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# Palaeogeographic reconstructions of the Russian Boreal areas and Svalbard during the Triassic

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## Abstract

Triassic palaeogeographic and palaeoclimatic environments of the Russian Arctic Boreal Province and Svalbard are reconstructed. Multi-facies complexes of clayey, silty and sandy deposits, with various biogenic nodules, accumulated throughout the Triassic, whereas phosphate accumulation was especially characteristic of the Middle Triassic. The entire region consisted of a series of shelf palaeobasins to the south of a wide, deep-water basin that we call the Northern Basin. This was connected to the Palaeo-Pacific. The climate of the region remained warm, with variable humidity, throughout the Triassic. The Franz Josef Land Archipelago stood out for its humid sedimentation during this period. Changes in the sedimentation regime caused by tectonic activity in parts of the territory took place around the Middle–Late Triassic transition. Sharp regression occurred in adjacent areas at the end of the Triassic because of the Atlantic Ocean opening. This provides an explanation for the absence of upper Norian and Rhaetian deposits in the Barents–Kara region. The general accumulation of sediments in the region only resumed in the Early Jurassic.

*The following paper presents a brief review of the results of a lifetime work by Tatjana M. Pčelina and Marianna V. Korčinskaja, both with long and distinguished careers in the fields of the biostratigraphy and geology of Svalbard and the Russian Arctic regions. Much of their early work was carried out at a time when Soviet geologists had little or no access to the mainstream of international thought regarding plate tectonics and continental configurations, making their overview even more remarkable in its insight and breadth.*

*Tatjana M. Pčelina, born in Leningrad in 1925, has spent 17 field seasons in the Arctic, each usually lasting two or three months, and she has published more than 60 scientific contributions. She has worked for the Institute of Arctic Geology (NIIGA), which was eventually reorganized as the All-Russian Research Institute for Geology and Mineral Resources of the World Ocean (VNII Okeangeologija), and its subordinate organization Sevmorgeologija, since 1949. She has studied all areas of Svalbard with Mesozoic sediments, and following the advent of subsea drilling she has also studied the wells in the Russian Barents Sea. Her main emphasis has been on stratigraphy and palaeogeography, and she was the first to understand the great regional similarities of the Mesozoic succession, and especially the Triassic, within the Arctic realm. She has been a pioneer researcher in Russian Arctic research, and reports that she always felt comfortable in the field and with students.*

*Marianna M. Korčinskaja, born in Leningrad in 1930, has undertaken fieldwork for 25 seasons, each typically of two or three months in duration; her fieldwork in Siberia usually lasted up to four months in each season. She has authored 40 publications, mainly on ammonoids and bivalves from Svalbard and Franz Josef Land, and has studied the stratotype of the Olenekian of Siberia. Like her colleague Pčelina, she worked for the Institute of Arctic Geology and the All-Russian Research Institute for Geology and Mineral Resources of the World Ocean.*

*—Atle Mørk & David Worsley*

Palaeogeographic and palaeoclimatic settings have been reconstructed for the Triassic sedimentary development of the Arctic Boreal Realm using lithological and biostratigraphic data from the Svalbard Archipelago (Mørk et al.

1982; Mørk et al. 1999; Pčelina 1983, 1985, 1996), Franz Josef Land (Preobraženskaja et al. 1985; Dypvik et al. 1998) and the New Siberian (Novosibirsky) Islands (Preobraženskaja et al. 1975). Throughout the whole area, these Boreal Triassic deposits are represented by various facies including muddy, silty and sandy sediments, with concretions and interbeds of mainly biogenic carbonates. Here we will discuss platform areas with mainly marine sedimentation. Tectonic and climatic conditions controlling sedimentation periodically changed throughout the Triassic. Relatively warm climates with alternating humidities dominated throughout the period in these Boreal regions. In general, restricted conditions of sedimentation can be traced throughout the Arctic shelf and north-east Asia (Dagis et al. 1979).

