

Problems and progress in establishing a Late Neogene Chronostratigraphy for the Central Paratethys

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1. Late Neogene Chronostratigraphy of the Central Paratethys: "A Perfect Babel"

If Late Neogene chronostratigraphy of the Mediterranean can be regarded as one of the best known time intervals of the stratigraphic column, on the other end Late Neogene chronostratigraphy of Paratethys is likely to appear, some decades after its introduction (Regional Committee on Mediterranean Neogene Stratigraphy (RCMNS), 1971; Steininger and Rögl, 1979; Rögl and Steininger, 1983; Papp et al., 1985; Steininger *et al.*, 1988; Nagymarosi, 1990; Steininger *et al.*, 1990; Stevanović et al., 1990; Müller and Magyar, 1992), as a source of confusion and misunderstanding ("A perfect Babel", Magyar and Hably, 1994) rather than the common language which should facilitate stratigraphic correlation and communication among earth scientists from different countries and various disciplines in the field of Earth Sciences.

Apart from obvious difficulties of correlation between non-marine stages of the Paratethys and standard marine stages (even in "Chronostratigraphy and Neostatotypen" series, as late as 1990, the authors could not decide if the Pontian stage correlates to the Pliocene or to the Miocene), it clearly turned out that the Paratethys Stage System is affected by serious problems of internal consistency. Not even the distinction into Central and Eastern Paratethys could serve to obtain a clear subdivision of chronostratigraphic units at a more local scale. On the contrary, when the Paratethys Stage System was about to be officially introduced, a sort of "scientific competition" started among stratigraphers working in the area of the Carpathian basin. Various Authors established their own subdivision or "biostratigraphic definition" of chronostratigraphic boundaries and relative stratotype which, in most instances, revealed to have rather different chronological meanings.

In particular, the boundaries and the internal subdivision of the broad time interval between the Sarmatian (upper Middle Miocene) and the Pleistocene have not been unambiguously defined. Several stages and substages were proposed, like Serbian, Slavonian, Portaferrian, Malvensian, Kunsagian, Balatonian and the scientific debate sometimes got the flavour of an international competition. Most of these units were vaguely defined, on the basis of mollusc assemblages or lithostratigraphy, and lacked, or simply neglected, magnetostratigraphy, radiometric ages or plankton stratigraphy.

The use of different names or even different meanings for the same names has proliferated to such an extent that, possibly, the only "neutral" chronostratigraphic term one could use to indicate rocks of that time interval is "Pannonian *s. l.*" as it was originally introduced by Roth (1879) more than a century ago.

2. A chronostratigraphic "gap" between the Pannonian *s. str.* and Pontian *s. str.* stages of Central Paratethys

In a recent paper two of the authors (S. and H., in Sacchi et al., in press) reviewed the stratigraphic framework of SW Pannonian basin and suggested a new chronostratigraphic subdivision of the "Pannonian *s. l.*" stage. Following Müller and Magyar (1992), Sacchi et al. (in press) proposed that the base of the Upper Pannonian of the Hungarian tradition (Upper Pannonian *s. Lőrenthey*, 1900; Pontian *s. Stevanović*, 1951; Balatonian *s. Jámbor*, 1987) should be definitively considered older than the base of Pontian *s. str.* (as it is defined in the Black Sea region).

In particular the upper boundary of Pannonian *s. str.* stage should be conclusively fixed at the termination of the first major phase of deepening of the "Pannonian Lake" as it is suggested by its historical definition (see Korpás-Hódi, 1983; Jámbor, 1987). This is recorded in the stratigraphic sequence of the Pannonian basin as a "peak transgressive" of a 2nd-order transgressive-regressive cycle (Sacchi et al., in press). Since this event does not correlate in time with the base of the Pontian *s. str.*, Sacchi et al. (in press) have proposed that the Pannonian *s. str.* (Lower Pannonian *s. Lőrenthey*, 1900) and the Pontian *s. str.* stages should no longer be considered as representing contiguous time intervals as they are separated by a major chronostratigraphic "gap" of about 2 Ma. The same authors have suggested that a new stage or substage (preliminarily indicated with the informal name *Transdanubian*) should be introduced to fill this "gap" which approximately correlates to *Congeria unguicaprae* and *Congeria balatonica* beds (Middle Pannonian *s. Halaváts*, 1903).

In the following pages we discuss a number of possible ways to "fill" the chronostratigraphic "gap" between the Pannonian *s.str.* and Pontian *s.str.* and will try to illustrate arguments in favour as well as arguments against each proposed solution, in order to stimulate further discussion within the "Neogene community".

3. How to fill the chronostratigraphic "gap"?

Of the several possible solutions to fill the "gap" in the Late Miocene Chronostratigraphy of Central Paratethys, we discuss here four (Fig. 1). We are aware of the fact that some of them imply major changes in the fundamentals of the Paratethys Stage System. At the same time, however, we are convinced that to leave the System as it is at the present, would be the worst decision.

