

# The Upper Proterozoic of Timan and the Kanin Peninsula

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## Introduction

The Precambrian of Timan and the Kanin, Rybačij, and Varanger peninsulas forms a continuous fold belt across the northern Russian platform (Timanides, Baikalides, Hyperborean zone, "Timan corridor"). Despite some similarities in lithology there is no commonly accepted stratigraphic standard for subdivision and correlation. This is because of the relatively monotonous lithologies (mainly terrigenous sequences), the absence of reliable marker beds, the extremely poor fossil content, and a complex tectonic setting.

On the basis of geologic-geophysical data, ŽURAVLEV and GAFAROV (1959), proposed a tectonic zonation of the Timan-Kanin region parallel to the margin of the Pre-Baikalian Russian Platform. Recent geological studies have proved that the western (outer) and eastern (inner) zones of the folded basement differ both in rock type and in grade of metamorphism and dislocation.

The most complete section through both zones was recorded on the Cetlasskij Kamen', Čil'menskij Kamen', and Vymskaja Range in Central Timan. The stratigraphy is unclear because the only fossils occur in a carbonate sequence (the Bystrinskaja Formation) within tectonic blocks along the boundary separating the two zones. There are two interpretations of this section: Some geologists suggest contemporaneous deposition of the different facies within each zone (KAL'BERG 1948; RAZNICYN 1962, 1972; GECEN 1970) while others claim an older ("Pre-Bystrinian") age for the lower metamorphosed terrigenous formations of the western zone, and a "Post-Bystrinian" age for the shale complex of the eastern zone (ŽURAVLEV and OSADČUK 1962; ČERNYJ 1965) stratigraphy.

Three formations have been recognized within the western zone: the Svetlinskaja, Četlasskaja, and Džežimskaja Formations (ŽURAVLEV and OSADČUK 1960, 1963; GECEN 1970). They are separated by unconformities, which are, however, unlikely to be of regional extent.

*The Svetlinskaja Formation* (over 1850 m thick) forms the observed base of the Precambrian section of Timan and is composed of light, fine- to medium-grained quartzites with thin bands of quartz-sericitic shales.

The *Četlasskaja Formation* (2500 to 2700 m thick) has continuous horizon of quartz conglomerates at the base overlain by intercalated dark quartzitic sandstones and mica-quartz and quartz-chlorite slates. The upper part of the formation is characterized by rhythmic alternations of quartz-sericite, quartz-sericite-chlorite, and coaly-argillaceous shales with feldspathic quartzite, quartzitic sandstone, and siltstone.

The *Džežimskaja Formation* (up to 850 m thick) rests unconformably on the *Četlasskaja Formation*, and has a gritstone unit with conglomerate lenses at the base (GECEN 1970). It is divided into two members. The lower member (up to 350 m) is made up of intercalated grey quartzites, siltstones, and shales similar to those of the *Četlasskaja Formation*. The upper member (500 m thick) consists largely of light, feldspathic quartzites and arkosic quartzite-sandstones.

The upper *Četlasskaja Formation* (up to 700 m thick) and the entire *Džežimskaja Formation* (up to 900 m thick) are exposed in southern Timan (ŽURAVLEV and OSADČUK 1963). Above this an observed thickness of 350 m, of grey or red dolomitic limestones and algal dolomites was measured. These were assigned to the *Bystrinskaja Formation*.

Algal dolomites form several horizons from which RAABEN (ŽURAVLEV et al. 1966) has recognized Upper Riphean stromatolites: *Gymnosolen giganteus* RAABEN, *G. ramsayi* STEINM., *Inseria dječimi* RAABEN, *Conophyton miloradoviči* RAABEN, *Tunquissia* sp. SEMIKH., *Kassiella enigmatica* RAABEN, *Parmites concrescens* RAABEN.

The *Bystrinskaja Formation* marks the boundary between the western and eastern zones and is usually faulted against the terrigenous sequences. According to GECEN (1970) in southern Central Timan, the terrigenous sequence overlying the carbonates of the *Bystrinskaja Formation* is equivalent to the *Svetlinskaja*, *Četlasskaja*, and *Džežimskaja Formations* of the type section. However, ŽURAVLEV and OSADČUK (1960, 1973) think that the *Bystrinskaja Formation* lies stratigraphically above the *Džežimskaja Formation* and they subdivide it into two members. The Lower carbonate member (up to 2000 m thick) contains the same assemblage of Upper Riphean stromatolites as in Southern Timan. The Upper member (2000 to 2200 m thick) consists mainly of shales with thin dolomite bands. In northern Central Timan (Cil'menskij Kamen') the stromatolite *Poludia polymorpha* RAABEN was found in the dolomites, suggesting an upper Upper Riphean age. However, farther south shales assigned to the Upper member are intruded by diabases dated at 1200–1220 m.y. (MAL'KOV 1969). This supports GECEN's (1970) proposal of different ages for geographically scattered rock-units assigned to the Upper member of the *Bystrinskaja Formation*.

