Nomenclature of the Neogene of Austria *)

(With a Stratigraphic Chart)

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1. Development of Neogene Stratigraphy in the Vienna Basin

Neogene research in Austria began in the Vienna Basin with the work of d'Orbigny who, in 1846, described the foraminifera. In 1856, M. Hoernes described the gastropods and introduced the term Neogene; to the marine deposits were added the Cerithium beds and Upper clay or Congeria beds. In 1873, Th. Fuchs proposed a further subdivision of the Neogene which was in use until 1927.

Pontian (Le Play, 1842)
Sarmatian (E. Suess, 1866)
Mediterranean Stage II (Th. Fuchs, 1873)
Mediterranean Stage I (Th. Fuchs, 1873)

The Mediterranean Stage I was considered to comprise the deposits in the areas of Eggenburg and Horn. Mediterranean Stage II was considered to comprise the lower clay, the clay and sand of the Lithothamnium limestone of M. Hoernes. A monograph by F. X. Schaffer, 1910—1925, describes the molluscan fauna of Mediterranean Stage I in the area of Eggenburg and contains a bibliography of the older literature.

A systematic division of the Neogene was made by C. Mayer-Eymar, 1857 to 1858. This division served as the basis for later expansion.

It was recognized, particularly through the work of F. X. Schaffer in 1914, that there existed a sequence of strata between the Eggenburg-Horn deposits and those of Baden as well as the Lithothamnium limestone. This sequence was called "schlier" and/or Grund beds.

In 1927, F. X. Schaffer introduced a previously universally accepted division of the Miocene to the Austrian literature.

Pannonian or Pontian
Sarmatian
Tortonian
Helvetian
Burdigalian

Exploration work carried out by the oil industry since 1925, particularly the work of K. Friedl, has added greatly to our knowledge of Neogene stratigraphy in the Vienna Basin. The information obtained up to 1951 was summarized by R. Janoschek. R. Grill, in 1953 and later papers, has added to

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our knowledge of the stratigraphy of the Waschberg zone and adjoining areas through micropaleontological studies. Exploration results obtained by the Österreichische Mineralölverwaltung Aktiengesellschaft from 1957—1963 in the Molasse zone of Lower Austria were published in 1964 (cf. F. BRIX & K. GÖTZINGER, 1964). Those of Rohoel-Gewinnungs Aktiengesellschaft, obtained in the Molasse zone of Upper Austria and the Salzburg area, were published in 1958 (F. ABERER). E. BRAUMÜLLER in 1961 has given a general review of the paleogeography of the Molasse between the Salzach and the Inn and Enns rivers. The distribution of the Oligocene and the Lower and Middle Miocene was described by J. KAPOUNEK and co-workers in 1965. A general picture of the division of the entire Tertiary was given by R. JANOSCHEK in 1964. In a paper now being published, R. GRILL, 1968, summarizes the geology of a large part of northeastern Lower Austria.

2. Basis of Regional Correlation in the Neogene

The Comité Néogène Méditerranéen began its study of Neogene stratigraphy with the subdivisions proposed by C. MAYER-EYMAR in 1857—1858. It soon became evident that stage names were being used for different geological ages in different countries. In the course of the 3rd meeting of the committee at Bern in 1964, an attempt was made to fit the type areas into a system of tropical plankton zones. The 4th meeting at Bologna in 1967 considered the value of the customary stage names for regional correlation and it was found that the stratigraphic types meet the requirements only in part.

As a basis of regional correlation, there was proposed a division on the entire Neogene (Miocene and Pliocene) into four superstages here called Neogene ranges N I—IV. The question of nomenclature of the superstages remains undecided for the present.

The lower limit of the Miocene was defined by the abundant occurrence of *Globigerinoides trilobus* and *Miogypsina gunteri* and *M. tani,* thus marking the beginning of the first Neogene range N I. The appearance of "*Praeorbulina*" (= *Orbulina glomerosa* and others) marks the lower limit of the second Neogene range (N II). The lower limit of the third Neogene range (N III) would be marked by the appearance of *Globorotalia menardi* and others. The fourth Neogene range (N IV) is represented by the Pliocene in outcrops along the Arda River in Italy. The N IV Neogene range is represented in Austria only in the youngest limnic-fluviatile deposits and is not shown in the table.

