# CYCLICITIES IN THE SVIDOL FORMATION NEAR CEROVO VILLAGE, NW BULGARIA

# George Ajdanlijsky

University of Mining and Geology "St. Ivan Rilski", Sofia 1700, E-mail: ajdansky@staff.mgu.bg

#### ABSTRACT

Based on detailed lithofacial studies of a section of Svidol Formation (Lower Triassic) located near Cerovo Village, Svoge District, a one-sequence stratigraphic unit was recognized and subdivided into transgressive and highstand system tracts. Parasequence sets, parasequences and higher-order cycles are recognised and characterized within each system tract. The unit is 27 m thick and corresponds to the sequence stratigraphic unit in the same formation that was earlier described near Sfrazen Hamlet, northerly along the Iskar Gorge. The detailed study of the inner architecture of the higher-order cycles allows high-resolution stratigraphic correlations between the two sections. Comparative analysis of the data from the two sections indicates variations in the thickness and structure of the higher-order cycles units of the sequence. The absence of reliably determinable fossil fauna in the section do not allow a correct definition of its chronostratigraphic span. The character of the described mesoscale cyclicities enables their comparison with those, established in other parts of the Lower Triassic section in the area and is a step toward elaboration of a general cyclostratigraphic model for the whole Lower Triassic Series in the studied area. The collected new data about the structure of the formation suggest a possible tide-dominated delta character in some portions of the depositional environment.

#### INTRODUCTION

The rocks of the Svidol Formation represent the transition between the red continental successions of the Petrohan Terrigenous Group (Lower Triassic) and the typical marine carbonate rocks of the Iskar Carbonate Group (Lower-Upper Triassic). Even in the nomination of the formation (Čatalov, 1974), "... the cyclic structure of its facieses ..." has been pointed out among its main characteristics. According to the same author (Čatalov, 1975), the typical for this formation types of stratification and its lithologic composition indicate, that the unit was formed in the conditions of a low-relief terrigenous-carbonate tidal flat.

Despite of its wide distribution in NW Bulgaria and the Moesian platform, Svidol Formation is poorly exposed because of the specific lithological features of the rocks that build it up. For this reason, detailed lithofacial and stratigraphic descriptions of concrete sections of the unit are practically lacking in the literature. The Iskar Gorge is one of the few areas in Bulgaria, where relatively complete and frequent outcrops of the Svidol Formation occur. The southernmost outcrop of the unit, that is located in the gorge near Cerovo Village, Svoge District (Fig. 1), provides excellent opportunities for a detailed lithofacial and stratigraphic study.

This paper presents the first, more detailed lithologic and stratigraphic description of the Svidol Formation in the area of the Iskar Gorge. Object of study is the section at the "Red wall" locality in the eastern end of Cerovo Village. On the basis of detailed field and laboratory lithofacial studies, different in rank sedimentary cyclicities are characterized and a sequence stratigraphic subdivision is proposed. After a comparison with results from earlier analogous investigations on Svidol Formation (Tronkov and Ajdanlijsky, 1998 b) near Sfrazen Hamlet, located to the north along the gorge, conclusions about the formation structure and traceability of the characterized stratigraphic units and levels in the area are drawn.



Figure 1. Schematic map of Svidol Formation outcrops (gray) in the area with location of the studied section.

The description of the fluvial deposits is based on the Miall (1996) lithofacial scheme. The lithologic determinations in the Svodol Formation are according to the proposed by Sultanov (1980) classification of clay-carbonate rocks. The field color description of the rocks in the section is based on the Rock-Color Chart (1991).

#### SECTION DESCRIPTION

The description of the studied section includes the bordering parts of the underlying Petrohan Terrigenous Group (PTG) and the overlying Mogila Formation. The aim is to provide a more correct determination of the scale, character and genesis of the sedimentological cyclicity in the Svidol Formation and a correct comparison with those in the other part of the Lower Triassic Series in the area.





