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Stratigraphy, sedimentology and palaeogeography of the high-tatric Triassic in the Tatra Mts.

ABSTRACT: On the basis of lithologico-stratigraphic studies, confirmed by new faunal finds, Alpine stratigraphy has been established in the high-tatric Triassic and following stages distinguished: Seis, Campilian, Anisian, Ladinian, Carnian, Norian and Rhaetic. A description is given of the conditions of sedimentation, facial variability, and the palaeogeography of the high-tatric Triassic, as well as its relation to other palaeogeographo-structural units.

INTRODUCTION

The present paper reports the results of research work on the stratigraphy, palaeogeography and sedimentation of the high-tatric Triassic in the Tatra Mts. These studies have been systematically carried on since 1955, in the Laboratory of Dynamic Geology of the Warsaw University, partly with support of the Polish Academy of Sciences, and the Geological Institute of Poland.

I should like to express my special thanks to Prof. Dr. E. Passendorfer for his guidance during the preparation of the present work, also for the helpful discussion and revision of the text. Thanks are also due to Mr. J. Lefeld for kindly reading my work.

In view of the paucity of fauna in the high-tatric Triassic the faunistic and stratigraphic knowledge of these areas is not adequate. The writer has, therefore, treated here more at large problems concerned with sedimentation and palaeogeography whose study is on a better way tu solution.

A comprehensive paper published by the writer contains the main stratigraphic profiles (Kotański 1959), and situation maps of the localities mentioned in the present work, together with comments on the documentation material he has used here.

GENERAL NOTE

The sedimentary series of the Tatra Mts. is divided into two major tectonic and palaeogeographic units: the high-tatric and the sub-tatric unit.

The high-tatric lies directly on the crystalline core of the Tatra Mts. The sub-tatric is situated farther north and was overthrust from the south. The sub-tatric unit is divided into two nappes, the lower sub-tatric (Križna) nappe and the upper sub-tatric (Choč) nappe.

The folded high-tatric series may be divided into three tectonic units. These are the autochtonic Kominy Tylkowe unit, the Czerwone Wierchy fold and the Giewont fold.

Generally speaking the sub-tatric sedimentary basin was of intrageosynclinal character, the high-tatric of intrageanticlinal. Palaeogeographical differentiation in the various tectonic units is distinctly reflected in the character of Triassic sediments.

According to traditional (though somewhat schematic) opinions the Triassic of the Choč nappe was completely marine, the lower sub-tatric nappe marine in the middle part only, but continental in the lower and the upper part. In the high-tatric fold series the Triassic formation is characterised by the presence of numerous stratigraphic gaps.

STRATIGRAPHY

The high-tatric Triassic of the Tatra Mountains has been known since long ago. V. Uhlig (1897) referred to the Triassic red shales intercalated by sandstones, followed by cavernous limestones and dolomites (Zellendolomiten). Moreover, he assigned the Keuper age to shales, sandstones and quartz conglomerates from Czerwone Żlebki. Quartzite conglomerates and sandstones at the base of the here defined Triassic were by Uhlig referred to the Permian, while a limestone and dolomite series at its top has been referred to the Lias.

New data on Triassic stratigraphy and palaeogeography were contributed by M. Limanowski (1903). He assigned to the Lower Triassic a part of the quartzitic sandstones, by Uhlig referred to the Permian, and introduced the Permo-Triassic term.

On the basis of Uhlig's stratigraphic views Cz. Kuźniar (1913) has carried out a number of petrographic analyses of rocks, subsequently recognised as Triassic.

In 1921 Uhlig's "Liasjurakalk" was by F. Rabowski (1921) referred to the Middle Triassic. Initially that author based his conclusions on tectonic grounds. Subsequently (1931) he collected a lamellibranchian fauna which proved his view. The assignment of a powerful series of limestones and dolomites to the Middle Triassic considerably simplified tectonic conceptions and laid the foundation stone for new more detailed stratigrahpic investigations.

After E. Passendorfer (1934), a more complete sedimentary series might be supposed in the Kominy Tylkowe series, inasmuch that the thickness of Middle Triassic rocks observed in the Czerwone Wierchy series, and still more so in the Giewont series, was markedly smaller. E. Passendorfer has encountered within the Triassic of Mt. Giewont numerous segments of crinoids identified as *Dadocrinus gracilis*. This is an index form of the lower part of the Wellenkalk in Upper Silesia. F. Rabowski (1959) when correlating the Middle Triassic above Tomanowa Pass and from the Kominy Tylkowe massif, with the Middle Triassic of Mt. Giewont, likewise observed on Mt Giewont the absence of the upper Middle Triassic complex, 400 to 500 m thick. On the ground of earlier differentiations by Slovakian authors (Koutek 1920, Zoubek 1930) St. Sokołowski (1948) and E. Passendorfer (1950) referred to the Werfenian quartzitio sandstones and conglomerates regarded as Permo-Triassic.

Thus, the Triassic, in the time of Uhlig assigned to a limited series of rocks not more than several tens metres thick, subsequently has grown to a thickness involving several hundred metres and constitutes the most powerful formation within the Tatra Mountains.

The stratigraphic concepts in respect to the Tatra Triassic have thus far lacked uniformity. The Lower Triassic has for a long time been commonly known as the Werfenian owing to lithological analogies with the East-Alpine Triassic. The Middle Triassic was referred to as the Muschelkalk, the Upper Triassic as the Keuper. At the same time several lithological types corresponding to the Alpine Triassic were distinguished (Slovakian geologists and K. Guzik, 1956) in the sub-tatric series of the Middle Triassic. The nomenclature used was therefore a mixed one, partly that of the Alpine and partly of German Triassic.

The Tatra Mountains lie within the Alpine geosyncline. The Tatra Triassic, though deviating from the classic geosynclinal sediments of the Eastern Alps, is, nevertheless, less closely allied with the German Triassic than has heretofore been believed. E.g. the so called "Carpathian Keuper" of the high-tatric series is not a continental sediment, since the red clastic littoral deposits are merely one of the facies among typically marine carbonate rocks bearing an Alpine brachiopod fauna. On the other hand, it has been ascertained many-a-times that the attempt of close age and facies correlations with the Eastern Alps is likewise misleading.

The writer's studies have led to the differentation of all Alpine stages of high-tatric Triassic. Some of them: the Campilian, the Anisian and the Norian, have been distinguished on characteristic fauna, others on palaeogeographical conclusions.

LOWER TRIASSIC (Scythian)

The Lower Triassic is characteristic by the presence of clastic facies. On analogies with the Alpine sediments it has long been referred to the Werfenian.

Until recently the Werfenian age had been assigned only to red shales with intercalations of sandstones, and the so called cavernous limestones and dolomites. Sokołowski (1948) referred to the Werfenian the complete series of quartzite sandstones and conglomerates, believed to be Permo-Triassic. This was done on reliable evidence, since Werfenian beds in this interpretation rest unconformably on crystalline rocks and on the Permian (Koperszady series, Passendorfer 1950, 1957). While the lower boundary of the Werfenian is established with certainty, a new sedimentation cycle being started with the Werfenian, the Werfenian-Middle Triassic boundary has not been palaeontologically estabhlished.

In the earlier papers of Rabowski (1925), as well as those of E. Passendorfer (1951) and of M. Turnau-Morawska (1947, 1955) this boundary was placed over the cavernous limestones and dolomites. In his last report, F. Rabowski (1954) referred them to the Middle Triassic, probably on Alpine analogies (Gignoux 1956). Initially the present writer concurred with this opinion (1955a) on the fact that, within the Giewont series, cavernous limestones and dolomites may be sedimentarily replaced by limestones and dolomites previously referred to the Middle Triassic. However, on his later investigations the present writer (1956 a,c) inferred that the boundary between the Werfenian and the Middle Triassic stretches far higher above the so called cavernous limestones and dolomites since deposits containing an Upper Werfenian fauna occur in their top. *Moyphoria costata* and *Naticella costata* recovered from these rocks indicate the presence of a Campilian stage to which have likewise been referred the so called cavernous limestones and dolomites, while the underlying clastic rocks are assigned to the Seis (chart 1).

Within the Czerwone Wierchy series the development of the Werfenian is similar. However, the Seis and Campilian beds there have been left mostly below the shearing plane. In the Giewont series lower Campilian Myophoria beds replace the cavernous "limestone and dolomite" series. Moreover it has been ascertained that the so called cavernous

