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Tectonic Structure of Novaya Zemlya

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THEME 8: Polar Urals, Novaya Zemlya and Taimyr: The Northern Connection of the Uralides

Summary: Recent interpretation of the geology of Novaya Zemlya Archipelago and adjacent shelf areas of the Barents and Kara Seas based on all data, including seismic profiling permit the authors to suggest that. Novaya Zemlya is an accretional assemblage of three tectonic blocks (terranes): The southern Block with Baikalian basement, the Central Block with Karelian basement and the Northern Block, having an autonomous way of evolution. Analysis of litho-tectonic assemblages has revealed the main stages of evolution, the most prominent of which are: collision of the Southern and the Central blocks in Late Riphean - Cambrian, rifting with these blocks in Middle - Late Devonian and total orogeny (including the Northern Block) due to the collision of the Barents and the West Siberian plates in the Late Triassic - Early Jurassic.

INTRODUCTION

The geological surveying of the Novaya Zemlya Archipelago at a 1 : 200 000 scale has been carried out by Polar Marine Geological Expedition (Novaya Zemlya division). Adjacent off-shore areas at a 1:1 000 000 scale have been mapped by the Marine Arctic Geological Expedition (off-shore division). These surveys have provided a substantial data base for understanding the structure and tectonic evolution of the Novaya Zemlya fold system and its relationships to adjacent basins (GRAMBERG 1988, KORAGO et al 1984).

MAIN STRUCTURAL FEATURES

The Novaya Zemlya Archipelago an uplifted part of the Paihoi - Novaya Zemlya fold system, having more than 200 km in width is partly covered by the Barents and Kara Seas. Tectonically it is dominated by an early Mesozoic antiform between the Barents and the West Siberian basins. The conjugation of this antiform with the Barents Sea basins expressed by the thrust zone, which can be traced under flat lying MZ-KZ cover by seismic records. The boundary of the antiform and the West-Siberian basin is less evident (Fig. 1).

Novaya Zemlya (Fig. 2) is an accretional assemblage of three blocks: the Southern block with Baikalian basement, the Central Block, with Karelian basement, and the most peculiar Northern Block with unknown basement, but older than Late Riphean. The blocks are bounded by deep-seated fault zones: Baidaratsky and Sporonavoloksky.

The fold belt of Novaya Zemlya is the result of Early Kimmerian (late Triassic to early Jurassic) tectonic movements, due to inferred collision of the Barents and the West Siberian plates, the stress being directed from ESE to WNW, as shown by the thrusting and reversed folding in the western flank of Novaya Zemlya (Fig. 1).

The Novaya Zemlya fold system is composed of Yuhznonovozemelsky (YNZA) and Severonovozemelsky (SNZA) anticlinoria (Fig. 2). The anticlinoria are separated by the Karmakulian saddle and related synclinoria - Barents to the west and Kara to the east. The most prominent feature is the Main Novozemelsky fault zone. Kimmerian deformations are not uniform in the Southern, Central and Northern blocks, being dependent on the basement structure and different features of the Paleozoic strata; they have different orientation to the Kimmerian compression. For the Southern block symmetrical folding is typical and thrusting is not typical. The fold trend of the YNZA inherits the sublatitudinal trends of the Baikalian basement structures. In the core of the YNZA, the Baikalian basement is exposed. In the Central block linear folding, accompanied by intensive thrusting, is wide spread. In the Northern Block the folding is of simple pattern.

The SNZA occupies the Central and Northern blocks. Within the Central Block its structure is very complex and asymmetric: zones with isoclinal folding and thrusting alternate with rather simple open folding. The most complex compressional structure is recorded along the Main Novozemelsky thrust zone. Structures of the SNZA have sublongitudinal trends, similar to those in the Riphean basement folding. The northern part of SNZA, within the Northern Block, differs by having relatively simple structures, preserving the sublongitudinal trend.