Figure 2. Lithologic-stratigraphic column of the studied section. Legend: Lithotypes (1-22): Clastic rocks (1-14): 1 - claycarbobate breccia-conglomerate; Sandsones (2-5): 2 -pure; 3 -silty: 4 – mudy: 5 – limy (dolomitic): Siltstones (6-9): 6 –pure: 7 – sandy; 8 –mudy; 9 – limy (dolomitic); Mudstones (10-13): 10 - pure; 11 - sandy; 12 - silty; 13 - limy (dolomitic); 14 hyporocks; Carbonate rocks (15-22): Dolomites (15-17): 15 pure; 16 - sandy; 17 - silty; 18 - mudy; Limestones (19-23): 19 - pure; 20 - sandy; 21 -silty; 22 - mudy-sandy; 23 - mudy; Sedimetary structure and texture (24-34): 24 - massive; 25 discontinuous; 26 – even, parallel; 27 – large scale trough cross-bedding; 28 - low angel cross-bedding; 29 - small scale cross-bedding; 30 - a) flaser, b) lenticular, c) nodular and d) bidirectional ripples; 31 – gravel structure: a) imbrication, b) lag structure and c) lenses; 32 – bed shape: a) wedge and b) scour-and-fill: 33 – synsedimentary deformational structure: a) slides and b) slumps; 34 – gravel grain size : a) <2 cm ; b) 2-5 cm and c) 5-10 cm; 35 – clastic mica: a) chaotic and b) paralel to lamination. Index – content (%) in the unit; 36 – paleopedogenic and evaporite products: a) spots, b) single and clusterlike calcretes, and c) gypsum crystal. Index - mineralogy: crb carbonate, dol – dolomite; 37 – fossils and trace fossils: a) brachiopoda, b) crinoids and c) bioturbations. The abbreviations are explained in the text.

#### The Petrohan Terrigenous Group

The uppermost part of the Petrohan Terrigenous Group comprises a cyclic fluvial succession with significant development of paleopedogenic products both in allo- and authochtonous position. The thickness of the individual fluvial cycles ranges from 3,5 m to 4,5 m, rarely to 9 m. The base of the cycle is an erosional surface, covered by channel claycarbonate breccia-conglomerates (lithofacies Bbr). Upward in the cycle dominate cross-laminated sandstones of lothofacieses SI and Str, which alternate with hyporocks (lithofacies Fm  $\mu$  FI) and less commonly with siltstones and mudstones (lithofacies Fsc). Synsedimentary deformations and escape structure are frequently observed in the sandstones.

The boundary between PTG and Svidol Formation is a rapid lithologic transition and can be traced on the basis of: (1) the disappearance of the features of channel erosion, disappearance of the wide development of paleopedogenic products and inundates; and (2) the appearance of thin layers of dolo-marls, appearance of features of intensive bioturbation of the deposits and the domination of bi-directional over one-directional ripple marks (Tronkov and Ajdanlijsky, 1998a; Ajdanlisjky, 2000, 2001a).

According to the stratigraphic subdivision of the PTG proposed by Tronkov and Ajdanlijsky (1998a), the described interval belongs to the uppermost part of mesocycle MC-2.

#### **The Svidol Formation**

The studied section of the Svidol Formation is a type 2 sequence unit with thickness about 27 m, which is build up of transgressive and highstand system tracts (Fig. 2). The lithologic composition of the formation shows a large variety of terrigenous, terrigenous-carbonate and carbonate rocks (Fig. 3).



Figure 3. Lithologic characteristics of all representative rocks for the studied outcrop of Svidol Formation (according to the classification diagram of Sultanov, 1980).

**The transgressive system tract** (TST) is 20,7 m thick. Its lowermost part (7,4 m) is build up of two parasequences, represented by upward-fining lithofacial successions (Fig. 2, Iti-hofacial units 27-42). The parasequence thickness is 3,5 and 3,9 m. Fine-grained lithofacies, hyporocks with massive structure dominate in the interval. As a rule, paleopedogenic spots, calcretes and cluster-like aggregates with calcite or dolomite composition appear in the upper part of both units. There again, the most abundant bioturbations are observed. As a whole, the interval shows the maximum mica content in the formation.

If we exclude the appearance of yellowish-gray to pale-olive (5Y7/2-10Y6/2) nuances and the few thin layers of limy grayish- orange (10YR7/4) sandstone, the colors of this interval are identical to those that dominate in the uppermost part of the PTG.