CHART 1

STRATIGRAPHY OF THE HIGH-TATRIC TRIASSIC

<table>
<tr><th rowspan="3">Sub-division</th><th rowspan="3">Stages / High-tatric series</th><th colspan="7">Kominy Tylkowe Series</th><th colspan="3">Czerwone Wierchy Series</th><th rowspan="3">Giewont Series</th></tr>
<tr><th rowspan="2">Spis-Michałowa Valley</th><th rowspan="2">Czerwone Żlebki</th><th rowspan="2">Smytnia Valley</th><th colspan="2">Cicha Valley</th><th colspan="2">Chochołowska Valley</th><th colspan="2">„pod Ciemniakiem” root twist region</th><th rowspan="2">Upper limb of the fold</th></tr>
<tr><th>Jawor</th><th>E part</th><th>Przełęcz w Kulawcu Pass</th><th>Slope of Mt. Bobrowiec</th><th>NW Rzędy</th><th>SE Rzędy</th></tr>
<tr><td rowspan="3">Upper Triassic</td><td>RHAETIC</td><td>—</td><td rowspan="3">—
Tomanowa beds.
alternating black and brown shales with oolithic iron ores, also flora-bearing quartzites
alternating conglomerates, sandstones
red and green shales
apple-green dolomites</td><td>(there are profs of Rhaetic transgression in the neighbouring areas)
—</td><td>—</td><td colspan="3">black shales and limestones with crinoids, corals, calcareous algae and bryozoans
Tomanowa beds: alternating black and brown shales with oolithic iron ores, also flora-bearing quartzites —</td><td>—</td><td>—</td><td colspan="2">(there are proofs of Rhaetic transgression)
— —</td></tr>
<tr><td>NORIAN</td><td rowspan="2">—
alternating beds of light platy dolomites, also of yellow, black and pink dolomite shales</td><td>—
yellow weathering platy dolomites with cherts, also dolomitic shales and banded limestones</td><td>—</td><td></td><td rowspan="2">arenaceous dolomites, yellow marly dolomites, shales, sandstones and conglomerates
—</td><td rowspan="2">—
alternating red shales, sandstones and conglomerates
—</td><td rowspan="2">—
platy dolomites and dolomitic shales, red shales, sandstones and conglomerates, dolomites and shales</td><td rowspan="2">—
dolomites and limestones bearing a brachiopod fauna, alternating dolomites and red and black shales</td><td colspan="2">(there are proofs of Norian transgression)
— —</td></tr>
<tr><td>CARNIAN</td><td>alternating conglomerates, sandstones, shales, dolomites and limestones</td><td>—</td><td>—</td><td>—</td><td>—</td></tr>
<tr><td rowspan="2">Middle Triassic</td><td>LADINIAN</td><td colspan="4">alternating beds of limestones and dolomites with distinct predominance of dolomites
fossils: *Encrinus* sp., recrystallised algal structures</td><td>—</td><td colspan="2">—</td><td colspan="3">alternating beds of limestones and dolomites with predominance of dolomites
fossils: *Encrinus* sp.
(Upper limb: —)</td><td>—</td></tr>
<tr><td>ANISIAN (Virglorian)</td><td>Illyr
Pelson
Hydasp</td><td colspan="3">alternatig beds:
yellow weathering platy dolomites,
vermicular and crinoidal limestones with *Dadocrinus*
grey saccharoid limestones
grey saccharoid dolomites
basal breccia</td><td>—</td><td colspan="2">—</td><td colspan="4">alternating beds:
yellow weathering platy dolomites, vermicular crinoidal limestones with pelecypods and gastropods and with *Dadocrinus grundeyi*
grey saccharoid limestones
fossils: *Pecten discites, Gervillia mytiloides, Modiola triquetra*
grey saccharoid dolomites
basal breccia
(Giewont: —)</td></tr>
<tr><td rowspan="3">Upper Triassic (Scythian = Werfenian)</td><td rowspan="2">CAMPILIAN</td><td colspan="4">supra-Myophoria dolomites
Myophoria beds: alternating yellow weathering dolomites, black bituminous limestones black, red and green shales, also intraformational breccias;
fossils: *Myophoria costata* and *Naticella costata*
so called cavernous limestone and dolomite series:</td><td>—</td><td colspan="2">—</td><td colspan="3">supra-Myophoria dolomites
Myophoria beds:
alternating yellow weathering dolomites, black bituminous limestones, black shales also intraformational breccias;</td><td rowspan="2">fossils: *Myophoria costata*</td></tr>
<tr><td colspan="10">alternating green shales and grey dolomites also ashy and yellow marls</td></tr>
<tr><td>SEIS</td><td colspan="11">red and green shales interbedded by calcareous sands
red brittle sandstones and shales
quartzitic sandstones and quartz conglomerates</td></tr>
</table>

limestones and dolomites do not constitute a particular lithological horizon in the meaning so far used in literature. More likely they are a tectonic or slope breccia formed on rocks *in situ* (Kotański 1956a, 1959), as yet very little known.

It should be pointed out that the Seis and Campilian terms — so called after the Seiser Schichten and the Campiler Schichten of the Eastern Alps — have long ago been introduced into the nomenclature of the Alpine Triassic by Hungarian (Balogh 1948, 1952, Balogh & Panto 1952, 1953), Slovakian (Mišik 1953, Němčok 1953, Mahel 1956a, b), and Bulgarian (Bončev 1955) authors. The Campilian fauna only has been recovered from the Tatra Mountains, i.e. by M. Limanowski (1901) from the sub-tatric series, and by the present writer (1956 a, c) from the high-tatric series. So far there is no palaeontological evidence for the presence of the Seis. The corresponding beds have been assigned to this stage on analogies with the Triassic of Slovakia and of the Alps. Their age is also reasonably established on their stratigraphic position below Campilian deposits with which they are sedimentarily connected.

MIDDLE TRIASSIC

The complete Middle Triassic profile occurs nearly throughout the Kominy Tylkowe series. It is proved by sedimentary connection with the Campilian and the Keuper, the latter likewise being in sedimentary connection with the Tomanowa beds of Rhaetic age (Raciborski 1890). Both stages of the Middle Triassic — the Anisian (Virglorian) and the Ladinian must, therefore, fit into these boundaries.

For the sake of convenience the boundary between the Campilian and the Anisian has been placed at the bottom of the so called basal breccia. It contains Werfenian — mainly lower Campilian — rock-fragments and occurs in all units of the high-tatric series, likewise in the sub-tatric series (Kotański 1958). Grey saccharoid dolomites, towards the top passing into grey saccharoid dolomitic limestones with parallel (granular) lamination, overlie the basal breccia. Over these beds there is a thick series of alternating limestones (mostly vermicular) and dolomites. An abundant fauna of crinoids, belonging to the species *Dadocrinus grundeyi,* has been recovered from the limestones, suggesting the Anisian (Lower Hydaspian) age (Lefeld 1956, 1957). It should be pointed out that vermicular limestones, being a most specific sedimentary structure, are likewise of stratigraphic significance. In the Western Alps they namely occur (Briançonnais series and the Pre-Alps — Jeannet & Rabowski 1912, Blanchet 1934, Gignoux & Moret 1938, Gignoux 1957) in the lower zone of the Middle Triassic, similarly as in the Tatra Mountains. The earlier conclusions of the present writer postulating the occurrence of vermicular limestones in the upper part of the Middle Triassic (1955 b) must be modified inasmuch that the boundary between the Werfenian and the Middle Triassic has been shifted considerably upwards (Kotański 1956a). Structures similar to vermicular structures from the Alps and the Tatra Mountains are also known from the Muschelkalk of Upper Silesia and Germany (Wellenkalk) where they are grouped within the Lower Muschelkalk (Gogolin beds). The youngest Triassic deposits of the Giewont series, probably also those in the greater part of the Czerwone Wierchy series, belong to the Anisian.

Ladinian sediments (limestones alternating with dolomites), also occur in the Kominy Tylkowe series. So far, however, they have not yielded an index fauna. The presence of large trochites of genus *Encrinus* possibly suggests the Ladinian.

Lamellibranchs locally occurring within the Anisian have no stratigraphic significance. They are *Pecten discites, Gervillia mytiloides* and *Modiola triquetra* collected by F. Rabowski (1931). The present author has discovered numerous new localities with these forms, mostly within lower Anisian saccharoid limestones (Kotański 1959). Calcareous algae of the Dasycladaceae group are known to be important index fossils in the Alpine Triassic. In the high-tatric Triassic they have been dolomitised or re-crystallised to such an extent that it cannot be with certainty established with which species of genus *Diplopora, Physoporella, Teutloporella* or *Gyroporella* we are dealing.

UPPER TRIASSIC

Upper Triassic rocks in the high-tatric series have been long known (Czerwone Żlebki) and, on their facial development, assigned the Keuper age. Owing to sedimentary connection with the Middle Triassic on the one hand, and with the Rhaetic of the Tomanowa beds on the other hand, their upper Triassic age is beyond doubt. In the carbonate Upper Triassic series of Rzędy pod Ciemniakiem, probably corresponding to the Norian, the writer has recently discovered a brachiopod faunule not yet identified.

Both stages of the Upper Triassic, i.e. the Carnian and the Norian are developed as the Keuper clastic series of Czerwone Żlebki.

In the Smytnia Valley clastic deposits are covered by a thick dolomite series. The Upper Triassic here is thus clearly bi-partite. The lower part probably belongs to the Carnian, the higher to the Norian. Similar bi-partition likewise occurs in the NW part of Rzędy pod Ciemniakiem and on the Tomanowski Twardy Upłaz.

In the Spis-Michałowa Valley (Szeroka Jaworzyńska Massif) the whole Upper Triassic is developed as yellow dolomites and dolomitic shales. This is, therefore, the marine facies of the Upper Triassic, involving the Carnian and the Norian. A similar profile of the Upper Triassic also occurs in the SE part of Rzędy pod Ciemniakiem. Stratigraphic correlations of the Upper Triassic in the high-tatric series are difficult owing to strong facial differentiation. The ascertained occurrence in the Upper Triassic of a purely marine facies compels us to put aside the term of „Keuper" and to introduce purely Alpine stratigraphic nomenclature (Kotański 1956 d).

The Upper Triassic has been recorded from the Kominy Tylkowe series only, from the Świerkule unit (Jaroszewski 1957) and from the root twist zone of the Czerwone Wierchy fold. It is unknown from the true Czerwone Wierchy series or from the Giewont series. Upper Triassic palaeogeography is more at large dealt with in the following chapter.

RHAETIC

In Czerwone Żlebki and above the Kraków Ravine, lie the Tomanowa beds, directly overlying the Upper Triassic developed in a red clastic facies. They are brown quartzite sandstones, also black and brown shales with oolithic iron ores, bearing a flora permitting their assignment to the continental Rhaetic (Raciborski 1890, Uhlig 1897).

Moreover, coral, oyster and bryozoan limestones have long been known from the Chochołowska Valley. On analogies with the sub-tatric Rhaetic they have been referred by Uhlig (1897) correctly to this stage. These analogies were also noted by W. Goetel (1916).

However, since no faunistic evidence has thus far been provided by these deposits, their age cannot be accurately established. Horwitz and Rabowski (1922) referred them to the Rhaetic-Hettangian owing to their stratigraphic connection with the Lias.

Recent excavations in Przełęcz w Kulawcu Pass permitted to ascertain that the studied rocks have a sedimentary connection both with the Lias, and with the newly discovered uppermost Norian beds. The exposed section obviously indicates that Rhaetic beds are represented there too. To the Rhaetic must in the first place be referred the above considered rocks which display previously noted analogies with the sub-tatric Rhaetic.

In 1956 the marine Rhaetic of the Chochołowska type was recorded by the writer also from the Cicha Valley. Since the occurrence here of links somewhat higher than those in the Chochołowska Valley is not quite out of the question, the Tomanowa beds are reasonably referable to the lowermost Rhaetic and uppermost Norian. Their relation to Norian dolomites could not, regretfully, be determined, since these two facies exclude one another. The Tomanowa beds are connected either with the clastic facies of the Upper Triassic (Czerwone Żlebki) or rest directly on the Campilian (Cicha Valley). They are the first sediment laid down after a prolonged continental period which prevailed during the Upper Triassic in some parts of the Tatra Mountains.

Facial variability, palaeogeographic conditions in the particular high-tatric series, Upper Triassic orogenic movements and the period of denudation, are more comprehensively dealt with in the next chapter.