The age of the Messiniano beds in Italy, according to absolute age determinations, ranges from 7 to 11.8 million years B. P. Correlating with the sediments of the Vienna Basin (R. SELLI, Bologna 1967), this would correspond to the Pannonian and the Sarmatian of the Vienna Basin would have to be the correlative of the Tortoniano of Italy. In any event, it is certain that the "Tortonian" of the Vienna Basin is older than the type locality of the Tortoniano of Italy. Numerous other discrepancies can be noted.

The division of the Neogene into four superstages should provide the framework for worldwide correlation. Locally, Neogene stratigraphy should be tested

within this framework and the fossil content of the local sections be examined according to biostratigraphic criteria.

3. The Basis for the Division of the Neogene in Austria

The Neogene of Austria consists of two great sedimentary cycles. Each cycle began with pure marine sediments and fauna, and changed into and ended with brackish-limnic sediments and an endemic fauna.

The First Miocene Cycle begins in the Molasse with marine faunas of the type of the Eggenburg beds. This faunal ingression with the molluscan faunas characteristic of the central Paratethys is an important criteria in the correlation of the Austrian sediments. The cycle ends with beds containing an endemic fauna with *Rzehakia*, the so-called Oncophora beds. The occurrence of the Oncophora beds is contemporaneous in Austria and Czechoslovakia. The basal faunal ingression in the Molasse came from the Indo-Pacific area (cf. J. SENEŠ, 1959).

The Second Miocene Cycle begins with a faunal ingression from the Mediterrean area. Its base is formed by marine beds which in Styria are called Styrian schlier and in Lower Austria the Laa formation. The occurrence of *Praeorbulina* and *Globigerinoides bisphaericus* (= *G. sicanus*) allows a correlation with pure marine planktonic zones. The second cycle ends with the Sarmatian which contains a relic marine fauna. The Pannonian follows with a progressively increasing freshwater influence.

In eastern Austria, the endemic faunas of the Sarmatian and Pannonian are very rich and their evolutionary changes permit detailed biostratigraphic zonation. The vertebrate fauna of this area is remarkably rich. A precise correlation with the Mediterranean area cannot be made at the present time. Continued research on the ostracods and mammals of this area hold some promise of correlation.

The terms Sarmatian and Pannonian are meaningful in Austria and in the area of the central Paratethys and should be retained. They represent times of continous sedimentation and therefore offer valuable chronological information.

4. Review of the Development of the Neogene in Various Areas of Austria

The following is a brief review of the Neogene in the various areas of Austria. The nature of this paper does not permit the listing of all formational names. The application of the new nomenclature is just suggested. All correlations noted are based on the most recent results.

The term formation is here used in the stratigraphic sense, being a rock unit that can be mapped, having a definite outline and obvious characteristics by which it may be traced from place to place and distinguished from other formations. The formation may consist of a single or several rock types in which case the different types are denoted as a member or lens. The formation has no time implication and may transgress time boundaries. It should show evidence of some past event different from succeeding or preceding events.

The term cycle is here used to designate a sequence of faunas beginning with a pure marine ingression and ending with endemic faunas.

a) The Molasse between the Salzach—Inn and Enns Rivers

The shale stage of the Rupelian is overlain by beds, which in the southern part of the Molasse zone, particularly in the Puchkirchen area, were penetrated by a number of wells. In the north the marginal facies of the Linz sands and grayish-brown shales are correlative. Drilling in the Puchkirchen area penetrated great thickness of facies characteristic of this area. For the above sequence of strata, R. JANOSCHEK and K. KOLLMANN propose the term Puchkirchen formation. The type section is considered to be the well Puchkirchen 1, the core samples of which are filed with the Geological Survey of Austria, Vienna. The Puchkirchen formation comprises the section between the shale stage and the transgression of the Hall formation, or the first transgressive cycle of the Miocene (cf. F. ABERER, 1958).

According to the nomenclature to date, the lower Puchkirchen formation and its equivalents comprise the Chattian. Chattian age for the unit is based on the occurrence of *Miogypsina complanata* in the well Kirchham 1 (I. KÜPPER, 1966) and mammal finds in the Linz sands. The upper Puchkirchen formation and its equivalents comprise the Aquitanian. A more accurate age determination of that section is not presently possible by means of paleontological methods. Therefore, according to the definition worked out at Bologna in 1967, the boundary between the Oligocene and the Miocene lies somewhere within the Puchkirchen formation or above it.