The *Kisloručeskaja Formation*, described and named by ŽURAVLEV and OSADČUK (1962) outcrops in the eastern zone of Central Timan and consists largely of strongly folded shales metamorphosed to the biotite-chlorite subfacies of the greenschist facies.

The lower part of the formation (500 to 600 m thick) is composed of variegated quartz-micaceous and sericite-chlorite-quartz slates with subordinate

bands of mica quartzites. Above is a sequence (up to 1500 m thick) of phyllitic quartz-biotite shales, the upper part containing units of magnetite-bearing calcareous shales. The section is capped by a sequence of thin-bedded quartz-sericite and chlorite shales often with graphite and bands of feldspathic quartzites.

The outcrops by the well 200 km east of Central Timan exposures and Northern Timan and Kanin Kamen' Ridge are also thought to belong to the Kisloručeskaja Formation (ČERNYJ 1965; ŽURAVLEV and OSADČUK 1962).

*The Barminskaja Group* (up to 3700 m thick) includes the shales of Northern Timan and is subdivided into three formations: the Cape Rumjaničnaja, Maločernoreckaja River, and Jambozerskaja Formations (ČERNYJ 1965; GECEN 1968). A timegap and angular unconformity are indicated between the Cape Rumjaničnaja and Maločernoreckaja River Formations. The Cape Rumjaničnaja Formation (500 to 700 m thick) is made up of garnet-biotite and sericite-biotite shales. The Maločernoreckaja River Formation (2000 to 2500 m thick), consists of alternating dark garnet-quartz-bimicaceous slates, sometimes calcareous, and graphite-bearing green albite-quartz-chlorite shales (meta-volcanics?), and feldspathic quartzites. The Jambozerskaja Formation (1000 m thick) is composed mainly of dark-grey quartz-sericite shales and light-grey quartzite-sandstones with flysch-like rhythms.

Within the strongly folded Precambrian complex of the Kanin Kamen' Ridge three groups are recognized: the Mikulinskaja, Tarachanovskaja, and Tabuevskaja Groups (GECEN 1971).

The Mikulinskaja Group consists of amphibolite facies rocks outcropping in two areas on the Kanin Peninsula, the South-East, and along the North-West coast. In the South-East the Cape Mikulinskaja Group consists of rhythmically alternating dark-grey porphyroblastic garnet two-mica plagiogneisses and lighter equigranular garnet two-mica quartzite shales. Conformable and non-conformable pegmatite veins are common. The boundary with the overlying series is tentatively drawn at the base of a marker bed of garnet-bimicaceous shales with inclusions close in composition to greisenized granites (metaconglomerates) (?). The thickness of the gneiss-shale sequence is more than 500 m.

In the north-west of the Kanin peninsula a sequence (700 to 800 m thick) of alternating micaceous quartzites, garnet-staurolite two-mica slates, and quartz orthoamphibolites was assigned to the Cape Mikulinskaja Group. Lenses of quartz conglomerate-breccias were found in quartzites of lower (?) beds. The quartzite-amphibolite sequence is intruded by small bodies of granite-syenites, lamprophyre dykes, and pegmatite veins. IVENSEN (1964) and ČERNYJ (1965) thought that the presence of pegmatite veins substantiated the theory that contact-metamorphism was responsible for the high metamorphic grade of the country rocks. However, the presence of staurolite in crystalline schists opposes this.

*The Tarachanovskaja Group* (4300 to 5300 m thick) is developed along the south-western slope of the Kanin Kamen' Ridge and is represented mainly by quartz-micaceous slates with units of quartzites in the lower and upper

parts of the section. These rocks are metamorphosed to epidote-almandite and biotite-chlorite subfacies of the greenschist facies. A bed of peculiar thin-banded forsterite-diopside-dolomite and diopside-calcite “skarnoids” as well as lenses of poikiloblastic garnet-amphibole hornfels, resulting presumably from selective metamorphism of marls and sand-carbonate nodules, is present in the lower part of the series. Gabbro-diabase bodies altered into amphibolites, intruded prior to folding, are associated with rocks of the Tarachanovskaja Group.