Litho-tectonic assemblages of southern and central blocks

As a result of detailed geological surveying the following litho-tectonic assemblages have been distinguished (Fig. 3):

1) Early Riphean (1550-1490 Ma Tab. 1) terrigenous-carbonate assemblage: marbles, quartzites, and schists metamorphosed in epidote-amphibolite facies.
2) Late Riphean to Vendian, flysch-greywacke, deep water assemblage: polymictic volcaniclastic sandstones, phyllites, carbonaceous slates, metamorphosed in greenschist facies.
3) Late Riphean to Vendian (680-735 Ma, Tab. 1), alaskite granite-granodiorite Mitjushev igneous suite.
4) Cambrian to Middle Devonian, shallow shelf assemblage: feldspar-quartz sandstones, dolomites, limestones, shales, siltstones, gravelites and conglomerates, with phosphate

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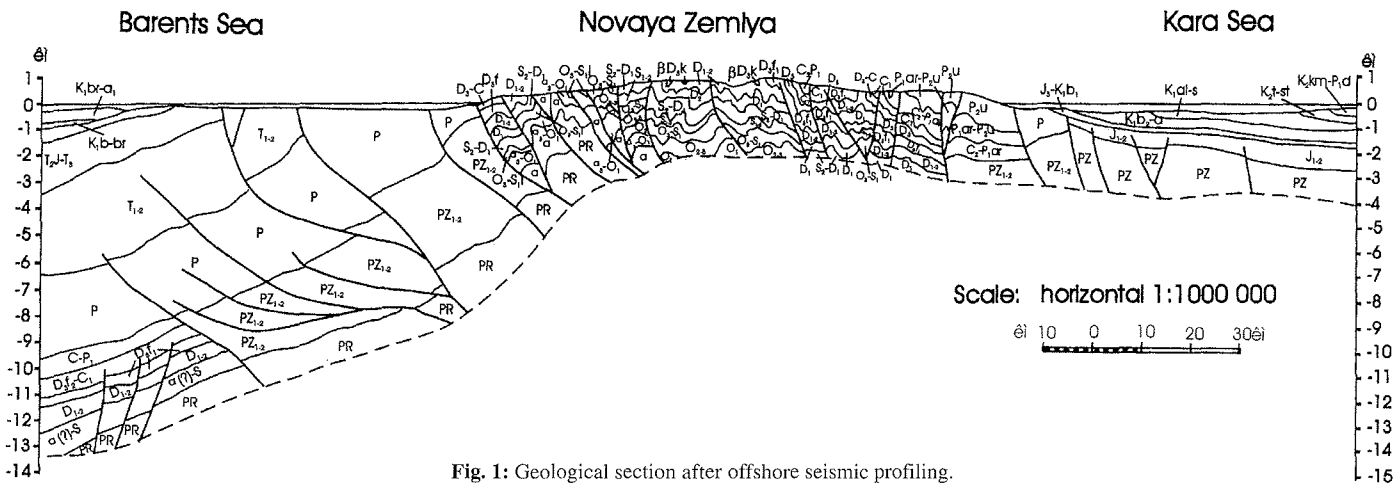

Fig. 1: Geological section after offshore seismic profiling.

nodules, bioherms, numerous fossils, ripples marks and bioturbation.

5) Late Devonian to Early Carboniferous carbonate - shelf assemblage: limestones, calcarenites, bioherms and calcareous sandstones.
6) Middle to Late Devonian carbonaceous - carbonate - volcaniclastic rocks of the initial stage of rifting: claystones, siltstones, shales, tholeiitic basalts, tuffs, tuffites, polymictic sandstones, gravelites, conglomerates, intruded by gabbro-dolerites sills and dykes.
7) Late Devonian to Permian deep water, carbonaceous - siliceous - carbonate rift related assemblage: claystones, siltstones, rodochrosite - bearing siliceous rocks, turbidites, olistolites, olistostromes, with graded bedding, and slumping.
8) Late Permian flyschoidal and turbiditic assemblage: the trough fill under conditions of avalanche sedimentation: polymictic, greywacke sandstones, claystones, siltstones, olistolites, olistostromes, and calcareous sandstones.
9) Upper Permian to Lower Triassic molasse assemblage coastal marine, subaeral: multicoloured sandstones, siltstones, claystones, and conglomerates; with basaltic and andesitic tuffs.
10) Late Triassic - Early Jurassic (196-210 Ma by U-Pb, (KORAGO. & CHUKHONIN 1988) granitoid, collisional suites: alaskites, granites, granodiorites, and monzodiorites.