The transgression of the first Miocene Cycle according to the above definition follows the Puchkirchen formation. The term of "Haller Schlier" (V. PETTERS, 1936) with the type locality at Bad Hall in Upper Austria, has been correlated with the Burdigalian and confirmed by the presence of *Miogypsina intermedia*. At present, it is not certain whether the upper limit of the Burdigalian and the top of the Haller Schlier are identical. For facies distribution and division of the Haller Schlier see F. ABERER, 1958.

R. JANOSCHEK and K. KOLLMANN propose that the Haller Schlier and its equivalents in the Molasse zone between the Salzach — Inn and Enns Rivers are to be called the Hall formation. Deposits in the same area formerly termed Helvetian should now be designated Innviertel formation. The latter, or Innviertel formation, lies conformably over the Hall formation and was described and divided in detail by F. ABERER in 1958 for the middle and western part of the area:

Oncophora beds

Treubach sands
Braunau schlier } Glauconitic member
Mehrnbach sands

Ried beds	Schlier zone with Rotalia
Ottnang schlier Atzbach sands Vöckla beds	Schlier zone with Robulus in a broader sense

The Ottnang schlier was chosen as the stratum typicum of the Innviertel formation and Ottnang the locus typicus in Upper Austria.

The upper limit of the Innviertel formation with Oncophora beds corresponds to the end of marine sedimentation. Lying unconformably on the Innviertel formation are coal bearing freshwater beds with gravels in the area of Trimmelkam, Hausruck, and in the Kobernausser Forest (cf. F. ABERER, 1958).

b) The Molasse between the Enns and the Danube, North of the Danube, and the Waschberg Zone

In the Molasse zone between the Enns and the Danube, the Melk formation is correlative with the Puchkirchen formation. The Hall and Innviertel formations show the sand-streaked Schlier facies. At the top are the Oncophora sands in the area of Tulln.

North of the Danube, in the areas of Eggenburg and Horn, typical Eggenburg beds and their correlatives form the marginal facies. In the interior of the basin they are marly. The type locality of the Eggenburg formation is the Loibersdorf beds with the section near Loibersdorf as the type locality.

In the Waschberg zone, the Michelstetten beds, whose facies differ from those of the Melk formation, must be regarded as correlative. Overlying is a shaly marl (R. GRILL, 1962). A biostratigraphic division of the latter is not yet possible. The older part is included in the imbricate structure of the Waschberg zone, while a younger part lies above that structure (J. KAPOUNEK and co-workers, 1965). The younger shaly marl would be correlative to the Luschitz formation.

c) The Stratigraphy of the Neogene of the Vienna Basin

The nomenclature of the Neogene of the Vienna Basin has been based on the system of division as established by C. MAYER-EYMAR. As a result of the previously mentioned difficulties, an attempt was made, jointly with stratigraphers from Czechoslovakia, to introduce new terms for the Vienna Basin (J. KAPOUNEK and co-workers, 1960).

The Pannonian and Sarmatian remain unchanged for the Vienna Basin as the Pannonian and Sarmatian formations. The term "Tortonian" has been replaced in the Vienna Basin by the new term of Baden formation. The lower limit of the Baden formation was defined by the appearance of *"Praeorbulina"* (= *Candorbulina* = *Orbulina* = *Globigerinoides* = *Porticulasphaera*).

Based on experience in the Vienna Basin, it is not necessary to subdivide the Baden formation (e. g. Lanzendorf formation for the Lagenidae zone). Also,

there is no reason why the zone of arenaceous foraminifera, including the *Bulimina-Bolivina* and *Rotalia* zone should be correlated with the Tortoniano of Italy and left as Tortonian s. str. Therefore, the zonal division of the Baden formation according to R. GRILL, 1941, is retained.

The Carpathian formation, at the base of the Baden formation, contains *Globigerinoides bisphaericus*. The extent and facies relationships of this formation have been described in detail (I. CICHA, J. SENEŠ & J. TEJKAL, 1967). In Austria, the Laa formation is correlative. For the distribution and facies relationships in Lower Austria, see J. KAPOUNEK and co-workers, 1965.