The middle part of the TST is build up of three parasequences with total thickness 6 m. The thickness of a single unit varies from 1,9 m to 2,15 m. Terrigenous rocks still dominate in this interval, but in contrast to the previous one, every parasequence forms a upward-coarsing lithofacial succession. Generally, the sandy lithofacieses are of wide occurrence and the carbonate content in the rocks is increasing upward. Characteristic for the interval is the wide development of bi-directional small-scale cross-lamination (ripple marks), the graduate disappearance of the aleopedogenic features (here presented only by spots), the shift of the bioturbated intervals to the middle part of the parasequences as well as the preserved mica occurrence in the sediments (mainly in its uppermost parts). Flaser and nodular lamination are significant. One small-scale slump-like synsedimentary deformational structure is observed in the lowermost of the three parasequences (Fig. 2, PS-3) in the package (Fig. 2, lithofacial unit 54).

The red colors, represented mainly by moderate red (5R4/4-6), are gradually replaced upward in the interval by ochre and whitish-beige (5YR7/2-10YR7/4) ones.

The pattern of the uppermost 7,3 m of the TST is entirely different from that of the two already described intervals. Despite the preservation of the tendency from the middle part of the tract the parasequences to form upward-coarsening facial succession, here they are built up predominantly of marls, dolo-marls and muddy dolomites. The stages of maximum deepening are marked by silty marls. The sandstones are untypical for the interval. Most often, the role of the coarsest sediments is played by hyporocks or sandy limestones, developed as single 10-15 cm thick layers. Terrigenous mica is practically absent. Fine-bedding dominates among the structures in this interval.

In the lower two of the four parasequences that build up the interval, upward-thinning sets of dolomite-marl couplets occur. There again, in one of the courser dolomite layer, single small gypsum crystals were observed that are orientated perpendicular to the bedding. At the same level, small-scale synsedimentary slide-like structure occur. Upward in the package, the thickness of the parasequences decreases - from 2,15 m in its lower part, to 1,6 m in the upper one. There, mainly within the layers of massive micrite limestones, single and poorly defined brachiopod and bivalve fragments were found.

Medium-dark to medium-gray colors (N4-5) dominate over the ochre and whitish-beige tones (10YR7/3-6/6) in this interval.

As a whole, the TST is build up of retrogradational parasequence sets, and only in its uppermost part shows the features of aggradational pattern on stacking. The maximum flooding surface (mfs) is marked by a thin fine-laminated dark-gray silty marl layer (Fig. 2, lithofacial unit 103).

**The highstand system tract** (HST) is 6,4 m thick and is build up of a progradational parasequence set, in which the thickness of the single parasequences gradually increases upward from 1 m to above 3,1 m (?). The parasequence set can be subdivided into two groups: (a) the lower two parasequences, which show bipartite trend of lithofacial coarsening (a feature, which is slightly hinted also in the uppermost parasequence (Fig. 2, PS-9) of the TST; and (b) the parasequences from the upper part of the tract that are represented by upwardcoarsening facies successions. Despite of the domination of marls and dolomites in this part of the section, the role of the coarsest sediments in the parasequences is plaid by limy sandsones. Parasequence PS-11 (Fig.2, lithofacial units 111-115) is build up by dolomite-marl couplets successions, similar to those in parasequences PS-6 and PS-7, but in contrast to them, detrital fragments of crinoids are observed in the coarser part of every couplet. More complex is the structure of the parasequence PS-12, which represents a succession of five uniform marl-mudstone-sandstone triplets (Fig. 2, lithofacial unit 116). In the uppermost parasequence of the TST, features of small-scale intraformational erosion are observed.

In the confines of HST, a relatively rapid change from grayish colors again to ochre, green and even red (10R6/5) is noted.

The upper boundary of Svidol Formation (Fig. 2, SB-2) is erosional and transgresive.

### The Mogila Formation

The described in detail by Tronkov (1983) cylicity in the shallow-marine carbonate successions from the lower part of Mogila Formation is observed very well in this section. Here, in the lowermost part of the formation, fining-upward cycles with thickness from 2,8 m to 3,1 m occur. Generally, the single cycle is formed of cross-bedded to massive calcarenites, parallel bedded and massive micrite, clayey to muddy limestone and dolomicrites, which vertically replace each other. The base of the cycles is a low-relief erosional surface, often covered by single, mainly dolomicrite pebble- to cobble-sized intraformational clasts.