Northern blocks

11) Late Riphean to Early Ordovician carbonaceous, argillaceous and coarse terrigenous assemblage of slope and rise: phyllites, metasandstones, metasiltstones, polymictic conglomerates, turbidites with gradational bedding and slumping.
12) Early Ordovician to Early Devonian carbonate and terrigenous - carbonate shelf assemblage: claystones, siltstones, quartz and polymictic sandstones, conglomerates, and limestones, with graptolites, bioherms and cross bedding.
13) Early Devonian to Early Carboniferous carbonate and terrigenous-carbonate shallow water shelf assemblage: limestones, usually algal, dolomites, minor siltstones, claystones, sandstones, and conglomerates, with cross bedding.
14) Middle Carboniferous to Permian carbonate - terrigenous shallow water and subaerial assemblage: claystones, siltstones, sandstones, and minor oolitic organic-detrital limestones.

NN	Location	Rock	208 Pb / 206 Pb	207 Pb / 206 Pb	Age, m.a.	Reference
110 k-b	Sulmeneva Bay, 56°07'E 74°31'N	Schist, Zircon	0,13 0,11	0,0961±0,0045 0,0930±0,0050	1550±80 1490±100	KORAGO & CHUKHONIN (1988)
107 k-12 a	—*—*—*—*—*—	Granite, Zircon	0,09	0,084±0,004	1300±90	KORAGO et al. (1984)

NN	Location	Rock mineral	K %	AR^{40}	AR^{40} / K^{40}	Age m. a.	Reference
107 k-a	Sulmeneva 56°07'E 74°31'N	Schist, Amphibole	0,41	21,99	0,04495	645±53	KORAGO & CHUKHONIN (1988)
103 k-7	—*—*—*—*	Granite, Muscovite	6,53	312,1	0,04006	584±27	

Tab.1: Pb-Pb thermo-emission method Results of isotopic dating of schists and granites from Novaya Zemlya. Used constants (year $^{-1}$): $\lambda_{238}=1{,}5513\times10^{-10}$; $\lambda_{235}=9{,}8485\times10^{-10}$; $\lambda_{\varepsilon}=0{,}581\times10^{-10}$; $\lambda_{\beta}=4{,}962\times10^{-10}$; $U^{238}/U^{235}=137{,}88$, after GRAMBERG (1988), KORAGO et al. (1984), KORAGO & CHUKHONIN (1988)

