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# A SEDIMENTOLOGICAL ANALYSIS OF THE SULPHATIC EVAPORITIC LITHOFACIES IN THE SALT BRECCIA IN VALEA REA, ISTRIŢA HILL (CARPATHIANS FOREDEEP)

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**ABSTRACT.** This paper presents the diagnosis and the interpretation of the evaporitic facies from the Southern side of Carpathians Foredeep, in the Badenian deposits at Valea Rea (Istriţa Hill, Buzău County, Romania).

**СЕДИМЕНТОЛОЖКИ АНАЛИЗ НА СУЛФАТНИТЕ ЕВАПОРИТНИ ЛИТОФАЦИЕСИ В СОЛНАТА БРЕКЧА ВЪВ ВАЛЕА РЕА, ИСТРИТА ХИЛ (ПРЕДНИ КАРПАТИ)**

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**РЕЗЮМЕ.** В работата се представя описание и интерпретация на евапоритните фациеси от южната страна на Предните Карпати сред баденските находища при Валеа Реа (Истрита Хил, окръг Бузау, Румъния).

In Valea Rea anticline core from Istriţa Hill, Buzău district, the low molasse outcrops (Fig. 1), which is represented in more formations: Burdigalian age *Doftana Formation* (Ştefănescu and Mărunţeanu, 1980), Langhian age *Câmpiniţa Formation* (made up of *marl and globigerina tuffs = Slănic tuff*) (Săndulescu et al., 1995) and Langhian age *Cosmina Breccia* = *high evaporitic formation* (Săndulescu et al., 1995).

On Valea Rea, *Cosmina Breccia* (salt breccia) appears in the presence of saline springs and efflorescences and it is made up of grey-blacky clay matrix, sometimes bituminous, sometimes siltic, micaceous with clastorudite levels vaguely layered. Breccia clastes have a fine ruditic granofacies and they are represented by lithic pebbles (marl and grey-greenish clay), grey fine micaceous calcareous sandstones, gypses and gipsiferous sandstones, black shales and globigerina tufaceous marls. Scaterred, there are also fine green schistes clastorudites. At the bottom and at different levels (as lenticular or wavy beds lithons) there are sulphatic evaporites as gipsiferous marls, alabastrin clastic gypsum laminites. The salt is strongly impure and the „salt piles" are in fact zones with a higher salty concentration.

The sulphatic evaporites in Valea Rea basin appear in the clay matrix of the salt breccia (*Cosmina Breccia*) in the form of 5-6 blocks of 3-6 m size and more submetrical blocks which contain distinct sulphatic facies, which are unique for the Romanian evaporitic realm, but similar as component parts of sulphatic sequences which are described in Northern Carpathian Foredeep in Southern Poland, Eastern Galitia, Podolia, Bucovina (see Fig. 2).

The sulphatic evaporitic sequence in Valea Rea is made of different litofacies (Fig. 1) that can be seen in different blocks which are kept in a succession by referring to a typical megasequence of the Badenian sulphatic deposits which is compiled by occurences in the Northen Carpathian Foredeep (Fig. 2). With some uncertainty which refers to the corelation of internal facies with external facies and to some peculiarity of an excessive development of breccias, the sequence in Valea Rea corresponds to the low part of the megasequence which is typical for Southern Poland. We may also add that Piatra Verde (Teişani-Slănic) sequence corresponds the high part of the same megasequence. More litofacies appear in the succession (Fig. 1) as following (*dolomitic siltolutitic shales = ISL-D*, *disturbed facies in clastorudite siltolutit = dLS-g*, *gypsified cianobacteria laminites = ci-g*, *sabre-like selenite gypsum = sa-g*, *sabre-like selenite* gypsum in the nucleation cones arrangement = *sa-cn-g*, *grass-like selenite gypsum = gr-g*, *glassy selenite gypsum in gigantic twins = gl-g*, *alabastrin nodular mosaic gypsum = n-m-g*, *(alabastrin) nodular mosaic gypsum miming precussor glassy selenite twins = r-m-g (gl-g)*, *skeletal gypsum clastorudite debris flow = DF-g*, *skeletal gypsum = sk-g*, are defined and interpreted in Figure 3.