SEDIMENTATION AND PALAEOGEOGRAPHY

Lower Triassic

Seis

Seis rocks, described in a number of post-war works (Sokołowski 1948, Passendorfer 1950, Turnau-Morawska 1947, 1955), have not been more closely investigated by the present writer. They consist of conglomerates and quartzitic sandstones dark brown in colour, doubtlessly transported by streams from a far distant area, as is indicated by the predominance in pebbles of vein quartz. These sediments rest directly on crystalline rocks. In one site only, in the Jagnięcy crest, they overlie the Permian Koperszady series. Very little is as yet known on the trends of sedimentation and conditions of deposition of the clastic material here. An analysis of the constituents of arenaceous rocks has, however, shown their origin to be partly from the denuded Permian Verrucano mantle (Passendorfer 1950), partly from the crystalline core resembling the Tatra core (Turnau-Morawska 1955).

Recently K. Borza (1958) has suggested that they are of marine origin. This opinion concurs with detailed sedimentological studies of P. Roniewicz (1959). So far the prevalent opinion has been that Seis rocks, at least so in the lower portion, are of fluvial origin (Passendorfer 1957).

It is a well known fact that Werfenian deposits overlie crystalline rokcs quite flatly, board-like.

The writer's detailed studies on the south slope of Mt. Giewont have shown that the bottom surface of the Werfenian is by no means so flat as it appears to be. Depressions and elevations doubtlessly due to erosion, are there observable (Kotański 1959, table XVII). During the Seis these depressions were filled by sediments but it was not until the Campilian that they became completely filled up.

Coarse-clastic conglomerates and sandstones of the lower Seis grade upwards into more argillaceous series (red and green shales, occasionally calcareous, also sandstones). No marine fauna has so far been found in them, though in the sub-tatric series Werfenian deposits with strong lithological resemblances have long been known to contain marine forms (Limanowski 1901).

Seis deposits are, in the first place, recorded from the Kominy Tylkowe series (Stežki, Jagnięcy crest, Szeroka Jaworzyńska, Koszysta, Żółta Turnia, Skrajna Turnia, Cicha Valley, Tomanowa Pass, Ornak, Kulawiec, Bobrowiecka Pass), also from the Giewont series (Sucha Woda Valley, Siodełko, south slope of Mt. Giewont, Kondracka Pass). Within the Czerwone Wierchy fold the Seis has been left below the shearing plane during the orogenic movements. It crops out in the Szeroka Jaworzyńska Massif and above Jawor in Cicha Valley only in the core of the Czerwone Wierchy fold.

Observations from these exposures have shown that there are no important lithological or facial differences in the Seis throughout the high-tatric units. Its development is extremely uniform.

Campilian

The Campilian stage has not been differentiated by previous authors in the present meaning of the term. Though the so called cavernous limestones and dolomites belonging to it have long been known, their origin used to be quite differently interpreted. In most cases they have been regarded as marine breccias (Turnau-Morawska 1955, Kotański 1955 a) or as reef products (Kuźniar 1919), while lately they have been referred to the Middle Triassic (Rabowski 1954, Kotański 1955 a). Naturally, also the higher layers (Myophoria beds and supra-Myophoria dolomites) were included into the Middle Triassic.

It has now become clear that quite different interpretation must be given in respect to the origin of the so called cavernous limestones and dolomites than that so far accepted. This type of beds (marine breccias) does not actually occur as a stratigraphical horizon. Other beds, however, exist within the horizon of cavernous limestones and dolomites, either completely unknown or very inadequately described. At the bottom these are alternating layers of green shales and dark-grey compact dolomites bearing traces of organic structures. Sporadically the dolomites are strongly fractured and permeated by a net system of veins of yellow coarse-crystalline calcite. This complex is generally coated by a thick cover of slope breccias. Above this complex the dolomites are interbedded by grey and yellow marls. A layer of ashy marls occurs in the top of this assemblage. The marls here are mostly permeated by a net of veins of coarse crystalline calcite, producing one of the types of breccias described as "cavernous limestones". For more details regarding "cavernous limestones and dolomites" see Kotański 1956a and 1959.

Hence, beds from the „cavernous limestones and dolomites" series are a normal marine deposit. They are characterised by unstabilised sedimentation which is clastic in the case of red and green argillaceous shales but carbonate in the case of dolomites and marls. Alternating shales and dolomites, indicated ununiform supply of terrigenic material, intermitted by chemical or organo-chemical sedimentation.

Myophoria beds, belonging to the Upper Campilian, consist of black shales (locally green or red) alternating with black bituminous limestones with occasional banded structures of the bioherme type (calcareous algae), also of distincly bedded platy dolomites. These dolomites bear a fauna containing lamellibranchs of *Myophoria costata* and of gastropods *Naticella costata.*

Neither here has the carbonate sedimentation type become stabilised. Besides carbonate organo-chemical rocks shales occur here with a high percentage of detritic quartz. The sea where these deposits were laid down was a shallow one. This is indicated both by the fauna and the great abundance of slide- and still more of intraformational breccias. They are composed of fragments of newly laid down but already consolidated deposits of bituminous limestones, dolomites and black shales. An abundance of the intraformational breccias is one of the most characteristic features of the Myophoria beds. These breccias were formed when wave action attained sea bottom, breaking up the bottom deposits, possibly during heavy storms.

The Myophoria beds are followed by an assemblage of dark-grey platy yellow weathering dolomites, locally of the pea-like variety (possibly recrystallised algal structures), with sporadical intraformational breccias. These are the so called supra-Myophoria dolomites. Only organo-chemical deposits were laid down then, showing no traces of terrigenic material, similarly as in the Middle Triassic.

The Campilian has been distinguished in all the high-tatric series. In the Kominy Tylkowe series a classic exposure occurs on the south side of Mt. Panienki (Kotański 1956a, 1959). Moreover, Campilian deposits are known from the valleys of Tomanowa, Staroroboiańska and Cicha, from Dubrawiska, the Szeroka Jaworzyńska Massif, also from the higher part of Koperszady Zadnie Valley. In the Czerwone Wierchy series Campilian rocks most frequently constitute the core of the fold (the Seis together with the crystalline rocks has been left behind during the folding). Their best exposures are in a gully below Chuda Turnia, in Mułowy Valley and Rozpadlina Valley, Kondratowa Valley (Piekło), in Myślenickie Turnie, and Hala Gąsienicowa. In the High Tatra they are encountered in the Szeroka Jaworzyńska massif. In the Giewont series the Campilian stretches in a wide belt on the south slopes of Mt. Giewont and Kalacka Turnia. It also crops out in Mała Łąka Valley, on the pass near the Siadła Turnia, in the Mechy Pass near Kopa Magura, in the bed of the Sucha Woda Valley and on Mt. Mała Koszysta.

In all these places the Campilian rocks are very much alike. It is only within the series of Kominy Tylkowe and of Czerwone Wierchy that three distinct subdivisions of the Campilian are observable: beds from the cavernous limestone and dolomite series, Myophoria beds, and supra-Myophoria dolomites. In the Giewont series, on the other hand, (the south slope of Mt. Giewont) the characteristic facies of the Myophoria beds starts already in the lower Campilian, while "beds from the cavernous limestone and dolomite series" are nearly completely absent. In some sections the boundary between the Myophoria beds and supra-Myophoria dolomites descends fairly low down, while in others shales from the Myophoria beds come up nearly to the top of the Campilian. Black Campilian shales never attain any great thickness. It is only in Kalacka Turnia that they display a thickness over the average figure.

On these unimportant differences, however, it is hardly possible reliably to establish the palaeogeographical assignment of units without a determined tectonic position.

On the south side of Mt. Giewont, where much research work has been done, it is possible to ascertain the strong facial variability and depth differences of Myophoria beds in the particular sections. The pre-Triassic unevenness of the substratum (Kotański 1959, table XVII) was levelled during the Campilian.

Middle Triassic

The Middle Triassic is characterised by the formation of a powerful series of carbonate sediments — limestones and dolomites — whose morphology presents some of the most typical Tatra scenery (Rzędy and Zdrapiska in the Kominy Tylkowe Massif, slopes of Kościeliska Valley near Hala Pisana, Rzędy pod Ciemniakiem, Krzesanica, Valleys Rozdlina and Świstowa, part of the south side of Mt. Giewont, and finally Zamki and Upłazki in Szeroka Jaworzyńska Massif). Ladinian rocks are far less common than those of the Anisian, having been denuded from many places during the Upper Triassic and Lower Jurassic.

Anisian

The Anisian begins in all the high-tatric units with the so called basal breccia (Kotański 1955 a, 1956 a). This breccia is mainly composed of dolomite fragments from the Myophoria beds, also of supra-Myophoria dolomites and green shales from the "cavernous limestone and dolomite series". Mt. Chuda Turnia (see Kotański 1956 b) is the only locality where Seis quartzite and quartzitic sandstone fragments occur in the basal breccia. This indicates that this sedimentary breccia is made up of fragments (also pebbles locally passing into conglomerate) of rocks occuring several tens of metres lower down. Thus we may suppose here a temporary emersion of some parts of the high-tatric and sub-tatric (Kotański 1958) sedimentation basin during which erosion attained the bottom Campilian beds.

The difficulty here encountered is that now the Anisian basal breccia does not rest directly on the Seis (Chuda Turnia excepted) but on a complete Campilian. Hence where can we look for the eroded parts?

They may possibly have occurred in the lower limbs of high-tatric folds, at present mostly unknown. Should it be so, the supposed squeezings out may actually have occurred on a considerably smaller scale.

The basal breccia constitutes an important episode in the palaeogeographical evolution and is followed by sediments totally different than in the Campilian. They begin with grey saccharoid dolomites passing towards the top into grey saccharoid dolomitic limestones with characteristic granular lamination (Kotański 1955 b). This consists in that crystalline dolomite grains are seen in a parallel arrangement on the dark calcareous background of the rockmass. Hence they are carbonate rocks of clastic origin, similar to the dolomitic sandstones from the Tatra Eocene. The supply source of clastic material is probably the crushed reefs or algal biohermes. Their re-crystallised relicts may possibly have persisted as white "tubercules" on the weathered surface of dolomites and of saccharoid limestones. Locally these rocks display characteristic cyclic sedimentation (Kotański 1955 b, fig. 2 and p. 353—354).