At the base of the Laa formation, there is schlier in the northern Vienna Basin, Oncophora beds in the area of Matzen — Schönkirchen, and Oncophora sands in the Molasse north of the Danube. In the Vienna Basin, for the sequence of schlier poor in fossils, the *Elphidium* and *Bathysiphon-Cyclammina* schlier, the term of Luschitz formation was proposed (J. KAPOUNEK and co-workers, 1960). This formation transgresses, with schlier basal debris, over alpine basement. The Luschitz formation is distinctly different from the Eggenburg and Laa formations.

In large areas of the Molasse north of the Danube, the Eggenburg formation transgresses over older deposits or crystalline rocks. Its base can thus be well established (cf. J. KAPOUNEK and co-workers, 1965). In the Vienna Basin, correlatives of the Eggenburg formation were found locally in wells (Großkrut 5, Reinthal 1).

d) Ödenburg Gate, Eisenstadt Basin, Landsee Embayment, and the Area East of the Swell

The Neogene of the Ödenburg Gate was described by M. VENDL in 1930 and 1933, and the Landsee Embayment by R. JANOSCHEK in 1932. Considering a number of other special papers, there is general agreement with the Vienna Basin in the Pannonian and Sarmatian. The Baden formation is represented by the Lithothamnium limestones, the Walbersdorf schlier (zone of arenaceous foraminifera) and the Ritzing sands (Upper Lagenidae zone). The Lower Lagenidae zone is absent. Thin beds with lignites are thought to be time-equivalents.

The Brennberg boulder gravels below the lignites are comparable to the Aderklaa conglomerate in the Vienna Basin. The Auwald gravels and the freshwater beds of the Brennberg mountain may be considered as the oldest.

e) Styrian Basin

The Neogene of the Styrian Basin was restudied by K. KOLLMANN in 1965 in view of earlier pertinent publications. Emphasis should be placed on the papers of A. WINKLER-HERMADEN who published his main work "Geologisches Kräftespiel und Landformung" in 1957. Extensive geological and geophysical exploratory work carried out by the oil industry has served as a basis of re-evaluation.

The biostratigraphic division of the formations is equivalent to that of the Vienna Basin. The facies of the deposits are often highly diversified consisting of interfingering of coarse clastics and limestones with clays and sands.

In the Styrian Basin, marine sedimentation begins with the "Styrian schlier". The occurrence of *Globigerinoides bisphaericus* confirms the correlation with the Laa formation and therefore with the Carpathian. In places, the "Styrian schlier" is represented by limnic equivalents, such as the higher Eibiswald beds and other deposits, which are found on the top of limnic-fluviatile sediments of the lower Eibiswald beds.

f) Carinthia

Considering their location in the alpine area, the deposits of the Neogene of Carinthia are chiefly limnic-fluviatile. The Sattnitz conglomerate, the beds of Penken and Kleinzapfen etc. may be correlated with zones F—H of the Pannonian of the Vienna Basin based on land snails and mammals.

The Rissoa beds in the Lavant Valley, and other comparable occurrences in that area, may be correlated with the older Sarmatian of the Vienna Basin (P. Beck-Mannagetta, 1952). The marine Mühldorf schlier is correlative to the Upper Lagenidae zone. At the base there are limnic deposits called the Granitztal beds.

5. Discussion of Time-Stratigraphic Units in the Central Paratethys

As the conventional stage names can no longer be used, there arises the question of how their functions are to be replaced. There is no doubt that in the small sedimentation zones of the Paratethys, a variety of sediments were deposited at the same time. This variety can be expressed only through different names for the beds and formations. On the other hand, it is necessary to fit the various beds and formations into a time schedule replacing the conventional stage names.

Terms such as Sarmatian and Pannonian were often used in international stage division. It should be borne in mind, however, that the application of those terms can be meaningful only in the central Paratethys. There, however, they meet all requirements of biostratigraphy and cannot be replaced by any better terms.

Judging by the planktonic foraminifera, the base of the Baden formation is equivalent to the base of the Second Neogene range; the upper boundary is formed by the base of Sarmatian. There is at present, no proof for the correlation of the base of Sarmatian with marine faunas of the Mediterranean area.

If one maintains the terms of Pannonian and Sarmatian in their present functions as time-stratigraphic units or stages, it would make sense to add another stage comprising the series so far called Tortonian. The Tortonian in the Vienna Basin would have to be denoted as Baden formation and the time-stratigraphic unit as Badenian.