Valea Rea litofacies (Fig. 4 and 5 = successions of facies and typical parasequences) compound parasequences ABC, ABC … type within following settings: A – shallow water (selenite in gigantic twins, skeletal gypsum debris, skeletal gypsum domal packages); B – shallower subtidal (sabre-like selenite, bended selenite (the bends are made of carbonatic lamine and grass-like clastoruditic selenitic gypsum ); C – intertidal–subtidal (laminitic criptalgal gypsum, sabre-like nucleation cones gypsum in a context of cianobacteria mats).

From a paleogeographic point of view, the evaporitic basin from Valachian Subcarpathians is an integral part of the Foredeep Badenian basin of the Carpathians (sensus largo), which is bordered by barriers and which have a zonal facies distribution (Fig. 6 and 7). At the moment of marl and globicerina tuffs deposition, which mark a high sea level and the communication between Tethys and Paratethys, the Northern border of the basin is marked by Paleogene flisch ritmites ridges, and the Southern border is marked by a cliff of the Moesian Platform in Gura Şuţii-Finta-Tinosu line. The general background is of epeiric platform, a bit affected by the tide, with ridges, islands and a large development of the shallow and lagunar sea realm. The accumulation of piroclastites and sea deposits, as globigerina marls and then a correspondent of Baranow beds – from the Northern Carpathian Foredeep uniformed the morphostructural relief of Sub-Miocen basement. Siliciclastites and Lithothamnium limestones of Baranow beds from the Northern Carpathian Foredeep existed in this Southern sector too, as can be seen in the reworks in Răchitaşu-type sandstones (e.g. Vispeşti – in Istriţa Hill).

At the beginning of the Badenian evaporitic sedimentation, the early stiric phase folding, on the background of a highstand degree, determines a change of the tectonic balance with an internal uplift and water transgression over foreland. On the Moesic and East-European platforms extended areas appear; they are favorable to the generation of contemporary sulphates with the accumulation in foredeep. From one spot to another, on the inner border, to the emergent sides of the Carpathians, halite is accumulated in several more subsidence basins. Regionally, are formed a system of interconnected salinas. They are extended, of shallower water, and they are separated by island barriers or accumulative banks. The floor surface has slight inclinations towards the centre. On the external border we can see more or less carbonatic ramps. The sulphate deposits were deposited in front and under the carbonatic shelfs, which are partially covered by *Lithothamnium* reefs. The sulphatic deposits facies variation reflects the ramp morphology, to such an extent that we may distinguish different paleogeographic zones that are batimetrically distributed (Fig. 6):

1 – the subtidal zone includes low energy lagunar (salinas) environments and high energy banks which may be exposed to the ebb. Some salinas may communicate with the open sea by a zone of external shelf. The low energy flats may be frontally deliniated by bioclastic or sulphatic sand beaches (during storms, the sand may be brought by the wind through creeks, salt pans or from the adiacent seafloor);

2 – the intertidal zone is a high energy area where microbian algal mats are developed, which are periodically disturbed and which may be by subtidal creeks or periodically saline or salmastre ponds. The hypersaline pools may contain unispecific, periodically numerous populations. The creeks have metric depths and are very large (sizing in tens of metres) and they contain a lag of semilitified intraclastes, which are eroded and transported from the neighbouring flats. They may also contain levee or point-bar gipsarenit facies and all of them may laterally migrate considerably.

3 – the supertidal zone contains the sabkha area with algal mats more frequently disturbed (mud-creek, intraclastes, chips) in which nodular sulphates may precipitate and that may be cemented with aragonite, high-magnesium calcite, microcrystalline dolomite, gypsum (lamina, pavements broken in intraclastes). The sabkha area is larger in the external side of the Badenian evaporitic basin.