**STANDARD
CHRONO-
STRATIGRAPHY**

**GENERAL PARATETHYS CHRONOSTRATIGRAPHY
(Pannonian basin)**

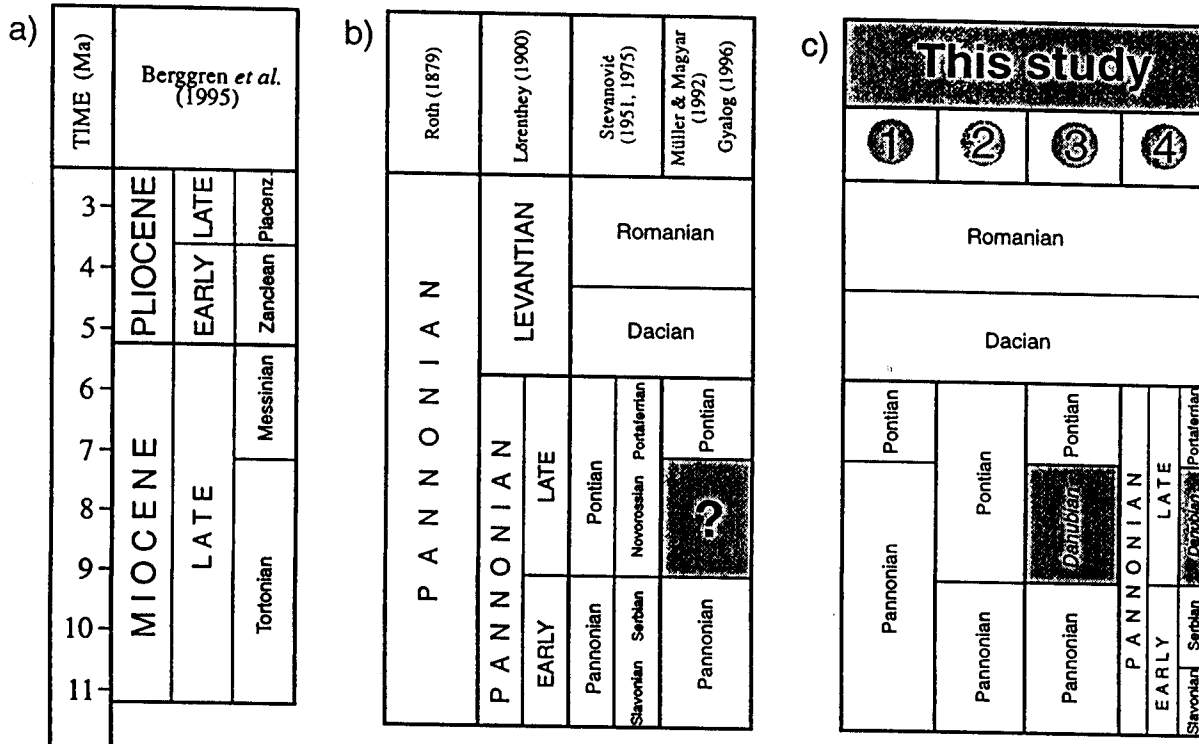


Fig. 1 - Correlation between (a) Mediterranean and (b) Central Paratethys chronostratigraphic units for the Late Neogene. Column (c) illustrates four possible solutions we discuss in this study in order to outline a self-consistent chronostratigraphic framework for the Late Miocene of Central Paratethys, Pannonian basin, in the light of recent data (see the text for further discussion):

- ① Shift the boundary between Pannonian s. str. and Pontian s. str. Stevanović (1951) up to the base of the Euxinian basin Pontian (Eastern Paratethys).
- ② Maintain the Pontian s. Stevanović (1951) only for the Central Paratethys and use the term Pontian with two different meanings.
- ③ Introduce a new stage in order to "fill the chronostratigraphic gap" between the Pannonian s. str. and Pontian s. str. (as used in the Euxinian basin).
- ④ Delete the stage name "Pontian" from the Western-Central Paratethys stage system and reintroduce the use of the term "Pannonian" s. Lorenthey (1900).

Solution 1: Shift the boundary between Pannonian s. str. and Pontian (s. Stevanović, 1951) up to the base of the Euxinian basin Pontian (Eastern Paratethys)

Advantages:

- We would not have to introduce new stages, but simply revise Stevanović's correlation (1951) in the light of recent data (Müller and Magyar, 1992; Sacchi et al., in press).
- The term "Pontian" could be used with the same meaning both for the Central and the Eastern Paratethys.