### DISCUSSION AND CONCLUSSIONS

According to their structure, the established two system tracts (TST and HST) and the divided in them four intervals (parasequence set) in the studied section of Svidol Formation almost completely correspond to those, established by Tronkov and Ajdanlijsky (1998b) in the section of the same formation situated to the north along the gorge, near Sfrazen Hamlet. The subdivision of the TST into three intervals as well as the general features of the interval structure are almost identical. The same concerns the number of similar interval parasequences from the two sections – three for the middle interval of TST and four for HST (intervals B and D in the scheme proposed by Tronkov and Ajdanlijsky, 1998b). The absence of suitable exposures in the middle part of the Sfrazen section and in the lower part of Cerovo section hampers the exact comparison of the structure of the other two intervals.

The comparative analysis of the thickness of these units reveals a tendency to a relatively stable increase (from 27% to 47%) of the thickness of almost all four parasequence sets in the northern (near Sfrazen) section. An exception from this tendency is only the lower interval of the TST, the thickness of which remains almost constant in both sections (7,4 m and 8 m, respectively). The obtained data from the preliminary studies in other sections of the Svidol Formation in the area of Iskar gorge completely confirmed this tendency.

The identity in the parasequence set structure, as well as the almost complete identity (as a scale and as a structure) of the dolomite-marl couplets succession in both sections allows a high-resolutional stratigraphical correlation between them. The different as order cyclicities in the TST from the two sections can be very well correlated.

Except for a refinement of the existing stratigraphic model of Svidol Formation, the present study reveals also some differences in its structure between the sections in the area of Iskar Gorge and those from Teteven district and Vratchanska Stara planina Mountain, published by Čatalov (1974). For example, the described by Čatalov second (upper) cycle in the formation (represented only with its transgressive part) was not established in the sections from the Iskar Gorge. Another significant difference is connected with the structure of the interval of the formation that represents the stage of the maximum deepening of the sedimentary environment. While in Teteven area, this interval is almost completely composed of micritic and biodetrital limestones, that from the sections in the gorge is build up mainly of mixed terrigenous-carbonate lithofacieses.

According to Čatalov (1975), the Svidol Formation was formed under the conditions of an epicontinental tidal flat, for witch the cyclic development of the sedimentary processes was characteristic. On the basis of new data (Hori et al., 2001) it could be supposed, that the described above sedimentary architecture and cyclicity could be a product of tide-dominated delta complex development as well.

The data obtained about the scale and character of the mesoscale cyclicity in Svidol Formation in the area of the Iskar Gorge are comparable with the characteristics of the mesocyclicity established in the PTG (Tronkov and Ajdanlijsky, 1998a; Ajdanlijsky, 2000; 2001b) and in the Mogila Formation (Tronkov, 1983) in the same region. The fluvial mesocycles (MC-0, MC-1 and MC-2) within the PTG as well as the sequence stratigraphy unit described in Svidol Fromation are of the same order (probably 3-rd order, according to the scheme proposed by Miall, 1997, Table 3.1). The subdivision of these fluvial mesocycles into submesocycles and fluvial cycles, respectively the subdivision of the sequence into system tracts, parasequence sets and parasequences, reflects the transition to the next (higher-order) level of cyclicity in them. The structure of the individual parasequences in the Svidol Formation and especially the subdivision of distinct sedimentary couplets and triplets series in some of them on one hand, and the described by Tronkov (1983) and Nikov (1999f) cyclicity in the Opletnja (lower) Member of the Mogila Formation on the other, approximately correspond to the 5-th order cyclicity described by Goldhammer et al., (1987, 1990) in the Latemar's Alpine Triassic platform carbonates.

The absence of reliably determined fossil fauna in the studied section does not allow us to define more precisely the chronostratigraphic range of the above described cyclicities.

The meso- and upper-rank cyclicities recognised in Svidol Formation section near Cerovo Village, are identical with those, described by Tronkov and Ajdanlijsky (1998b) in the same formation at Sfrazen hamlet, located to the north along the Iskar Gorge. Despite some lateral variations in the form and the scale of their occurrence, they could be a good base for more detailed stratigraphic subdivision and correlation of the discussed formation in the area. The described mesoscale cyclicity is comparable to that, established in other parts of the Lower Triassic section in the area and provides a sound base toward elaboration of a general cyclostratigraphic model for the whole Lower Triassic Series in the studied area. The collected new data about the structure of the formation suggest a possible tide-dominated delta character of the sedimentary environment that controlled the deposition of the formation.