Based on data from the Mesozoic of Svalbard, Pčelina (1985, 1996) suggested that in the Triassic there was a vast, deep-water palaeobasin with a Boreal climate to the north of the shelfal areas of the archipelago. This basin, which Pčelina called the "Severny" (Northern) Basin, had connections with the Palaeo-Pacific Ocean. This suggestion is supported by studies of the biogeographic distributions of faunas carried out by Korčinskaja (1982). For example, many Boreal ammonoid species also inhabited the shelfal seas of the Palaeo-Pacific Ocean. This and other data allowed us to suggest that Svalbard and Palaeo-Pacific seawater temperatures were very similar in the Olenekian and Middle Triassic (Hudolej 1979).

The suggestion that the Palaeo-Pacific was connected to the Severny deep-water palaeobasin is also supported by our data regarding the peculiarities of sediment composition in the Triassic. The widespread distribution of phosphorites reflecting oceanic upwelling in the Middle Triassic of Svalbard was described by Pčelina (1985, 1996). The phosphorites form concretions, nodules, oolitic interbeds and thick packages of phosphate-bearing mudstone, with a $P_2O_5$ content of up to 6.25–11.35%. At the time of the Anisian maximum transgression, the already high input of water from the Severny deep-water paleobasin was increased even more. This upwelling carried a considerable quantity of nutrients to the shelf. A high concentration of phosphorus promoted the abundant development of planktic blue-green algal colonies, which were able to assimilate phosphorus from the seawater. In quiet hydrodynamic conditions with low sedimentation rates, the plankton were deposited and enriched the sediments with phosphorus. Heterotrophic bacteria reorganized the organic phosphorus into a mineral phase. A similar type of phosphorus accumulation and enrichment in the Middle Triassic of the New Siberian Islands was later described by Egorov & Baturin (1987).

Middle Triassic phosphorites are widely distributed throughout north-eastern Asia. Phosphorites are also known in the Middle Triassic of the Peary Land area in north-eastern Greenland (Kummel 1953), in the Sverdrup Basin of Arctic Canada (Embry 1997) and in northern Alaska (Grantz et al. 1990). In these regions, sedimentation in the Triassic also occurred in shelfal marine regimes. Our suggestion of the existence of the Severny deep-water palaeobasin has been disputed, but it is clear that all transgressions at that time in Boreal areas came from the north, where this palaeobasin is suggested to have developed. This is supported by data from Kotelny Island, in the New Siberian Archipelago, where there is increased marine influence, and by the deepening of the Triassic basin, as has been shown to the north of the New Siberian Islands (Preobraženskaja et al. 1975).

The existence of our postulated Severny deep-water paleobasin is supported by the data of Bragin (1991). Bragin described oceanic-type Triassic radiolarians found in intensely tectonized cherty and volcano-cherty rocks of eastern Koryak Plato, Sakhalin and Sikhote-Alin. All of these units were formed in a basin of oceanic type in tropical climatic conditions. There is no known facies transition from here to the terrigenous deposits of the western Boreal regions of north-eastern Asia. On the Amolon massif, Bragin (1991) established the presence of Middle Triassic radiolarians in clastic deposits already associated with a Boreal climate. Deposits with radiolarians in the Alaskan Brooks Range (Bragin 1991), on Kotelny Island (Egorov & Bragin 1995) and in Svalbard (Pčelina 1985, 1996) were formed in the same climate. Thin beds of radiolitic chert occur in the Svalbard Archipelago.

Perhaps increasing tectonic activity in the Palaeo-Pacific Ocean initiated volcanism in the Severny deep-water palaeobasin. Basic intrusives at the base of the Induan (Lower Triassic) on Kotelny Island were probably associated with this activity. At the beginning of the early Triassic, activation of tectonic processes in the Palaeo-Pacific Ocean initiated rapid submergence of the Severny deep-water palaeobasin, and of the northern Pangean Arctic shelves, initiating a large-scale regional transgression. Induan deposits in the Boreal areas usually rest unconformably on beds of various ages, although mainly on Upper Permian units. Stratigraphic discontinuities correspond to a part of or all of Induan time in some palaeouplifts. Palaeobasins inherited from the Late Permian, and located near high mountain massifs, show a different development. In Induan time these palaeobasins were activated, and deposition was characterized by turbiditic or mass transport. Triassic sediments are up to 1730–2300 m thick on the Admiralteiskiy Uplift, where there is

a gradual transition from Permian to Triassic sediments. A Triassic succession of up to 6–8 km thick is thought to be present in the northern Kara Region in the West Greembel'skiy large palaeobasin, located close to the vast Severozemelskiy Orogen (Pčelina 1998).