Drawbacks:

- The term "Pannonian" as a stage name, as well as the terms "Lower Pannonian" and "Upper Pannonian", would be used in a fourth meaning (after Roth, 1879; Lőrenthey, 1900 and Stevanović, 1951).
- The "Pannonian" stage would include rocks which have been reported as Pontian for several decades in the literature.
- The "Pontian" of the Pannonian basin is quite different both in terms of lithofacies and biofacies from the "Pontian" of the Euxinian basin. Their correlation is still uncertain, and cannot be regarded as well established.

Solution 2: Maintain the Pontian s. Stevanović (1951) only for the Central Paratethys and use the term "Pontian" with two different meanings

Advantages:

- We would not have to change the present chronostratigraphic framework for Late Miocene of Central Paratethys (i.e. the boundary between Pannonian s. str. and the Pontian s. Stevanović, 1951).

Drawbacks:

- Though the original definition of the base of Pontian s. Stevanović (1951) was the FAD of *Congeria zagrabiensis* and *Congeria praerhomboides*, etc., later Stevanović (1990) redefined the base of the Pontian according to the presumed coeval appearance of common molluscan species on both sides of the Carpathians. However Müller & Magyar (1992, 1995), showed that there is about 2 Ma difference between these two events. Consequently, no clear definition exists for the lower boundary of the Pontian s. Stevanović (1951).
- Even if we decide to adopt the Pontian s. Stevanović (1951), its internal subdivision should be modified as the use of the Lower Pontian substage "Novorossian" or "Odessian" for the lower part of Pontian s. Stevanović (1951) is clearly wrong; possibly there is not even a slight time overlap between the Pannonian basin "Odessian" and the Euxinian basin Odessian

Solution 3: Introduce a new stage to fill the “chronostratigraphic gap” between the Pannonian s. str. and the Pontian s. str. (as used in the Euxinian basin)

Advantages:

- The Pannonian s. str. would remain unchanged and we could use the Pontian with the same meaning throughout the Paratethys.
- This subdivision would fit a stratigraphic framework based on integrated sequence stratigraphic, biostratigraphic and magnetostratigraphic data (Sacchi et al., in press).
- The new chronostratigraphic unit (we propose the name “Danubian”) could substitute the lower substage of the Pontian s. Stevanović (1951), (“Novorossian” or “Odessian”), so that at least the substage system would remain relatively intact.

Drawbacks:

- A new stage (or substage) with a new name (“Danubian”) should be introduced in the already complex framework of the Paratethys stage system.
- Although the “Danubian” is likely to prospect good potential of correlatability through the various sub-basins of the Paratethys based on its magnetostratigraphic, sequence stratigraphic and biostratigraphic definition, it could be introduced only for Pannonian basin use, at least in the beginning.
- It would not solve, alone, the problems of correlating the Pontian stage through the Paratethys.

Solution 4: Delete the stage name “Pontian” from the Western-Central Paratethys stage system and reintroduce the use of the term “Pannonian” s. Lőrenthey, (1900)

Advantages:

- It would eliminate all problems caused by uncertain correlation of the Pontian and its substages across the Paratethys realm from southern Ukraine to the Pannonian basin.
- It would make it possible to refer the sedimentary sequence of a long-lived, large paleogeographic domain (the “Pannonian Lake”) to a single stage, thus interrupting the rather illogical practice of decoupling the paleogeographic term “Pannonian lake” and the stratigraphic term “Pannonian stage”.
- The internal subdivision of a relatively long Pannonian stage s. Lőrenthey (1900) into the four substages Slavonian and Serbian (Lower Pannonian), Danubian and Portaferrian (Upper Pontian), would offer an adequate stratigraphic resolution.
- Most of substages s. Stevanović (1951) could be kept in use and the Portaferrian could be tentatively correlated to the Pontian stage of Eastern Paratethys.

Drawbacks:

The only, though significant drawback of this solution is that it would make worthless the effort to introduce the Pontian stage into the Pannonian basin of the last 40 years.

4. A draft of proposal for a new chronostratigraphic unit

Following the above guidelines (including solution 1 and 2) it can be agreed, as a first step, that the "Novorossian" or "Odessian" (as the lower substage of Pontian *s. str.* Stevanović, 1951) is inadequate for the Pannonian basin and a new chronostratigraphic unit should be introduced in the central Paratethys system in order to fill the stratigraphic "gap" between the Pannonian *s. str.* stage of the Pannonian basin and the Pontian *s. str.* stage of the Euxinian basin. Hence the "Danubian" should be defined and formally instituted at least as a substage, whatever the final choice among the four proposed solutions may be.

According to the different options the "Danubian" could be introduced as the uppermost substage of the "Pannonian" of solution 1, or the lower substage of the Pontian of solution 2, or independent stage (solution 3), or the third substage of the Pannonian of solution 4.