The Carpathian, represented by the Carpathian formation has already been introduced into the literature through detailed methodic treatises and elaborate evidence (I. Cicha, J. Seneš & J. Tejkal, 1967).

The time-stratigraphic units of the Carpathian, Badenian and Sarmatian may be summed up as second Miocene cycle as opposed to the first Miocene cycle.

The division of the first Neogene cycle is best made in the Molasse between the Salzach — Inn and Enns Rivers. There, the Hall and Innviertel formations with continuous sedimentation can be distinguished. The Hall formation has its equivalent in the Eggenburgian. Extensive literature on the Eggenburgian is in print, as part of the series "Chronostratigraphy and Neostratigraphic Types".

The Innviertel formation covers the period between the Hall formation or Eggenburgian and the Carpathian. We choose together with ČSSR stratigraphers (Proposal of I. CICHA, A. PAPP & J. SENEŠ, in print) the Ottnang schlier as stratum typicum and Ottnang in Upper Austria as locus typicus of the Ottnangian. The latter thus represents the period between Eggenburgian and Carpathian.

As the time-stratigraphic unit underlying the Eggenburgian, the Egerian is proposed by T. BALDI, I. CICHA, A. PAPP & J. SENEŠ, based on the locus typicus of the unit at Eger, Hungary.

The Egerian in the area of Eger was defined through an abundant molluscan and foraminiferal fauna, as well as key forms of macroforaminifera. The Egerian is present in Austria in the Michelstetten beds in the Waschberg zone, the Melk formation in the Molasse between the Enns and the Danube and north of the Danube, and the Puchkirchen formation in the Molasse between the Salzach — Inn and Enns Rivers. The boundary between Oligocene-Miocene or Paleogene and Neogene occurs in the Egerian interval according to the definition worked out in Bologna in 1967.

The following is a comparison between the time-stratigraphic units proposed for the central Paratethys and the stage names so far in use.

Pannonian	—	Pannonian
Sarmatian	—	Sarmatian
Badenian	—	Tortonian
Carpathian	—	Upper Helvetian
Ottnangian	—	Lower Helvetian or Helvetian s. str.
Eggenburgian	—	Burdigalian
Egerian	—	Aquitanian + Chattian

As type localities were chosen ore are presently being proposed:

Paunonian	—	Vösendorf, Lower Austria
Sarmatian	—	Nexing, Lower Austria
Badenian	—	Sooß, Lower Austria
Carpathian	—	Slup, Czechoslovakia
Ottnangian	—	Ottnang, Upper Austria
Eggenburgian	—	Loibersdorf, Lower Austria
Egerian	—	Eger, Hungary

The question as to the justification of subdividing and designating time-stratigraphic units according to the international rules of stratigraphic nomen-

ZUR NOMENKLATUR DES NEOGENS IN ÖSTERREICH

A. PAPP – Tabelle 1

PLANKTON - BEREICHE IM NEOGEN (BOLOGNA 1967)	MOLASSE - ZONE: zwischen Salzach/Inn u. Enns	MOLASSE - ZONE: Enns - Donau	MOLASSE - ZONE: nördlich der Donau	Waschbergzone	Zeiteinheiten der zentralen Paratethys		Typus-lokalitäten (Vorschlag)	Stufenbezeichnungen in der bisherigen österreichischen Literatur
(MESSINIEN) N III ↑ Bereich mit Globorotalia menardi	Serie kohleführender Süßwasserschichten mit Schottern im Raume vom Hausruck Kobernaußer Wald und Trimmelkam ?		Hollabrunner Schotterkegel Ostracodenmergel lokal			PANNONIEN	Vösendorf N.Ö.	PANNON
			lokal entwickelt bei Hollabrunn Ziersdorf Langenlois		II. MIOZÄNZYKLUS	SARMATIEN	Nexing N.Ö.	SARMAT
? Einsatz von Orbulina universa N II Bereich mit Praeorbulina			Lageniden Zone	Lageniden-Zone		BADENIEN	Sooß N.Ö.	TORTON
Bereich mit Globigerinoides bisphaericus			Laaer Schichten	Laaer Schichten		KARPATIEN	Slup ČSSR	HELVET
N I	Oncophora-Schichten: Inviertler Serie: Glaukonit. Serie (Treubacher Sande (Braunauer Schlier (Mehrnbacher Sande; Rotalien Schlier - Rieder Schichten; Robulus Schlier im weit. Sinn (Ottnanger Schlier (Atzbacher Sande (Vöckla Schichten	Oncophora-Sande; Sandstreifen-Schlier	Oncophora-Sande; Mergelfazies	Eisenschüssige Sande und Tone; Schieferiger Tonmergel	I. MIOZÄNZYKLUS	OTTNANGIEN	Ottnang O.Ö.	HELVET
↑ Bereich mit Globigerinoides trilobus	Haller Serie		Eggenburger Serie			EGGENBURGIEN	Loibersdorf N.Ö.	BURDIGAL
	Obere Puchkirchener Serie: Graubraune Tonmergel im Norden	Melker Serie		Michelstettener Schichten		EGERIEN	Eger Ungarn	AQUITAN
Sporadisches Vorkommen von Globigerinoides trilobus	Untere Puchkirchener Serie: Linzer Sande im Norden							CHATT