The Tabuevskaja Group (up to 5000 m thick) begins with a flysch-like shale sequence (up to 1500 m thick) with units of feldspar-quartz sandstones at the base. The middle part (1500 to 2000 m thick) is characterized by a rhythmic alternation of metamorphosed carbonate siltstone and mudstone and includes a 100 m thick marker bed of metamorphosed calcareous magnetite-bearing siltstones. Argillaceous silty shales with numerous units of quartzite-sandstones and coaly shales dominate in the upper part (up to 1700 m thick).

The *Ludovatyje Mysy Formation* is a 700 m thick dolomite sequence exposed in an isolated narrow horst. It yields the Upper Riphean stromatolites: *Gymnosolen giganteus* RAABEN, *G. ramsayi* STEINM., *Insertia dzejimi* RAABEN, *Parmites con-crescens* RAABEN (ŽURAVLEV et al. 1966). The bore-hole data (GECEN and NAUMOV 1973) suggest that the Ludovatyje Mysy dolomites are overlain by a variegated shale sequence (up to 1700 m thick) tentatively assigned to the Vendian. Similar sequences assigned by different authors to the Vendian-Lower Cambrian (or even to the Ordovician) are known from bore-holes of other areas of the Timan–Pechora region.

### Conclusions

In summary, the Precambrian of the Timan–Pechora region has the following general features. It consists of lithologically uniform metasediments of mainly terrigenous origin, showing facies variation and rhythmicity, with an almost complete absence of coarse-clastic deposits and visible evidence of extensive unconformities. Carbonate sequences containing Upper Riphean stromatolites (the Bystrinskaja and Ludovatyje Mysy Formations), and a sequence with magnetite-bearing varieties of shale assigned by different authors to different parts of the section, may be used as regional markers.

K-Ar ages for shales and postfolding intrusions reported from different areas of the Timan and Kanin Peninsula (IVENSEN 1964) do not aid the subdivision of the section. The oldest ages (790–687 m.y.) were yielded by shales of the (?) Kisloručejkskaja Formation in southern Central Timan; farther north phyllite-like shales yield 660–640 m.y. (whole rock) and 560–483 m.y. in the Kanin Peninsula; similar values, 600–550 m.y., were determined for biotite from crystalline shales of the Mikulkinskaja Group. K-Ar ages of intrusive rocks (on mica from pegmatite bodies inclusive) show an irregular scatter over the range of 665–475 m.y. All these values imply only Pre-Vendian (prior to 680 m.y.) age for the shale complex deposition.

The authors believe that the shale complex of the eastern zone of Timan lies at the base of the Precambrian section and is Pre-Upper Riphean in age. The oldest are rocks of the Mikulinskaja Group (Kanin Peninsula) metamorphosed under amphibolite facies; they may belong to some other structural complex regenerated by the Baikalian folding. The area where the “Kislyj Ručej” shale complex is developed, includes the Kisloručejskaja Formation of Central Timan, Barminskaja Group of Northern Timan, as well as the Tarachanovskaja and Tabuevskaja Groups of the Kanin Peninsula, can be in general outlined on typical magnetic anomalies confined to units of magnetite-bearing shales. On the basis of stratigraphic position, the Kislyj Ručej complex may be correlated with the Middle Riphean Jurmatinskaja Group of the type section on the western slope of the Urals and with thick clastic sequences of Rybačij (the Rybačij Group) and Varanger (The Barents Sea and the Raggo Groups) peninsulas. These terrigenous complexes are very thick and intensely folded. They formed within the inner zone of the late Precambrian (probably mainly Middle Riphean) trough and are separated from the outer zone by a series of steep thrusts en echelon.

The outer zone includes terrigenous formations of Southern and Central Timan as well as carbonate formations (the Bystrinskaja and Ludovatye Mysy) dated, on the basis of the stromatolite assemblages, as upper Riphean (Min’jarskaja Formation of the Southern Urals). The Kil’dinskaja Group of the Kola Peninsula and the Tanafjord Group of North Norway also belong to the outer zone. This trough may have begun to form after the Upper Riphean and orogenic formations of Baikalides (the Volokovaya Group of the Srednij Peninsula, Vestertana Group of Finnmark) deposited in inherited or superposed depressions in Vendian time.

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