The compact subcrystalline limestone grades into dolomitic limestone with granular lamination by an increase in the number of the crystalline dolomite fragments. On dolomitic limestone or on dolomite the limestone rests directly, sharply delimited by a boundary locally bearing traces of outwashing, similar to hard ground. Traces of outwashing are also observable within assemblages of compact limestones as seam lamination outlined similarly to stylolite lines. From this section it is seen that both, limestones and saccharoid dolomites, have sedimented in a shallow sea. The sedimentation of the limestones, however, occurred at a relatively slow rate and was associated with brief sedimentary gaps while the saccharoid dolomitic limestones of detrital origin were laid down more abruptly.

These observations concur with the opinion of B. Sander (1936) who believes that the repeated cycles of sedimentation play an important role in the formation of this type of rocks. Breccias containing fragments of underlying deposits, clastic deposits on the hard grounds, numerous fairly extensive discontinuity surfaces, all these facts indicate that the material which is now a mechanical constituent had been deposited and eroded, redeposited and reeroded long before the formation of the final sediment.

The writer's studies have confirmed B. Sander's views as to the importance of the mechanical re-workink of primary sediments.

Grey saccharoid dolomites are a readily discernible lithological horizon of the lower part of the Anisian throughout the high-tatric series, and also in the sub-tatric series (Kotański 1959). Locally (south slope of Mt. Giewont, the "Organs" in Kościeliska Valley) a lamellibranchian fauna is encountered in saccharoid dolomites.

Alternating limestone and dolomite beds belong to the higher part of the Anisian.

It is just this alternating arrangement and cyclic repetition of the limestone and dolomite beds that constitute one of the fundamental and most difficult sedimentary problems of the Middle Triassic.

The several limestone and dolomite beds may be locally traced over large distances; in other places (the south side of Mt. Giewont, the Rzędy-Panienki Range) they display strong variations of thickness, interlocking and mutual replacement. Hence, in spite of strong facial variability, the formation of the individual limestone and dolomite horizons must be due to general changes of sedimentary and physico-chemical conditions prevailing in the Middle Triassic sea.

Several limestone varieties may be distinguished. They are vermicular, foraminiferal and oolithic limestones. Some limestones may, possibly owe their formation to calcareous algae, among others to diplopores. No coral limestones have so far been encountered.

Vermicular limestones are known (Kotański 1955 b) to be a special kind of slide breccia, or contain plastic flow structures. Thus far, vermicular structures have always been stated to be of organic origin only (algae, worms etc.). The connection of these structures with the disturbances in primary lamination is beyond doubt. Moreover it may be observed that besides flow disturbances, diagenetic deformations of the "boudinage" type may have also participated in the formation af certain types of vermicular structures consisting of alternating limestones and dolomites. Analogous structures have been described by Mc Crossan (1958) from the carbonate Devonian Ireton Formation in United States.

Crinoidal limestones are mostly of clastic origin, the crinoidal material is crushed and redeposited, possibly with the participation of turbidity currents, as is indicated by the occurrence of graded bedding (Kotański, op. cit.). "Crinoidal meadows" preserved *in situ* and which have not been redeposited are extremely rare (Lefeld 1956). The greater part of limestone material had, after deposition, been carried away by traction currents, as is suggested by the presence of diagonal current bedding (bottom of Sucha Woda Valley). Fine lamination is observable in some places, suggesting calm and slow sedimentation. Elsewhere horizons of hard ground and intraformational breccia are encountered.

During the formation of Anisian limestones terrigenic material was in some places supplied. On the south slopes of Mt. Giewont and Mt. Kalacka Turnia (the Giewont series) interbeddings of red arenaceous shales have been long recorded. They attain their maximum thickness below the Krzesanica summit (the overturned Kominy Tylkowe series near the root twist of the Czerwone Wierchy fold).

The majority of platy yellow weathering dolomites are doubtlessly primary, (S-dolostones after the nomenclature of Dunbar & Rodgers 1958). This may be inferred from the fine lamination common in dolomites, also the presence of dolomite fragments in intraformational breccias. The occurrence in dolomites of flow structures likewise suggests their dolomitisation at a very slow rate during periods of checked organo-detritic sedimentation of limestones. The paucity of fauna in limestone-dolomite sediments of the Middle Triassic suggests abnormal salinity conditions prevailing in the Triassic sea. Never, however, did salinity rise so high as to produce anhydrites, gypsum or salts, as had occurred both in the Alps and in the Triassic of the German type.

The problem of epigenetic dolomitisation has not so far been cleared up. Frequently it is observable that limestones and dolomites are traversed by thick veins of pink or white crystalline dolomites. Possibly these vein dolomites may be of secondary origin. In this connection, however, it must be mentioned that the veins reach upwards to a certain level beyond which they never pass. It is, therefore, possible that they are intraformational veins of Triassic age. Some of these dolomite veins may owe their origin to tectonic intrusions. They are perhaps the result of very strong plastic folding in places with strong tectonic deformations.

Ladinian

The Ladinian, as compared with the Anisian, shows poorer facial differentiation. This observation, however, may have been suggested by the few occurrence sites of Ladinian rocks which have been mostly removed by later erosion. Alternating limestone-dolomites occur also within this stage, but with the predominance of dolomites. They are here grey, fine crystalline. Ladinian limestones are not so distinctly vermicular. The occurrence is also noted of characteristic banded limestones with somewhat disturbed lamination, also numerous oolithic limestones. Apple-green platy dolomites make the transition to the Carnian.

Some of the most characteristic scenery shaped in alternating limestones and dolomites of Middle Triassic age occurs in Rzędy and Zdrapiska of the Kominy Tylkowe Massif, in the "Organs" of Kościeliska Valley, and in Zamki of the Szeroka Jaworzyńska Massif.

Upper Triassic

As is stated in the preceding chapter, fairly strong facial differentiation has taken place in the Upper Triassic. Clastic deposits of the "Carpathian Keuper" have been deposited in some places (Czerwone Żlebki) throughout the Upper Triassic. In other places (Smytnia Valley, NW part of Rzędy pod Ciemniakiem) red clastic sediments are deposited during the Carnian, yellow dolomites during the Norian. In the Spis-Michałowa Valley, however, and in the SE part of Rzędy pod Ciemniakiem, dolomite shale sediments formed throughout the Upper Triassic.

The existence of sedimentary transition from the beds of Ladinian dolomites to those of Carnian shales and presence of dolomite intercalations indicate that sedimentation was then still taking place in the sea. Plentiful clastic material derived from the denudation of emerged land was transported there. According to M. Turnau-Morawska (1953) the subtatric Keuper was supplied with material mainly from the crystalline core of the Tatra type. Remnants of this core are absent in deposits of the high-tatric Keuper.

At the present time we do not know any section suggesting that in any place of the high-tatric series the crystalline core had been attained by Upper Triassic erosion. At the best (see below) it may be supposed to have reached to the Werfenian. The "unfolding" of the Czerwone Wierchy and Giewont folds would cover up the entire area of the crystalline Tatra core. Since the Middle Triassic and Werfenian series are very thick in these folds neither can it be accepted that Keuper erosion within their sedimentation basin had reached to the crystalline core. Such sites, may, therefore, exist farther south or north from the Tatra Mountains.

On the studies of M. Turnau-Morawska it may be ascertained that the sedimentation of the Keuper shales took place within a marine environment. That author is of the opinion that the red colour of sediments does not necessarily imply a nonmarine environment. These observations may be supplemented by the fact that red and green shales are often interbedded with dolomites (e.g. in the lower part of the Smytnia Valley section). These dolomites strongly resemble Middle Triassic marine dolomites. When clastic sedimentation ceased, chemical or organochemical sedimentary agents came to play, forming Upper Triassic dolomites.

On the largest ledge in Rzędy pod Ciemniakiem, we may readily discern how the clastic-carbonate Upper Triassic facies in the NW part of this area interlocks the carbonate facies from its SE part. A fairly abundant brachiopod fauna, not yet identified, has been found here in black crinoidal limestones of the Upper Triassic (probably Norian). It indicates the existence of marine environment in the Upper Triassic of the high-tatric series.

The confirmation of this fact within the high-tatric series, so far regarded as distinctly intrageanticlinal, is a warning against too abrupt drawing of conclusions in respect to the distribution of palaeogeographic conditions in the Carpathian geosyncline. Facial variability, at least so in the Triassic, was far stronger both meridionally and equatorially than it has thus far been supposed.

It is far more difficult to clear up the origin of the sandstone and conglomerate beds. Their constituents suggest distant transport. Werfenian arenaceous beds may be regarded as one of the supply sources of quartz material. The conglomerates and sandstones here may be partly a delta-partly a fluvial deposit. In any case (Smytnia Valley, Rzędy pod Ciemniakiem, Czerwone Żlebki, Chochołowska Valley) these deposits have been transported by streams and, possibly, partly deposited in the sea. There are no signs of major intraformational erosion in the shale and conglomerate beds. This fact likewise suggests their sedimentation in a marine environment. The appearance of a thick layer of conglomerate not always means an upheaval, and that of shales and dolomites — a sea transgression. This cyclic pattern is rather referable to climatic agents.

According to E. Passendorfer (1955) the presence of cherts in limestones and dolomites of the Upper Triassic (at that time held to be Middle Triassic) indicates that the supply source of silica was a continent undergoing chemical weathering. In that author's opinion the same origin may be assigned to cherts (chalcedonies) in the sub-tatric Triassic.

On the basis of the above mentioned facts it may be inferred that, in some parts of the Kominy Tylkowe series sedimentation basin, Carnian sedimentation took place in the littoral sea zone. Even a sea regression from this area would not have brought about long-continued erosion activities.

Inasmuch as in Czerwone Żlebki continuity of sedimentation is observable between the Middle Triassic and the Keuper, it should, on the other hand, be stressed that periods of upheaval and denudation occurred in other parts of the high-tatric series. As is shown by F. Rabowski's map (1954), Middle Triassic sediments are completely missing between the Werfenian and the Lias in the Starorobociańska and Chochołowska valleys from the Iwaniacka to the Bobrowiecka Pass and still farther west. When studying these profiles V. Uhlig (1897) drew the conclusion that within the high-tatric series there is complete lack of Middle Triassic sediments in the limestone-dolomite facies, while the whole Triassic is represented by shale-sand deposits.