Deposition in Olenekian and Middle Triassic times occurred in deepening basin conditions, and under ongoing transgression, which reached a maximum in the Anisian. Similar facies conditions in zones of moderately arid climate are observed in the eastern parts of Svalbard, and in the New Siberian Islands. In these regions, the Olenekian dark clayey sediments include interbeds of biogenic limestones, with the same types of benthic blue and green algae, and algal concretions with numerous small bivalves and ammonoids. The Late Olenekian sediments of Kotelny, New Siberian Islands, are similar to sediments in north-eastern Svalbard. The first small phosphate concretions appeared in the dark, laminated shales of these regions, although these are characteristic of the Middle Triassic. Tectonic stabilization then began in the Middle Triassic. In the Anisian, relatively deep-water shelf conditions prevailed in areas distant from clastic sources, and organic-rich clays were deposited in anoxic zones, characterized by the accumulation of massive death assemblages of zoo- and phytoplankton, and by the formation of hydrogen sulphide.

In Franz Josef Land, facies conditions in the Early Middle Triassic were similar to those in western parts of Spitsbergen. Sedimentation here was in coastal marine and shallow water conditions. The humid climate type of sedimentation in the area was caused by the proximity of the Severozemelsky–Taimyr orogen, to the east of the archipelago (Pčelina 1998), and of the Severny deep-water palaeobasin to the north. Sediments are enriched in organic carbon. Lenses and thin beds of coal also occur. Fluvial and slump fabrics are typical. The volume of marine sediments increases in the western areas of the Franz Josef Archipelago.

At the Middle–Late Triassic transition, significant changes in palaeogeographic and palaeoclimatic settings occurred in connection with the activation of tectonic processes. In the Carnian, the whole Barents–Kara region became a zone with a humid climate. Prominent uplift of the region also occurred. In the northern part of the area significant shallowing of the basin occurred, and the stable marine sedimentation regime ended (Pčelina 1996, 1998). Marine transgressions in Carnian times are more typical for the north-western areas of the Barents region, and the role that sandy sediments play increases to a considerable extent. Stable marine sedimentational regimes prevailed in the eastern Arctic, including the New Siberian Islands and Wrangel Island (Preobraženskaja et al. 1975), and north-eastern Asia. Here, mainly clay-rich units with abundant faunas of ammonoids, bivalves and other species were deposited.

In the Barents–Kara region, the last transgression spread to northern areas in Early–Middle Norian times. Late Norian and Rhaetian deposits are absent (Pčelina 1980). Pčelina also suggested that Late Norian–Rhaetian deposits were absent in Franz Josef Land (Dypvik et al. 1998). At the end of large-scale cyclic Triassic sedimentation, a period of tectonic stabilization arrived in the Late Norian–Rhaetian, with low relief both in the sedimentation basin and on the surrounding subaerial massif. Marine waters left the Barents–Kara region, and went to the east in an area of the Palaeo-Pacific Ocean. Perhaps it was in this area that the beginning of the Atlantic opening commenced, leading to an abrupt regression in the Barents–Kara region (Pčelina 1998). In contrast, the eastern part of the Boreal Province is characterized by continuous Norian–Rhaetian and Jurassic marine sedimentation. Mainly clay sediments accumulated: on the island of Kotelny, they are 750-m thick; in north-eastern Asia they are up to 1000–2500-m thick. In the latter region these sediments contain abundant tuff and ash beds, sometimes including lava (Dagis et al. 1979).

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