## REFERENCES

- Ajdanlijsky, G., 2000. Paleopedogenic Occurrences in the Petrohan Terrigenous Group of the Berkovitza Unit, NW Bulgaria. - GSB Geol. Conf., 11-13 October 2000, Sofia, 315-317.
- Ajdanlijsky, G., 2001a. Synsedimentary deformations in the transitional interval between the Petrochan terrigenous group and Svidol formation near Sfrazen, western Bulgaria.
  Ann. Univ. Min. Geol, 43-44, part I, geology, 27-30.
- Ajdanlijsky, G., 2001b. Facial Architecture of the Petrohan Terrigenous Group (Lower Triassic red bed succession) in part of NW Bulgaria. – IAS 2001 21<sup>st</sup> Meeting, Davos, 3-5 Sept., 157.
- Čatalov, G., 1974. The facieses of the Svidol Formation (Lower Triassic) in Teteven Anticlinorium. – C. R. Acad. Bulg. Sci., 27, 2, 239-242. (in Bulg.)
- Čatalov, G., 1975. Facies Analysis of the Svidol Formation (Lower Triassic) of the Teteven Anticlinorium (Central Fore-Balkan). – Geol. Balc., 5, 2, 67-86.
- Goldhammer, R. K., P. A. Dunn, L. A., Hardie, 1987. High frequency glacio-eustatic sea-level oscillations with Milankovitch characteristic recorded in Middle Triassic platform carbonates in Northern Italy. – Am. J. Sci., 287, 853-892.
- Goldhammer, R. K., P. A. Dunn, L. A., Hardie, 1990. Depositional cycles, composite sea-level changes, cycle stacked

patterns, and hierarchy of stratigraphic forsing: Example from Alpine Triassic platform carbonates . – Geol. Soc. Am. Bull., 102, 535-562.

- Hori, K., Y. Saito, Q. Zhao, P. Wang, 2001. Architecture and evolution of the tide-dominated Chanbjiang (Yangtze) River delta, China. – Sediment. Geol., 146, 3-4: 249-264.
- Miall, A. D. 1996. The Geology of Fluvial Deposits. Sedimentary Facies, Basin Analysis and Petroleum Geology. -Springer, 582.
- Miall, A. D., 1997. The Geology of Stratigraphic Sequences. Springer, 433.
- Nikov, P., 1999f. Sedimentological and stratigraphical characteristic of the Lower Triassic limestones from the "Djurin Dol" deposit, Cerovo village, Svoge district, with with project for detail prospecting. – MSci. Thesys, UMG, S., 96 p. (in Bulg.)
- Rock-Color Chart. 1991. (7th printing) Geol. Soc. of Am., Boulder, Co.
- Sultanov, A., 1980. A new classificational diagram for claycarbonate rocks of the carbonate-clay-clasts system. – C. R. Acad. Bulg. Sci., 33, 8, 1103-1106. (in Bulg.)
- Tronkov, D., 1983. Mogila Formation (Lower-Middle Triassic) in Iskar gorge and Vraca Mountain (West Stara Planina). – Geologica Balc., 13, 6, 37-52. (in Bulg.)
- Tronkov, D., G. Ajdanlijsky, 1998a. The Profile of the Petrochan Terrigenous Group (PTG - Lower Triassic, Buntsandstein facial type) between Opletnja and Sfrazen, NW Bulgaria. - 1st International Conference of Epicontinenal Triassic - Hallesches Jahrbuch fur Geowissenschaften, Reihe B, Beiheft 5, 175-176.
- Tronkov, D., G. Ajdanlijsky, 1998b. Sequence Stratigraphy of the transition from continental to marine lower Triassic Sediments in Western Balkan (NW Bulgaria). – 16<sup>th</sup> Congress of Carpatho-Balkan Geol. Assoc., 30.08.-02.09.1998, Vienna, Austria, Abstract volume, 607.

Recommended for publication by Department of Geology and Paleontology, Faculty of Geology