The section from the Przełęcz w Kulawcu Pass — where the writer has lately done some excavation work — shows that yellow porous dolomites referable to the so far unknown uppermost Norian beds (in sedimentary association with marine Rhaetic) rest on shales of the "cavernous limestone and dolomite" series or on Campilian Myophoria beds. At the bottom of Norian dolomites sandstones and conglomerates occur in which Campilian rock fragments are also encountered. The absence of Middle Triassic sediments in the western margin of the Tatra Mountains, and likewise in the studied area, has, thus far, been attributed to squeezing. However, it seems surprising that such huge masses of limestones and dolomites had been squeezed out while soft shales persisted at their top and bottom. The interpretation by squeezing is reasonally suggested by the occurrence of Middle Triassic beds on the Kominy Tylkowe and Kominy Dudowe where they rest directly on Liassic sediments. It seems highly improbable that the absence here of Middle Triassic beds is due to a sedimentary break since no facial changes in these beds are observable within the Kominy Tylkowe Massif neighbouring with this area. It is more likely that in the western margin of the Tatra Mts. Middle Triassic deposits had been denuded during the Carnian, prior to Norian transgression. Carnian erosion in this area had thus, attained the Werfenian shales and quartzites, while elsewhere (the Czerwone Wierchy and Mt. Giewont series) only the upper strata of Middle Triassic beds had been eroded at that time (see below). During the Carnian (roughly speaking) within the Kominy Tylkowe series, clastic rocks were deposited or an upheaval occurred followed by denudation. During the Norian, sedimentary conditions of the littoral or fluvial type, prevailing during the preceding period, still persisted in some places (Czerwone Żlebki). Within the Smytnia Valley and in Mt. Żar, however, sedimentation of clastic deposits very nearly ceased. Limestones and dolomites sedimented there sporadically interbedded by dolomitic shales. This, together with the presence in these dolomites of detritic quartz grains permits — in spite of their characteristic yellow colour — to distinguish them from Middle Triassic dolomites. The stabilization of typically marine conditions in some parts of the high-tatric sedimentation basin, among others ascertained by faunal evidence, bears analogies to conditions prevailing in many Alpine sections (Hauptdolomit). The presence of thick dolomite and limestone beds has likewise been noted in the upper part of the sub-tatric Keuper (Kotański 1958).

The top of the high-tatric Upper Triassic crops out in very few places only.

In Czerwone Żlebki, conglomerates and red shales are in sedimentary connection (as stated by Uhlig 1897) with plant-bearing quartzite sandstones and black or brown shales of the Tomanowa beds. We are probably dealing here with a transition of the marine type of sedimentation into the continental-lacustrine type.

In the Przełęcz w Kulawcu Pass Norian dolomites display sedimentary connection with black shales and sandstones, and also fossiliferous limestones at the base of the Lias. Sedimentary continuity between the Upper Triassic and the Lias indicates that coral-lamellibranchian beds, possibly referable to the Rhaetic (Uhlig 1897), truly represent this stage. Deposits corresponding perhaps to the Rhaetic of Chochołowska Valley (recorded there not only from the Przełęcz w Kulawcu Pass but also from the neighbourhood of Bobrowiecka Pass, Uhlig 1897 and Wójcik 1959) have likewise been reported from the upper part of the Kraków Ravine where they overlie the Tomanowa beds. Hence it may be inferred that the Rhaetic marine invasion marked the commencement of the Liassic transgression. During the emergence in the Rhaetic time in Czerwone Żlebki (Tomanowa beds) marine environment persisted without break in the Chochołowska Valley area beginning with the Norian. Sea transgression had not reached the Czerwone Żlebki area before the uppermost Rhaetic, locally during the Lias (Upper) and even in the Bajocian.

In the Smytnia Valley Liassic beds have an abrasive contact with Norian beds. The Rhaetic is absent here both from the Tomanowa and the Chochołowska facies. The lowermost Lias is likewise lacking. Breccias and conglomerates occur at the base of Liassic rocks. They are built of large blocks of yellow Norian dolomites, moreover containing numerous minute dolomite fragments and quartz grains. The matrix is calcareous. The presence of numerous quartz grains within the conglomerates here, (towards the top grading into quartz-dolomite sandstones) indicates that, prior to the Liassic transgression, Norian dolomites had been overlain with a thick cover of sand and gravels brought here from afar by streams. As a result of abrasion, not only Norian dolomites are to be found in the sediments laid down at the foot of the cliff, but likewise the overlying sands and gravels which had been deposed after the Rhaetic sea transgression. Rocks of the marine Rhaetic are absent here, but they may have occurred previously. Finding of marine Rhaetic rocks among pebbles in the Liassic (Wójcik 1959) supports this statement. According to A. Radwański (1959) the calcareous Rhaetic deposit, filling up borings of lithophagae in Norian dolomite fragments, on the one hand indicates the lack here of sedimentary connection between the Rhaetic and the Norian, due to the intervening denudation. On the other hand presence of the Rhaetic infilling substance in the Norian fragments in Liassic sediments points out to the erosion of both Norian and Rhaetic sediments during the Lias.

The high-tatric Upper Triassic is known from the autochtonic Kominy Tylkowe series only. The complete absence of the Upper Triassic and the Lias is one of the most striking features in the Giewont and Czerwone Wierchy series. This, naturally, applies to the normal (upper) limbs of folds only. No reliable information is, however, available as to the lower limb of the Czerwone Wierchy fold which links the Kominy Tylkowe series with the normal Czerwone Wierchy series. This is a very difficult problem since, upon closer investigation, it has been ascertained that the lower limb of the Czerwone Wierchy fold has hardly anywhere been preserved so as to expose the Triassic beds of the overturned series too. The overturned layers of the Albian, Urgonian, Neocomian and Malm are the only known ones. The Triassic beds have been everywhere tectonically reduced. Under these conditions the Rzędy pod Ciemniakiem sections are of particular significance.

Tectonically this region belongs to the autochtonic series approaching the root twist of the Czerwone Wierchy fold, the beds here lying in an overturned position. Tectonically speaking this region does not truly belong to the lower limb of the Czerwone Wierchy fold but to the overturned and mutually overlapping digitations and scales of the Kominy Tylkowe series. Sedimentarily, however, it is an important link connecting the sedimentary Kominy Tylkowe series with the Czerwone Wierchy series.

In one of the gullies, somewhat above the Tomaniarski Twardy Upłaz, a sequence is observable showing the sedimentary contact of the Bajocian (crinoidal limestones) with the dolomites and shales of the Keuper. Moreover, it is noted that Bajocian beds do not rest quite conformably on the Keuper beds, but that a slight discordance (penaccordance) occurs. We may, therefore, accept that, after the deposition of the Keuper but prior to that of the Dogger, an old-Cimmerian phase of Alpine orogeny had occurred within the Tatra Mountains. In the Giewont series these movements were expressed by transgressive sequence of the particular Dogger horizons on Middle Triassic beds. The discordance, not discernible in a single section, becomes clear upon comparison of a number of parallel sections, e.g. those on the south slope of Mt. Giewont (Kotański 1959, table XVII).

It is only within the Kominy Tylkowe series, where Liassic deposits occur, that it is possible more precisely to date these movements, i.e. to determine whether they are post- or pre-Liassic. The sedimentary connections of the Lias with the Dogger, in the Kominy Tylkowe and Dudowe series, points out to their age as older than Liassic. It may be that the movements occurred during the Rhaetic before the deposition of the marine Rhaetic of the Chochołowska Valley but after the sedimentation of the Tomanowa beds. In the Chochołowska Valley these movements were not expressed by discordance and emergence, but by increased supply of clastic materials only. Moreover, continuity of sedimentation occurs between the Norian, the Rhaetic and the Lias.

How are we to account for the absence of Liassic rocks in the above mentioned Rzędy section, and throughout the Czerwone Wierchy and Giewont series? Three alternatives are presented: either they were never deposited during the Lias, or, after their deposition, were removed by Dogger transgression, or, finally, they were removed during the successive transgressions of the several Dogger stages.

The first alternative seems the most probable. The described Rzędy section corresponds to that site of the primary sedimentation basin where Liassic deposits probably never sedimented. The Norian sea stretched farther south of the primary sedimentation basin than did the Liassic sea. Hence the occurrence of the only, so far, known profile where Dogger rocks are in sedimentary contact with Keuper (Norian) rocks. The primary absence of Liassic deposits from the sedimentation basin of the Czerwone Wierchy and Giewont series is indicated by the lack of Liassic sandstones among pebbles in Bajocian, Bathonian and Callovian rocks. Nevertheless, it is quite possible that they have been denuded and completely removed from this area after the Lias but before the Dogger. In any case it is perfectly sure that during the Dogger transgression the Liassic deposits were absent, while Norian dolomites still occurred.

E. Passendorfer (1934) and F. Rabowski (1959) have previously postulated the lack of the upper strata of the Middle Triassic in the Czerwone Wierchy and Giewont series. Their opinion has been confirmed and more precisely stated on recent studies (Lefeld 1956 and Kotański 1956a). The lack of the Ladinian, in part possibly of the Anisian, has been ascertained within the Giewont series. These beds were doubtlessly deposited but were subsequently denuded. During what period did that far-reaching Norian erosion occur? Upper strata of the Middle Triassic deposits had been removed prior to the Norian transgression, as is indicated by the Rzędy section, and the absence of Middle Triassic pebbles in conglomerates and sandstones of the high-tatric Lias. The erosion here might have taken place during the Carnian. Hence it should be recognised that, after the sedimentation of deposits of the upper part of the Middle Triassic in the Czerwone Wierchy and Giewont series, there was a period of intense erosion and denudation during the Carnian (Upper Triassic orogenic phase). During this stage these deposits were eroded, similarly, maybe, as in the Chochołowska Valley and throughout the western marginal zone of the Tatra Mts. The Norian sea transgressed this area, and yellow dolomites were here deposited. After that, old-Cimmerian movements disturbed this area. They occurred in several stages with locally differentiated reach. E.g. in Przełęcz w Kulawcu Pass there is no unconformity. The first and most important of these phases took place after deposition of Norian dolomites but before that of the marine Rhaetic, yet probably after the deposition in other places of the Tomanowa beds. The following phases occurred after the Rhaetic from the Chochołowska Valley but prior to the Lias (Radwański 1959) or during the Lias. They resemble the Dogger movements separating the successive transgressions.

During the Lias the sedimentation basin of the Czerwone Wierchy and Giewont series was partly emerged and eroded. In some places, however, Norian dolomites had been preserved and were not eroded before Dogger transgression. This is indicated by the presence in Bajocian, Bathonian and Callovian deposits of numerous fragments of yellow Norian dolomites. Abrasion then attained the lower beds of the Middle Triassic, which may be also encountered in Dogger sediments. The successive Dogger transgressions formed abrasion platforms while Bajocian and Bathonian deposits locally penetrated deep into Middle Triassic beds (in the Kraków Ravine up to 40 m above the bottom of Dogger deposits), producing clastic dikes and veins, infilled by marine Dogger deposits.