The concept of an intermediate stage between "Lower Pannonian" (Pannonian *s. str.*) and "Upper Pannonian" (Pontian) is not new. Since early times of stratigraphic study on Pannonian strata, Halaváts (1903) had already defined a "Middle Pannonian" sequence as corresponding to *Congeria unguicaprae* and *Congeria balatonica* beds.

Name

We propose the name "Danubian" (from the name of the River Danube) for the new chronostratigraphic unit which should cover the un-named time interval between the Pannonian *s. str.* and the Pontian *s. str.*

One of the reasons for choosing this name has been the need of a symbolic separation from a sort of regional bias which affected the scientific community during the past decades. In fact, the rocks whose age falls within this time interval, widely outcrop through all the Carpathian basin and the River Danube has been often regarded, in this politically and ethnically fractured region, as a symbol of unity and cooperation among the various populations living in the "Pannonian basin".

The "Danubian" ("Transdanubian" in Sacchi et al., in press) time interval is actually not represented in any proposed stratotype of the Late Miocene Series of the Central Paratethys.

Rank of the Chronostratigraphic Unit

The Danubian has a duration of nearly 2.0 Ma. It could be ascribed to the stage or substage rank, depending on the overall reorganization of the chronostratigraphic framework for the Late Miocene of Central Paratethys which is discussed here.

Location of the Stratotype

A suitable stratotype for the Danubian stage is represented by the Fehérpárt section, which is presently used as faciostratotype for local (Hungarian) reference to the Pontian facies of the Black Sea (Müller and Szonóky, 1990). This section is exposed at the northern shore of Lake Balaton (*Tihany* peninsula), western Hungary. Unfortunately, the lower boundary of Danubian is not cropping out in that area but it has been cored in the near subsurface (55.4 m below the topographic surface at Lake Balaton shore, *Tihany-62* well) and is widely cropping out in the northern Transdanubia (Bakony, Vértes, Gerecse Mts.).

Biostratigraphic definition

In terms of molluscan biozonation the Danubian stage corresponds to the littoral *Congeria balatonica-Lymnocardium decorum* zone and part of the *Congeria unguilacaprae - Melanopsis pygmaea* zone (see Middle Pannonian of Halaváts, 1903). It corresponds fairly well to the sublittoral *Congeria prae-rhomboidea* zone and the *Spiniferites validus* microplankton zone, though it may outreach their rather uncertain upper boundaries.

Correlation with unconformity-bounded stratigraphic units (UBSU)

From the perspective of sequence stratigraphic units (sensu Vail, 1987), regarded as one type of unconformity-bounded stratigraphic units (Salvador, 1994), the Danubian stage is defined as a regressive-transgressive cycle bounded by two consecutive 3rd-order maximum flooding surfaces which are widely recognizable in the western Pannonian basin area, both in the outcrop and in the subsurface.

Magnetostratigraphic definition

Based on correlation with magnetostratigraphy of Iharosberény-I well, the lower boundary of the Danubian stage can be placed at the base of chron C4An of the global magnetic polarity scale (Cande and Kent, 1992, 1995).

Geochronology

According to the revised calibration of global magnetic polarity scale of Cande and Kent (1995), the lower boundary of the Danubian stage has a magnetostratigraphic age of 9.025 Ma.

Potential correlation with Eastern Paratethys stages

Based on its integrated stratigraphic definition the Danubian stage might be tentatively correlated with the Maeotian stage of the Eastern Paratethys.

4. Conclusion

Some decades after its official introduction, the Paratethys Stage System for Late Miocene is likely to appear an intricate puzzle with very few reference points in terms of geochronology. Most of Paratethyan stages were based on malacological data. Due to the general endemic nature of faunas and the overall shifting in time of depositional systems towards E-SE, the correlation of these stages at inter-basinal or even intra-basinal scale is problematic and both lithostratigraphic and biostratigraphic assemblages systematically tend to rejuvenate in that direction. We might even say that most stratigraphic correlation charts of the Late Neogene of the Paratethys reflect the true framework of lithostratigraphic or biostratigraphic units rather than chronostratigraphy.

The high degree of uncertainty in chronostratigraphic correlation implied in the System, resulted in an incredible proliferation of different stratigraphic subdivisions, often based on different stage names which in turn have often been used according to different meanings.

We are convinced that evident miscorrelation and internal inconsistency of the present-day Late Neogene Stage System of the Paratethys should be formally corrected in order to avoid further confusion. Accordingly the System itself should be significantly reset in the light of modern concepts of integrated approach where multiple biostratigraphy, magnetostratigraphy, isotopic stratigraphy and various kind of physical stratigraphy (including stratigraphy of unconformity-bounded units and astrostratigraphy) are applied in a multidisciplinary effort.

Advanced stratigraphic correlation should gradually lead, in perspective, to leave the regional Paratethys stage system for the standard time scale.

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