section is composed of terrigene-carbonate, terrigene and carbonate Permian marine deposits. In the region of Khuko they overlie with angular unconformity the Middle Carboniferous and the Middle Paleozoic, whereas in other regions they rest conformably on the lower stratum (Fig. 3). Presence of calcareous bioherms is representative. Somewhat different is a Permian section in the Pseashkho region where the upper part of the pile is composed of black clay shales and banded multicoloured jasper-shaped siliceous shales. All these piles are unconformably overlain either by true Lower Lias deposits, or assumed Triassic deposits. In the region of Pseashkho the contact requires additional studies. In the Khuko region all three Permian series were dated by means of fossil foraminifers, in other places the fossil findings proved poorer.

In the central part of the Major Range in the Baksan river basin in narrow grabens there is a 200 metres red conglomerates, gritstones and sandstones resting on crystalline schists. Sporepollen remains enabled to date the Lower Permian.

Eastwards, on the continuation of the Major Range zone, to the eastsouth of the town of Grozny, a Permian carbonate, lagoonmarine stratum was penetrated in holes in the Alpine nappe structures. Dolomites, sandy-silty marls with siderite, dolomite and ankerite were found here. The total thickness is up to 1000 m. Fossil foraminiferal remains testify to the Middle and Upper Permian.

The Upper Paleozoic in the tectonic zone of the Southern slope of the Greater Caucasus is presented by thick (up to 4000 m) marine, mostly terrigenous deposits conformably overlying similar Middle Paleozoic rocks, forming together with the latter one Desskaya group (Somin, Belov, 1967).

Upper Viséan — Lower Namurian deposits make up a part of the above-mentioned Kirarskaya suite. The section begins with conglomerates and includes dark clay shales, polymictic sandstones and gritstones, sporadic interbeds of siliceous shales and lenses of bioherm limestones with numerous coral remains. The Middle Carboniferous was established by means of corals and foraminifers of the Bashkirian stage (its upper part) in lenses of limestones occuring among black phyllite-like shales and sandstones with interbeds of intraformational conglomerates. This part is singled out as the Bakyldskaya suite.

There are no as yet reliable paleontological data on the Upper Carboniferous in the Desskaya group.

Permian deposits are presented by two suites. The Lailinskaya suite is composed mostly of plagioclase-quartzy sandstones and resembles the marine molassa. Somewhat lower its foot, in the layers that are tentatively included in the Bakyldskaya suite, foraminifers of the Sakmarian stage of the Lower Permian were found. The second, conformably occurring Chelshurinskaya suite is composed of rhythmically alternating phyllite-shaped shales, siltstones and sandstones. There are also arenaceous limestones and conglomerates. In the lower part of the suite there are foraminifers assigned to the lowermost parts of the Middle Permian, and in its upper horizons — foraminifers of the Upper Permian Murgabsky stage.

Further on, there occurs conformably the Gvadarashskaya suite composed of polymictic sandstones, gritstones, conglomerates, clay shales, short lenses of limestones. No fossils were recovered here. Proceeding from the stratigraphic position of this suite overlying the Chelshurinskaya one, it age is assumed to correspond to the Upper Permian — Triassic. This suite, as well as older parts of the Desskaya group section, is unconformably overlain by Lias deposits.

Upper paleozoic deposits appear to occur in Kakhetiya (Speroza ridge) where they are presented by a thick pile of arkose sandstones, likely of the Upper Carboniferous-Lower Permian age, and limestones near which in the secondary position the only one finding of Upper Permian brachiopods was recovered. It is also not excluded that they are of the Liassic age (ADAMIYA, 1968). When judged by the composition of clastic rocks, the above pile rested most probably on Preupper Paleozoic granite-metamorphic base.

On the Transcaucasian massif the Upper Paleozoic deposits overlie strongly unconformably old crystalline schists and granitoids. This is mostly a continental complex associated with the orogenic stage of development. On the Khramsky salient it is presented by a pile of tuffites, ashy and psammitic tuffs and less frequently tufobreccias of the acid composition, phtanites, tuff-sandstones, coaly-siliceous siltstones and claystones. The latter often contains reprints of the flora. In the lower part of the section there occur reefogene limestones with abundant remains of brachiopods, corals, foraminifers and algae. All these fossils testify to the Upper Viséan — Lower Namurian age of the lower part of the complex and the Upper Bashkirian of its upper horizons. The pile of the Dzirulsky salient contains lavas, lavabreccias and pyroclastolites, apolipa-rites and albitophyries (BELOV, 1967; ADAMIYA, 1968).

In the southern part of the Lesser Caucasus the Upper Paleozoic is presented only by Permian deposits of the submarine character. These are grey and bituminous algal and algal-foraminiferal limestones; in the upper part of the section there are pelitomorphous limestones, marls and clay shales. The complex is subdivided (ARAKELYAN, 1964; LEVEN, 1975) into a number of suites. When judged by paleontological data, the lowermost of them can be attributed to the Artinian stage of the Lower Permian, whereas the upper one corresponds to the Dzhulfinian and Chansinian stages of the Upper Permian. In this part of the Caucasus the Permian deposits are overlain without visible unconformity by clay shales and marls of the Lower Triassic Indian stage.

The researchers studying the Caucasian Paleozoic are still faced with a number of problems. The principal of them are aimed at determination of the age and elucidation of stratigraphic relationships between metamorphosed complexes of the Greater Caucasus and Transcaucasian. It is also necessary to determine more exactly the structural position of some strata in relation to the recent discovery of Hercynian nappes in the Forerange.

The advance of our knowledge of the Paleozoic of the Skiphean plate basement will depend on the results of drilling in search for oil and gas. Some less significant stratigraphic questions require a more detailed study.

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