Inasmuch that Triassic rocks of the lower limb of the Czerwone Wierchy fold are not actually known, the Świerkule unit (Rabowski 1954) may play an important role in palaeogeographic speculations. According to W. Jaroszewski (1956) it is a transition link connecting the Kominy Tylkowe series with the Czerwone Wierchy series (as is suggested on the presence there of Liassic rocks). Moreover, after that author it corresponds to the lower limb of the Czerwone Wierchy fold. Keuper conglomerates and shales were encountered by W. Jaroszewski in the Świerkule scale, suggesting that in some places the clastic littoral facies of the Upper Triassic extended as far as the Czerwone Wierchy series.

In some places of the Kominy Tylkowe series, near the root twist of the Czerwone Wierchy fold (Jawor, Rozpadlina Valley, Rzędy pod Ciemniakiem) Dogger sediments rest directly on the Middle Triassic — locally even on the Anisian. They have frequently been preserved (Jawor) in clastic veins only, like in the case of the high-tatric folds.

The Cicha Valley was a vast area of Upper Triassic denudation. Tomanowa beds (western part) and even Liassic rocks (near the Liliowe pass) rest there directly on the Campilian.

In the Szeroka Jaworzyńska Massif Liassic beds are missing altogether, while the Dogger rests there directly on the Norian or even the Anisian (the upper strata have been eroded during Upper Triassic and old-Cimmerian disturbances).

Upper Triassic sediments do not occur in the Koszysta elevation separating high-tatric series of the Western Tatra from that of the Szeroka Jaworzyńska depression. A. Michalik (1955) has described high-tatric Keuper from Polana Waksmundzka and at the foot of Mt. Wołoszyn. In the former of these sites it belongs to the subtatric series (Głazek, 1959) as perhaps in the latter one too.

It is, therefore, difficult to connect these two distant areas (Western Tatra and High Tatra). Still it should be pointed out that the autochtonic series of the Szeroka Jaworzyńska Massif resembles those of the high-tatric folds of Western Tatra (contact between the Dogger and the Anisian). This is particularly so in the section of the root twist of the Czerwone Wierchy fold in Rzędy pod Ciemniakiem (contact between the Dogger and the Norian).

All these conclusions call for a revision of opinions concerning the palaeogeography of the high-tatric series which were, thus far, strongly differentiated (chart 1).

HIGH-TATRIC TRIASSIC IN CONNECTION WITH TRIASSIC STRATIGRAPHY AND PALAEOGEOGRAPHY OF THE ADJACENT TECTONIC AND PALAEOGEOGRAPHIC UNITS OF THE CARPATHIANS, THEIR FORELAND AND THE ALPS

Together with other sediments coating the cores of the Inner Carpathians, the high-tatric Triassic of the Tatra Mountains belongs to the so called Tatrides series. These are intrageanticlinal deposits with stratigraphic gaps, shallow water conditions and small thickness of sediments. In distinction from the Tatrides, the Granides (sub-tatric series), formed south of the Tatride sedimentation basin according to the nappe theory, are built of intrageosynclinal sediments. The stratigraphic series here are more complete, with deep-sea sedimentation and greater thickness of deposits. Still farther south lay the sedimentation basin of the Gemerides, reaching to the central parts of the Alpine geosyncline (Andrusov 1936).

North of the Tatride sedimentation area occurred the Pieniny Klippen Belt, in direct contact with the Flysch Carpathians.

Facial differentiation of the high-tatric and sub-tatric series is most conspicuous in the Jurassic. The Triassic rocks, however, also display considerable differences. Particularly pronounced differentiation occurs between the high-tatric and sub-tatric series and the Gemerides.

A comparison of the high-tatric Tatra Triassic with other high-tatric, sub-tatric and Gemeride series is greatly hampered owing to the different stratigraphical methods, strong facial differentiation, paucity of fossils and tectonic complications.

Even a comparison with the high-tatric series of Mała Fatra, Lubochnia and Niżne (Lower) Tatra is difficult owing to schematic, often inexact stratigraphy and lack of detailed sections. In all these massifs the Werfenian consists of quartzites, quartzitic sandstones, red shales and locally of beds referred to cavernous limestones and dolomites. It should be pointed out that with the exception of Stare Hory, these strata contain neither gypsum nor anhydrites. Owing to absence of fossils both from Werfenian and Anisian beds of the Lower Tatra (Mahel 1956b) the boundary between the Werfenian and the Middle Triassic has not been definitely established. In the Tatra Mountains this boundary has been very accurately determined on Campilian and Hydasp fossils. Within the Lower Tatra zone (Stare Hory) the Werfenian age is assigned to fine bedded limestones referred to as „Wellenkalk". It is not quite clear whether this is a variety of vermicular limestones or limestones of Campilian age. Moreover, also Werfenian melaphyres are recorded from Stare Hory, associated with a phase of eruption not known in the Tatra Mountains.

In these units the Middle Triassic consists of alternating dark limestones and yellow dolomites. The limestones are grouped mostly near the bottom and are referred to the Anisian. The dolomites occur in greater masses higher up and are referred to the Ladinian. Occasionally (Lower Tatra) the Upper Triassic has developed in the „Carpathian Keuper" facies. In most cases the Lias rests transgressively on the Middle Triassic. It is quite possible that in some places the Upper Triassic too, may be represented by dolomites. Neither the continental nor the marine Rhaetic occurs within these massifs. On the other hand, no such exensive stratigraphic gaps are encountered as those in the Giewont series where Dogger beds rest directly on the Anisian. Notably interesting is the Triassic of the high-tatric series (at some earlier time probably occurring in Podhale) reconstructed on the base of exotics in the Upper Cretaceous conglomerates of the Pieniny Klippen Belt. Besides quartzites and shales, melaphyres and other extrusive rocks likewise belong to the Werfenian. Their occurrence brings the Werfenian strata here near to those of Stare Hory in the Lower Tatra region. The Haligowiecka clippe contains Middle Triassic beds of limestones and dolomites, while the Upper Triassic there consists of cavernous dolomites and shales.

A comparative study of the high-tatric series with subtatric series (Granides) and the Gemerides, likewise meets obstacles. They are mainly a consequence of the fact that stratigraphy there, particularly so of the upper sub-tatric units is based on lithological analogies with the several beds of Eastern Alps, on which stratigraphical conclusions have been drawn. As has been shown by M. Mahel (1956 a) on the geology of "Stratenska Hornatina", this method is highly misleading.

Within the scope of our present knowledge the Triassic of the lower sub-tatric nappe (kriżnianska) may be described as follows.

The Werfenian at the base consists of quartzitic sandstones overlaid by plantbearing sandstones and variegated shales, also containing *Myophoria costata* of Campilian age (Limanowski 1903). Still higher up occur yellow shales and cavernous dolomites. To the Anisian (Virglorian) have been assigned dark Guttenstein limestones with brachiopods cropping out at the entrance to the Bielskie Caves. These are overlaid by a thick series of dolomites, referred to the Ladinian. The Upper Triassic here has developed in the "Carpathian Keuper" facies. It is made up of clastic continental deposits. The next sea transgression here did not occur before the Rhaetic.

In the Tatra area the Triassic of the Choč nappe (Guzik 1936) is characterised by the presence within the Anisian of Guttenstein limestones, of nodular and platy dolomites within the Ladinian and of light dolomites intercalated by shales within the Upper Triassic. The Upper Triassic is sedimentarily connected with the Rhaetic. South of the Lower Tatra (Koutek 1933) the Choč Werfenian with melaphyres has been encontered, and recently a rich ammonite fauna in the Anisian (Andrusov & Kováčik 1955) has been described. Thus we may here observe the complete marine series of the whole Triassic. It should be stressed that it is just in respect to rocks of the Choč nappe that East-Alpine analogies are used, particularly so in Slovakia: Klaus limestones, Guttenstein limestones and Wetterstein dolomites and limestones, Lunz beds, Hauptdolomit, Dachstein dolomites, et caetera. Within the Gemerides we have the complete series of the marine Triassic, with a sea transgression during the Seis (numerous lamellibranchs and even ammonites), and with traces of terrigenic sediments during the Carnian — Lunz beds — (Balogh 1948, a, b, 1950, 1952, 1953; Balogh & Panto 1952; Mahel 1956 a). A volcanic phase occurred here during the Anisian. Very thorough research work has lately been done in respect to the Gemerides (Juho-Slovensky Kras, Slovensky Raj, Silicka Planina, Slovenske Rudohorie and Bück Mts). On the copious fossil material collected there it has been possible to determine the exact stratigraphy of those areas.

It may be inferred from the above statements that facial conditions prevailing in the described series suggest gradual southward deepening of the sea and increasing number of ammonites in the same direction (upper subtatric nappes, and the Gemerides). This appears to be the general pattern here. Some deviations from or even negations of this rule, however, occur.

The high-tatric Triassic from the Szeroka Jaworzyńska Massif and from the SE part of Rzędy pod Ciemniakiem displays facial development (dolomites, shales and limestones with brachiopods) which suggests close resemblance to the Choč Triassic. On the basis of the commonly accepted facial pattern, carbonate deposits are more probable in the Campilian of the sub-tatric than in that of the high-tatric series, while the occurrence of continental deposits is more likely in the Keuper of the high-tatric than of the sub-tatric series.

The present inadequate knowledge on the sub-tatric Triassic of the Tatra Mauntains, particularly so in the lower sub-tatric nappe, does not permit closer correlations with the high-tatric Triassic. The writer's preliminary observations (Kotański 1958) have, however, led to certain conclusions.

Investigations in the Tatry Bielskie Range have shown that the Triassic of the Hawrań digitation (Sokołowski 1948) strongly resembles the high-tatric Triassic. The following stages have been here distinguished: the Campilian made up of cavernous limestones and dolomites; the Anisian beginning with a basal breccia overlaid by a thick series of detritic dolomites and saccharoid limestones with intercalations of vermicular limestones and crinoidal limestones containing *Dadocrinus*; the Ladinian consisting of dolomites with *Encrinus* at the bottom and of platy dolomites at the top; the Upper Triassic developed in a normal sub-triassic facies.

Myophoria beds, developed similarly to those in the high-tatric series and in the Bielskie Tatry Range, have been distinguished in the sub-tatric series south of Zakopane, in many points of the Suchy Wierch digitation (Jowarzynka Valley, area N of Wrótka, Żleb (gully) Warzęcha). The Anisian basal breccia, here an equally important index horizon as in the high-tatric series, has been also encountered frequently in the sub-tatric series.