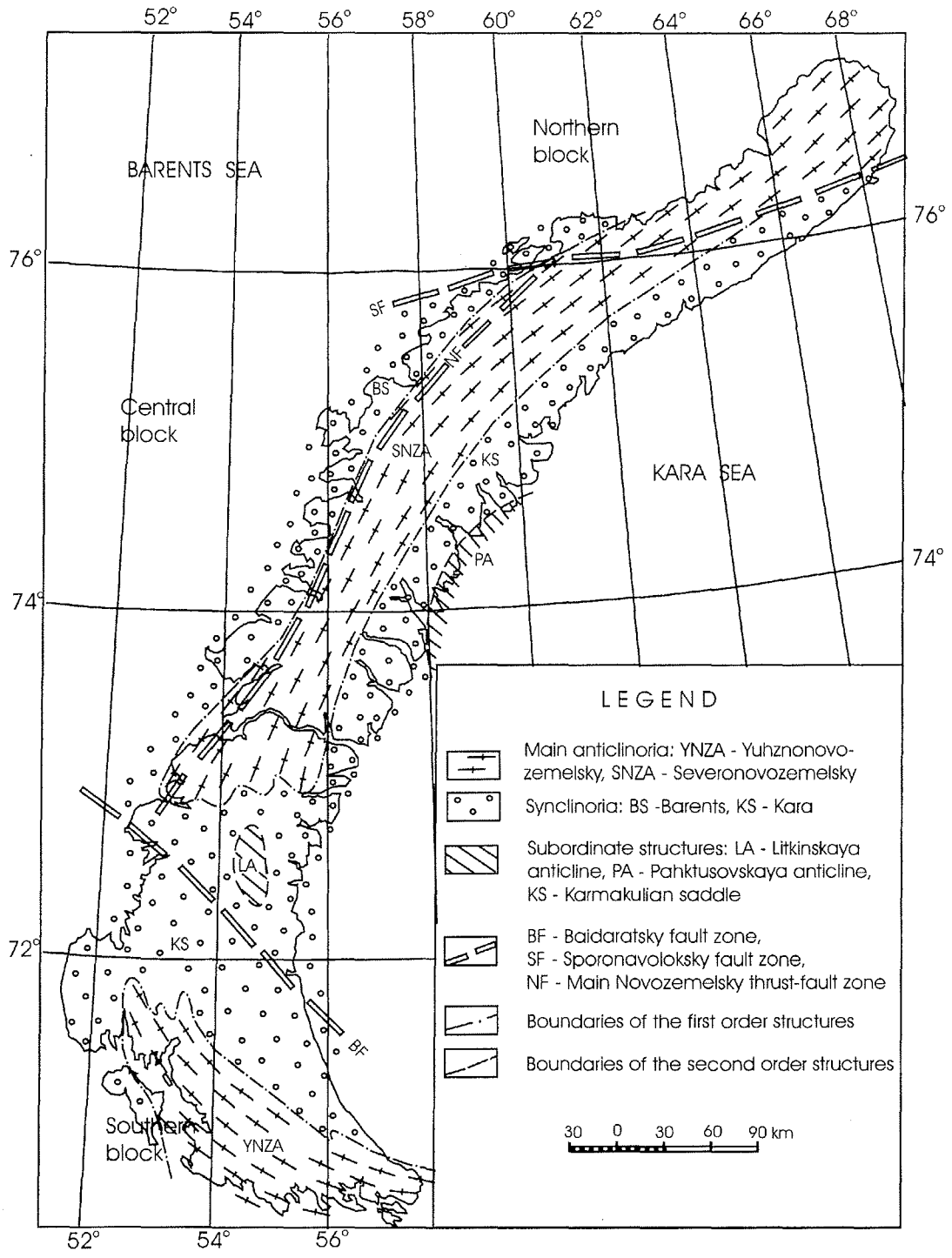

Fig. 2: Main structural elements of Novaya Zemlya fold system.

MAIN STAGES OF GEOLOGICAL EVOLUTION

Analysis of the distribution of the litho-tectonic assemblages has revealed the following main stages of geological evolution:

Late Riphean - Cambrian:

During this time the Southern and Central blocks collided along the Baydaratskaya fault zone and the Baikalian structures were formed. The Northern Block evolved independently.

Ordovician - Early Devonian

In this period a rather stable regime of a passive continental shelf existed for the Southern and Central blocks. The terrain of the Northern Block was developed under changing shallow to deep water shelf - slope conditions and graptolitic shale facies was widespread.