WIENER - BECKEN: Schichten-Serien[1]	WIENER - BECKEN: Schichten	WIENER - BECKEN: Biozonen	Ödenburger Pforte Eisenstädter Becken Landseer Bucht und östlich der Schwelle	STEIRISCHES BECKEN	KÄRNTEN
Pannonische Serie	Süßwasserkalk Fossilarme Schichten Congerien - Schichten	Zone F, G, H Zone D, E Zone A, B, C	Lignite v. Zillingdorf Fölikdelta Sande und Tone des Eisenstädter Beckens	Süßwasserkalk, Lignit, Schotter, Ton Schichten von Stegersbach u. a. Kapfensteiner Schotter, Lignit von Ilz, Ostracodenmergel	Sattnitz Kongl. u. a.
Sarmatische Serie	Verarmungs Zone Mactra -Schichten Ervilien-Schichten Rissoen- Schichten	Nonion granosum E. haueriinum E. reginum	Mactra-Schichten und Ervilien-Sch. von Wiesen Älteres Sarmat (Marzer Kogel)	Mactra-Schichten Ervilien-Schichten Rissoen-Schichten	Rosenbacher Kohleschichten Kucheler Horizont Rissoen - Schichten bei St. Stefan
Badener Serie	Tonmergel u. Sande Leithakalk Pötzleinsdorfer Sande Badener Tegel Schichten von Grund	Rotalien-Zone Buliminen-Zone Sandschaler-Z. obere) Lageniden-untere) Zone	Leithakalke Walbersdorfer Sch. Ritzinger Sande Lignite	Oberer Nulliporenkalk Tonmergel und Sande Unterer Nulliporenkalk Florianer Schichten Kreuzbergschichten	Dachbergschotter Mühldorfer Sch. (marin)
Laaer Serie	Aderklaaer Kongl. Aderklaaer Sch. Laaer Schichten	Zone mit Glob. bisphaericus	Brennberger Blockschotter	Vulkanite: Steirischer Schlier (marin) und limnische Äquivalente (höhere Eibiswalder Schichten u. s. w.)	Granitztaler Schichten (limnisch)
Luschitzer Serie	Oncophora-Sch. Fossilarmer Schlier Elphidien-Schlier Cyclammina-Bathysiphon-Schlier Schlierbasisschutt	Rzehakia und Limnocardiidae	Auwaldschotter Süßwasser Sch. vom Brennberg	limnisch-fluviatile Ablagerungen (tiefere Eibiswalder Schichten)	
? lokal in Bohrungen	?				

[1] Englisch: formations

clature is answered by the requirements of a region. In view of the long tradition and the huge quantities of material available regarding the Neogene in the central Paratethys, it is urgently necessary to set up for the beds and formations an overall time schedule meeting local conditions. That time schedule remains sub-ordinate to chronological systems internationally recognized, and is applicable in a limited area only. Since no internationally recognized chronological system is in existence, there is only one solution, namely, to use chronological systems for limited areas or regions so as to make possible a comparison of formations at least within those zones. The system proposed for the central Paratethys conforms to the series of "Chronostratigraphy and Neostratigraphic Types" as published by the Slovakian Academy. It is meant to be an aid to further pertinent paleontological and geological work.