It is not out of the question that the Campilian will also be discovered in the Krokiew digitation where none of the Lower Triassic stages have thus far been reported. On Mt. Nosal the Anisian basal breccia has been encountered. It constitutes there the core of the secondary reversed fold which is known to rest directly on the Campilian Myophoria beds.

From the Jaworzynka Valley the writer has collected several Limanowski's classical specimens of *Myophoria costata*. They were recovered from brown sandstones. The so called Myophoria beds, discovered by the present writer, occur considerably higher up. Hence, it may be inferred that within the sub-tatric series the Campilian age is assignable not only to the Myophoria beds distinguished in the high-tatric series, but likewise, to the uppermost part of the sandstone-quartzite series with Limanowski's Myophoria fauna. In this connection one would suppose the possibility of finding *Myophoria costata* also in the high-tatric sandstone-shales beds, so far referred to the upper Seis. On this evidence the lower boundary of the Campilian would be shifted considerably farther down.

In many places of the sub-tatric series (Mały and Wielki Kopieniec, Nosal, area N of Wrótka, Mała Świnica, Grzybowiec, Jaworzynka Valley), vermicular limestones, referable to the Anisian, have been found showing that they are far more common within the sub-tatric series than has heretofore been supposed.

The indubitable conclusion here is that the sub-tatric Werfenian and Anisian closely resemble the high-tatric Triassic. In the Ladinian and the Upper Triassic the differences are notably greater. A striking feature is the presence of Myophoria beds in the Campilian with horizons of intraformational breccias, Anisian basal breccia; also grey saccharoid dolomites and limestones, vermicular and crinoidal limestones (with *Dadocrinus)* in the Hydasp.

These analogies doubtlessly indicate sedimentary connections between the sub-tatric and high-tatric sedimentation basins of the Tatra Mts. They confirm the suggestions of K. Guzik and M. Mahel expressed during a discussion with the present writer. M. Mahel then postulated connections between the high-tatric and sub-tatric sedimentary series of the several sedimentary mantles of the Inner Carpathian crystalline cores. It is quite possible that the roots of the lower sub-tatric nappe in the Tatra Mts. do not occur within the massif of Vepor on the Hron, but somewhere between the High and the Lower Tatras. During the Upper Triassic, the Jurassic and the Cretaceous, these basins were not connected, although traces of such connections may occur (M. Mahel) in the gresten Liassic facies of both series. Mahel's suppositions that the sub-tatric sedimentation basin lay north of the Tatra Mts. is tectonically inadmissible. The sub-tatric nappes of the Tatra Mts. had surely been overthrust from the south (Goetel and Sokołowski 1929).

Should these hypotheses be confirmed, it must, nevertheless, be held in mind that the palaeographic conditions in the Inner Carpathians were far more intricate than it has been heretofore believed.

Analogies with the Alpine Triassic are noteworthy. Some of the most pronounced resemblances are noted with the Triassic of the Briançonnais series (Blanchet 1934, Gignoux 1932, 1956, Gignoux and Moret 1938, Passendorfer 1938). In both, the Tatra and the Briançonnais series the most characteristic deposits are vermicular limestones occurring in the lower portion of the Middle Triassic. Breccias, probably intraformational, are very numerous within the Briançonnais series. Stratigraphic gaps on the boundary between the Jurassic and the Triassic, as well as the associated local unconformities and the direct contact of the Dogger and the Middle Triassic resemble relations in the Czerwone Wierchy and Giewont series (Debelmas & Lemoine 1957).

Vermicular limestones are likewise known from the pre-Alpine Triassic (Jeannet and Rabowski 1912).

Should we, on this basis, attempt a correlation of the Tatra Mts. with one of the Alpine series, we should certainly choose the Pennine series, to which the Briançonnais series belongs. The presence in the pre-Alps of vermicular limestones does not bar this theory since, recently, (Gignoux 1956) the roots of the pre-Alpine series are placed between the Ultra-Helvetian and the Pennine series. M. Książkiewicz (1953) compared the high-tatric series with the Grisonides, probably on analogies with the pre-Alpine series which were regarded as Grisonic nappes.

The Flysch Carpathians would, in agreement with the general opinion (Książkiewicz 1953), correspond to the Helvetian zone. In that zone the Triassic is known to be strongly reduced showing some stratigraphic gaps. The same inferences were suggested by M. Książkiewicz (1956) on an analysis of the Bachowice exotics. This situation has probably been caused by the presence of the eastern end of the Vindelitic Range, situated within the Helvetian zone.

The high-tatric Triassic displays strong analogies with the Upper Silesian Triassic (Siedlecki 1949). Vermicular limestones are the equivalent of the Wellenkalk in the Gogolin beds. The analogies between these areas must have been close, as is indicated by the presence of *Dadocrinus grundeyi* (Lefeld 1957) recorded from Upper Silesia and the Tatra Mts. only.

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Z. KOTAŃSKI

STRATYGRAFIA, SEDYMENTOLOGIA I PALEOGEOGRAFIA TRIASU WIERCHOWEGO W TATRACH

STRESZCZENIE: Na podstawie badań litologiczno-stratygraficznych, popartych nowymi znaleziskami fauny, w triasie wierchowym zostały wyróżnione alpejskie piętra (seis, kampil, anizyk, ladyn, karnik, noryk i retyk). Zostały przedstawione warunki sedymentacyjne, zmienność facjalna i stosunki paleogeograficzne triasu wierchowego oraz jego stosunek do innych jednostek paleogeograficzno-strukturalnych.

Po dokonaniu przeglądu badań nad triasem wierchowym autor stwierdza, że dotychczas nie było jednolitości w ujmowaniu jego stratygrafii — stosowano nomenklaturę zaczerpniętą z facji alpejskiej i germańskiej triasu.

Badania autora umożliwiły wydzielenie wszystkich pięter triasu alpejskiego (tab. 1).

Trias dolny. — Składa się on z dwóch różniących się od siebie serii — klastycznej w dole (seis) i węglanowej w górze (kampil). Ostatnio zaczynają przeważać poglądy, że kwarcyty, piaskowce i łupki seisu są utworami rzecznymi osadzonymi w morzu i poddanymi działaniu czynników morskich. Utwory kampilu składają się z dwóch serii — zielonych łupków, szarych dolomitów i żółtych margli (tzw. dolomitów i wapieni komórkowych) w dole i warstw myophoriowych (żółte dolomity, czarne łupki i wapienie bitumiczne oraz brekcje śródwarstwowe) w górnej części. W warstwach myophoriowych zostały znalezione formy przewodnie *Myophoria costata* i *Naticella costata.*

Trias środkowy. — Anizyk zaczyna się tzw. brekcją podstawową składającą się z okruchów kampilu. Wyżej leży seria dolomitów i wapieni cukrowatych. Są to przekrystalizowane piaskowce dolomitowe pochodzące z rozkruszenia zdolomityzowanych uprzednio budowli glonów wapiennych. Wyżej leży seria naprzemianległych wapieni robaczkowych i żółtych płytowych dolomitów. Zostały w niej znalezione liliowce z gatunku *Dadocrinus grundeyi* (Lefeld 1956). W serii Giewontu i Czerwonych Wierchów utworów ladynu nie ma, gdyż zostały one usunięte w czasie erozji w górnym triasie, liasie i w doggerze. Ladyńskie dolomity są zapewne tylko w serii Kominów Tylkowych.

Trias górny. — W górnym triasie doszło do maksymalnego zróżnicowania facjalnego w wierchowym basenie sedymentacyjnym. W karniku powstają przeważnie czerwone, litoralne utwory klastyczne, a miejscami miała miejsce silna erozja docierająca aż do dolnego triasu. W noryku nastąpiła nowa transgresja morska, lub zapanowały znów warunki sprzyjające sedymentacji węglanowej. Tworzą się wtedy żółte łupkowate dolomity z wkładkami wapieni z fauną brachiopodową. Można jednak znaleźć i takie profile, gdzie sedymentacja węglanowa trwała bez przerwy od środkowego triasu, lub przeciwnie — czerwone osady klastyczne tworzyły się podczas karniku i noryku.

W retyku w związku z tym w jednych miejscach tworzą się klastyczne osady jeziorno-lagunowe (warstwy tomanowskie), a w innych ma miejsce zalew morza (chochołowska facja retyku). Miejscami można zauważyć, że morze retyckie jest bezpośrednią kontynuacją transgresji noryckiej. Na granicy triasu i jury w serii wierchowej miały miejsce zróżnicowane aczkolwiek lokalne ruchy starokimeryjskie.

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З. КОТАНЬСКИ

СТРАТИГРАФИЯ, СЕДИМЕНТОЛОГИЯ И ПАЛЕОГЕОГРАФИЯ ВЕРХНЕТАТРАНСКОГО ТРИАСА В ТАТРАХ

(Резюме)

После обзора исследований верхнетатранского (верхового) триаса, автор констатирует, что до настоящего времени не было единогласия в обработке его стратиграфии и применялась номенклатура, заимствованная из альпийской и германской фации триаса.

Исследования автора дали возможность выделения всех ярусов альпийского триаса (Таб. 1).