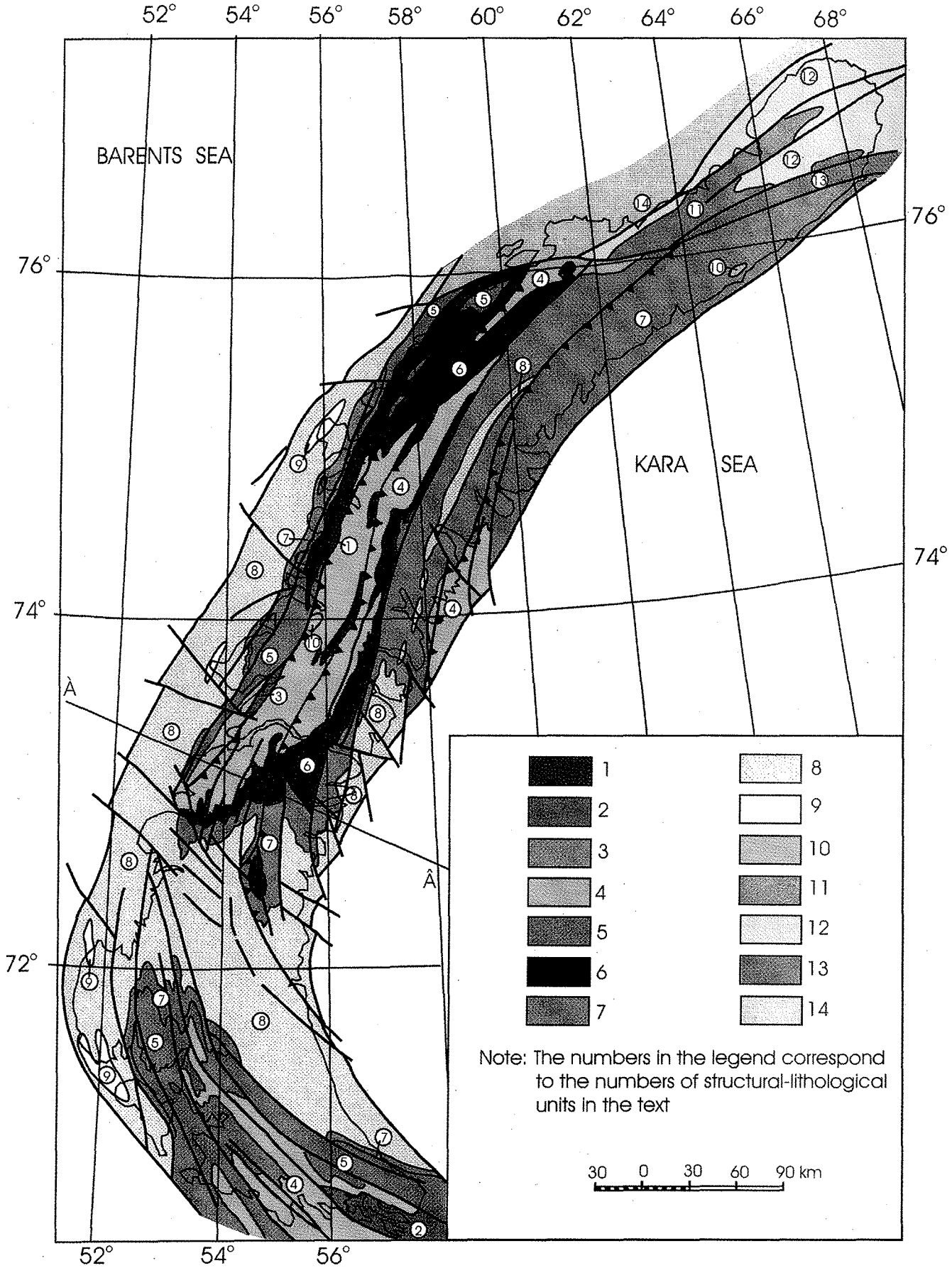

Fig. 3: Map of litho-tectonic assemblages. 1 = Early Riphean terrigenous-carbonate assemblage; 2 = Late Riphean - Vendian flysch-greywacke assemblage; 3 = Late Riphean - Vendian igneous suite; 4 = Cambrian - Middle Devonian shallow shelf assemblage; 5 = Late Devonian - Early Carboniferous carbonate - shelf assemblage; 6 = Middle - Late Devonian carbonaceous - carbonate - volkaniclastic assemblage; 7 = Late Devonian - Permian deep-water assemblage; 8 = Late Permian flyshoidal and turbiditic assemblage; 9 = Upper Permian - Lower Triassic molasse assemblage; 10 = Late Triassic - Early Jurassic igneous suite; 11 = Late Riphean - Early Ordovician assemblage of slope and rise; 12 = Early Ordovician - Early Devonian carbonate shelf assemblage; 13 = Early Devonian - Early Carboniferous terrigenous-carbonate assemblage; 14 = Middle Carboniferous - Permian carbonate-terrigenous shallow-water assemblage.

Middle - Late Devonian

The time of initial rifting in the Southern and Central blocks, culminating in the Frasnian. Submergence and consequent differential vertical movements with intensive magmatism (suboceanic tholeiitic basalts) took place. The Northern Block did not undergo rifting and a carbonate shelf existed, without magmatism.

Late Devonian – Permian

The stage of rifting with a trough forming and filling, strongly differentiated into different zones, from a rather stable carbonate shelf in the Barents zone to continental slope conditions in the Kara zone. In the latter under uncompensated deep water environment, flysch and carbonaceous, siliceous, carbonate assemblage were deposited. The history of the Northern Block continued to be quite different, with shallow water, stable conditions prevailing.

Late Permian - Early Triassic

The stage of intensive avalanche type sedimentation occured in a post rift basin, the Uralian orogen being the source area. Accumulation of flysch, with turbidites started in rather deep water and ended in shallow water conditions. Most part of the Northern Block, by contrast was occupied by a coastal marine environment or by partly eroded, land areas.

Late Triassic - Early Jurassic

The stage of total Paihoi - Novaya Zemlya (including the Northern Block) orogeny, with intensive folding, faulting and minor granitic magmatism, presumably, due to the collision of the Barents and the West Siberian plates.

Younger history

On the Novaya Zemlya archipelago, river valleys of Oligocene age cut to the Late Mesozoic to early Cenozoic peneplain, allowing us to suggest that its latest uplift started in the Oligocene.

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