Нижний триас. Нижний триас состоит из двух разнящихся между собой серий: кластический внизу (сейс) и карбонатной вверху (кампиль). В последнее время начинают побеждать воззрения, что кварциты, песчаники и сланцы сейса являются речными отложения-

TABELA 1

ZESTAWIENIE STRATYGRAFII TRIASU WIERCHOWEGO

Pododdziały	Piętra \ Serie wierchowe	Seria Kominów Tylkowych							Seria Czerwonych Wierchów			Seria Giewontu
		Dol. Spis-Michałowa	Czerwone Żlebki	Dol. Smytnia	Dol. Cicha		Dol. Chochołowska		Okolica skrętu korzeniowego pod Ciemniakiem		Skrzydło górne fałdu	
					Jawor	E część	Przełęcz w Kulawcu	Zbocze Bobrowca	NW Rzędy	SE Rzędy		
Trias górny	RETYK	—	— *warstwy tomanowskie*: naprzemianległe łupki czarne i brązowe z oolitowymi rudami żelaza oraz kwarcyty z florą	(istnieją dowody trangresji retyckiej w sąsiednich rejonach) —	—	łupki czarne i wapienie z krynoidami, koralami, *warstwy tomanowskie:* naprzemianległe łupki czarne i brązowe z oolitowymi rudami żelaza oraz kwarcyty z florą —	glonami wapiennymi oraz z mszywiołami		—	—	(istnieją dowody trangresji retyckiej)	
Trias górny	NORYK	— naprzemianległe warstwy dolomitów jasnych płytowych oraz łupków dolomitycznych żółtych, czarnych i różowych	naprzemianległe zlepieńce, piaskowce oraz łupki czerwone i zielone dolomity seledynowe	— żółto wietrzejące dolomity płytowe z krzemieniami oraz łupki dolomityczne i wapienie pasiaste	—		dolomity piaszczyste, żółte dolomity margliste, łupki, piaskowce i zlepieńce —	— naprzemianległe czerwone łupki, piaskowce i zlepieńce —	— dolomity płytowe i łupki dolomityczne, łupki czerwone piaskowce i zlepieńce dolomity i łupki	— dolomity i wapienie z fauną brachiopodową, naprzemianległe dolomity i łupki czerwone i czarne	(istnieją ślady transgresji noryckiej) —	—
Trias górny	KARNIK			naprzemianległe zlepieńce, piaskowce, łupki, dolomity i wapienie	—	—					—	—
Trias środkowy	LADYN	naprzemianległe warstwy wapieni i dolomitów z wyraźną przewagą dolomitów fauna: *Encrinus* sp. przekrystalizowane struktury glonowe			—	—	—		naprzemianległe warstwy wapieni i dolomitów z przewagą dolomitów fauna: *Encrinus* sp.		—	—
Trias środkowy	ANIZYK (wirgor): ilyr, pelson, hydasp	naprzemianległe warstwy: dolomity płytowe żółto wietrzejące oraz wapienie robaczkowe i krynoidowe z *Dadocrinus*; szare cukrowate wapienie; szare cukrowate dolomity; brekcja podstawowa				—	—		naprzemianległe warstwy: dolomity płytowe żółto wietrzejące oraz wapienie robaczkowe i krynoidowe z małżami i ślimakami oraz z *Dadocrinus grundeyi*; szare cukrowate wapienie fauna: *Pecten discites, Gervillia mytiloides, Modiola triquetra*; szare cukrowate dolomity; brekcja podstawowa			
Trias dolny (scytyk = werfen)	KAMPIL	dolomity nadmyophoriowe; *warstwy myophoriowe*: naprzemianległe dolomity żółto wietrzejące, czarne wapienie bitumiczne, łupki czarne, czerwone i zielone oraz brekcje śródwarstwowe fauna: *Myophoria costata* i *Naticella costata*; *seria tzw. wapieni i dolomitów komórkowych:* naprzemianległe łupki zielone i szare dolomity oraz margle popielate i żółte				—	—		dolomity nadmyophoriowe *warstwy myophoriowe* naprzemianległe dolomity żółto wietrzejące, czarne wapienie bitumiczne, łupki czarne oraz brekcje śródwarstwowe			fauna: *Myophoria costata*
Trias dolny (scytyk = werfen)	SEIS	łupki czerwone i zielone z przewarstwieniami piaskowców wapnistych; czerwone kruche piaskowce i łupki; piaskowce kwarcytyczne i zlepieńce kwarcowe										

ТАБЕЛЬ 1

СОСТАВЛЕНИЕ СТРАТИГРАФИИ ВЕРХНЕТАТРАНСКОГО ТРИАСА

<table>
<tr><th colspan="2" rowspan="3">Этаж \ Единица</th><th colspan="7">Серия Тыльковых Коминов</th><th colspan="3">Серия Червоных Верхов</th><th rowspan="3">Серия Гевонта</th></tr>
<tr><th rowspan="2">Спис-Михалова Долина</th><th rowspan="2">Червонэ Жлебки</th><th rowspan="2">Смытня Долина</th><th colspan="2">Тиха Долина</th><th colspan="2">Хохоловска Долина</th><th colspan="2">район корневого перегиба складки под Цемняком</th><th rowspan="2">верхнее крыло складки</th></tr>
<tr><th>Явор</th><th>Вост. часть</th><th>Перевал в Кулявце</th><th>Склон Бобровца</th><th>С-З Женды</th><th>Ю-В Женды</th></tr>
<tr><td rowspan="3">Верхний триас</td><td>РЭТ</td><td>—</td><td rowspan="3">—
томановские слои:
напеременлежащие черные и коричневые сланцы с оолитовыми железными рудами кварциты с флорой
напеременлежащие конгломераты, песченики и сланцы красные и зеленые
зеленковатые доломиты</td><td>—
(имеются данные о существовании рэтской трансгресии в смежных районах)</td><td>—</td><td colspan="3">черные сланцы и известняки с криноидами и корралами а также известковыми альгами и мшанками</td><td>—</td><td>—</td><td colspan="2">(имеются данные о существовании рэтской трансгресии)
— —</td></tr>
<tr><td>НОР</td><td rowspan="2">—
напеременлежащие слои светлых плитчатых доломитов а также доломитических сланцев желтых черных и розовых</td><td>—
желто-выветривающие плитчатые доломиты с роговиками а также доломитические сланцы и ленточные известняки</td><td>—</td><td>*томановские слои:* напеременлежащие черные и коричневые сланцы с оолитовыми железными рудами, кварциты с флорой</td><td rowspan="2">доломиты с зернами кварца, желтые мергелистые доломиты, сланцы песчаники киогломераты
—</td><td rowspan="2">—
напеременлежащие красные сланцы, песчаники и конгломераты
—</td><td>—
плитчатые доломиты и доломитические сланцы</td><td>—
доломиты и известняки с брахиоподовой фауной</td><td colspan="2">—
(имеются данные о существовании норийской трансгресии)
— —</td></tr>
<tr><td>КАРН</td><td>напеременлежащие конгломераты, песчаники, сланцы, доломиты и известняки</td><td>—</td><td>—</td><td>красные сланцы песчаники и конгломераты</td><td>напеременлежащие доломиты и красные и черные сланцы</td><td>—</td><td>—</td></tr>
<tr><td rowspan="2">Средний триас</td><td>ЛАДИН</td><td colspan="3">напеременлежащие слои известняков и доломитов с очевидным преобладанием доломитов
фауна: *Encrinus* sp., перекристаллизованные альговые структуры</td><td>—</td><td>—</td><td colspan="2">—</td><td colspan="2">напеременлежащие слои известняков и доломитов с преобладанием доломитов
фауна: *Encrinus* sp.</td><td>—</td><td>—</td></tr>
<tr><td>АНИЗ (вирглор)</td><td colspan="4">иллир
пелсон
напеременлежащие слои:
плитчатые желтовыветривающие доломиты
а также червячковые и криноидные известняки с *Dadocrinus*
гидасп
серые сахаровидные известняки
серые сахаровидные доломиты
базальная брекчия</td><td>—</td><td colspan="2">—</td><td colspan="3">напеременлежащие слои:
плитчатые, желтовыветривающие доломиты а также червячковые и криноидные известняки с пластинчатожаберными и брюхоногими моллюсками и с *Dadocrinus grundeyi*
серые сахаровидные известняки
фауна: *Pecten discites, Gervillia mytiloides, Modiola triquetra*
серые сахаровидные доломиты
базальная брекчия</td><td>—</td></tr>
<tr><td rowspan="3">Нижний триас (скиф — верфен)</td><td rowspan="2">КАМПИЛ</td><td colspan="4">надмыофориевые доломиты
мыофориевые слои: напеременлежащие желтовыветривающие доломиты, черные битуминозные известняки, черные, красные и зеленые сланцы, а также интраформационные брекчии
фауна: *Myophoria costata* и *Naticella costata*</td><td>—</td><td colspan="2">—</td><td colspan="3">надмыофориевые доломиты
мыофориевые слои: напеременлежащие желтовыветривающие доломиты, черные битуминозные известняки и сланцы а также интраформационные брекчии</td><td rowspan="2">фауна: *Myophoria costata*</td></tr>
<tr><td colspan="10">*комплекс т. н. кавернозных известняков и доломитов:* напеременлежащие зеленые сланцы и серые доломиты, а также пепельные и желтые мергели</td></tr>
<tr><td>СЕЙС</td><td colspan="11">красные и зеленые сланцы содержащие интеркаляции известковых песчаников
красные песчаники и сланцы
кварцитовые песчаники и кварцевые конгломераты</td></tr>
</table>

ми, осажденными в море и подверженными воздействию морских факторов. Отложения кампиля состоят из двух серий — зеленых сланцев, серых доломитов и желтых мергелей (так назыв. кавернозных доломитов и известняков) внизу, а также из миофориевых слоев (желтые доломиты, черные сланцы и битуминозные известняки, а также интраформационные брекчии) в верхней части. В миофориевых слоях были найдены руководящие формы *Myophoria costata* и *Naticella costata*.

Средний триас. Анизийский ярус начинается так назыв. базальной брекчией, состоящей из обломков кампильских осадков. Выше лежит серия доломитов и сахаровидных известняков. Это давние перекристаллизованные доломитовые песчаники, происходящие из раздробления доломитизированных предварительно структур известковых водорослей. Выше лежит серия попеременно лежащих червячковых известняков и желтых плитчатых доломитов. В ней были найдены криноиды из вида *Dadocrinus grundeyi* (Lefeld 1956). В серии Гевонта и Червоных Верхов образований ладина не встречается, так как они были удалены во время эрозии в верхнем триасе, лейасе и в доггере. Ладинские доломиты встречаются только в серии Коминов Тыльковых.

Верхний триас. В верхнем триасе дошло до максимальной фациальной дифференциации в верхнетатранском седиментационном бассейне. В карнийское время образуются преимущественно красные, литоральные, кластические образования, а местами произошла сильная эрозия, доходящая даже до нижнего триаса. В норийском ярусе наступила новая морская трансгрессия или же создались опять условия, благоприятствующие карбонатной седиментации. В то время образуются желтые, сланцеватые доломиты с известняковыми переслойками с брахиоподовой фауной. Можно, однако, найти и такие профили, в которых карбонатная седиментация продолжалась без перерыва от среднего триаса или же наоборот — красные, кластические отложения образовались в норийском и карнийском ярусах.

В *рэте*, в связи с этим, в одних местах образуются кластические озерно-лагуновые отложения (томановские слои), н в других имеет место морская ингрессия (хохоловская фация рэта). В некоторых местах можно заметить, что рэтское море является непосредственной континуацией норийской трансгрессии. На границе триаса и юры в верхнетатранской серии имели место дифференцированные, хотя локальные древне-кимерийские движения.