The evolution of the sulphatic sedimentation (Fig. 5 and 6) is based on the interpretation of the litofacies, which are remarkably lateral continuity, fact which allows the correlation of different profiles and their integration into a typical succession which is described in Northern Carpathians Foredeep (Fig. 2). The megasequence from Valea Rea (Istriţa Hill) corresponds to the low part of this succession, and the one from Piatra Verde (Slănic) corresponds to the high part of the above mentioned section.

Valea Rea sedimentation started in partially isolated salinas, with nucleation centers on floor (clay or biolaminitic floor) of the glassy selenite gypsum, while in local pans, adiacent pools ellipsoidal gypsum nodules were developed in the same cianobacteria mats. The batimetry corresponds the shallow sea area and it is supposed to be under 10 metres, and the brine body was big, stable and with a long residence of salinity. The growth of glassy selenite twins is made in successive decimetric generations, whose continuity is interrupted (disturbance, crystallization, stoppage, dissolution, erosion, biolaminite intercalated) by halocline fluctuations produced by storms with fresh water influx. In the case of batimetry falls, more frequently (by means of sedimentology than eustatism or tectonic uplift) the vulnerability to climatic conditions increases, the salinity residence is reduced, the basin energy increases, the crystals become indistinct upward, with curved composition plans (Fig. 9).

The variation of sedimentation conditions, in the subtidal-intertidal range, determines the alternation of thin lithones (0,10-0,20 m) of dolomitic gypsified biolaminites, disturbed facies gipsarenites, accumulations of selenite intraclasts in the biolaminitic nodular gypsum lag. Coming back to the initial shallow sea batimetry of salinas starts with a debritic slope accumulation of reworked clastorudites which come from a previous shallow water setting, periodically salty (as mouse creek skeletal selenitic intraclasts or incipient nucleation cones). Floor crystallization of the skeletal gypsum starts at the concentration through evaporation of the brine body in the case of sensibly reduced batimetry and in the context of high basin energy. Crystals are rolled and they grow interwoven, pushing the organic-lutitic algal mats film to the exterior. For the same batimetry (several metres), but for low basin energy, the sabre-like selenite floor under air/water interface crystallization takes place. In this area too, the picnoclinas fluctuations (caused by fresh water) determine the appearance of impurity plans or biolaminite plans or dissolution/corosion plans, which separate decimetric or metric successive sabre-like selenite generations. The batimetric fall through basin filling determines the development of variable conditions under subtidal/intertidal settings. Thus biolaminite lithones, nodular gypsum that mimes ghost glassy gypsum twins, sabre-like gypsum nucleation cones appear. At short time after the deposition of nucleation cones, the tectonic instability changes the slopes causing gravitational slump and debris flows. As a result of these gravitational flows metric blocks with nucleation cones appear. The emphasis of the process will engage the whole selenite megasequence and even its carbonatic sea floor, marked by algal reefs in gravity flows. We must add that the anticline structure Valea Rea can be included in an external alignment of diapiric faults in the foredeep from southern side of Eastern Carpathians, with platform basement. So, Valea Rea selenite megasequence, very similar to the development in Southern Poland results from interconnected lagunas and salinas system of shallow batimetry to the stage of intertidal flat that appears in basinward foreland side. Then, through lowstand local mechanisms, caused by tectonic balances (uplift on shelf or subsidence toward the basin center) of slopes, the sulphatic megasequence is engaged in the form of blocks in the slope deposits wedge of foredeep basin (Fig. 7 and 8).

So, Valea Rea parasequences follow the evolution from a deep brine body, stable, with a long residence to the low batimetry body through sediment filling, with a climatic vulnerability. This sediment is characterized by thin lithones of variable composition, at top being represented by intertidal facies biolaminite. The batimetric fall with a lowstand effect which was the next stage, determines the destruction of the megasequence top and even the destruction of the whole succession of algal carbonatic basement.

Recommended for publication by Department of
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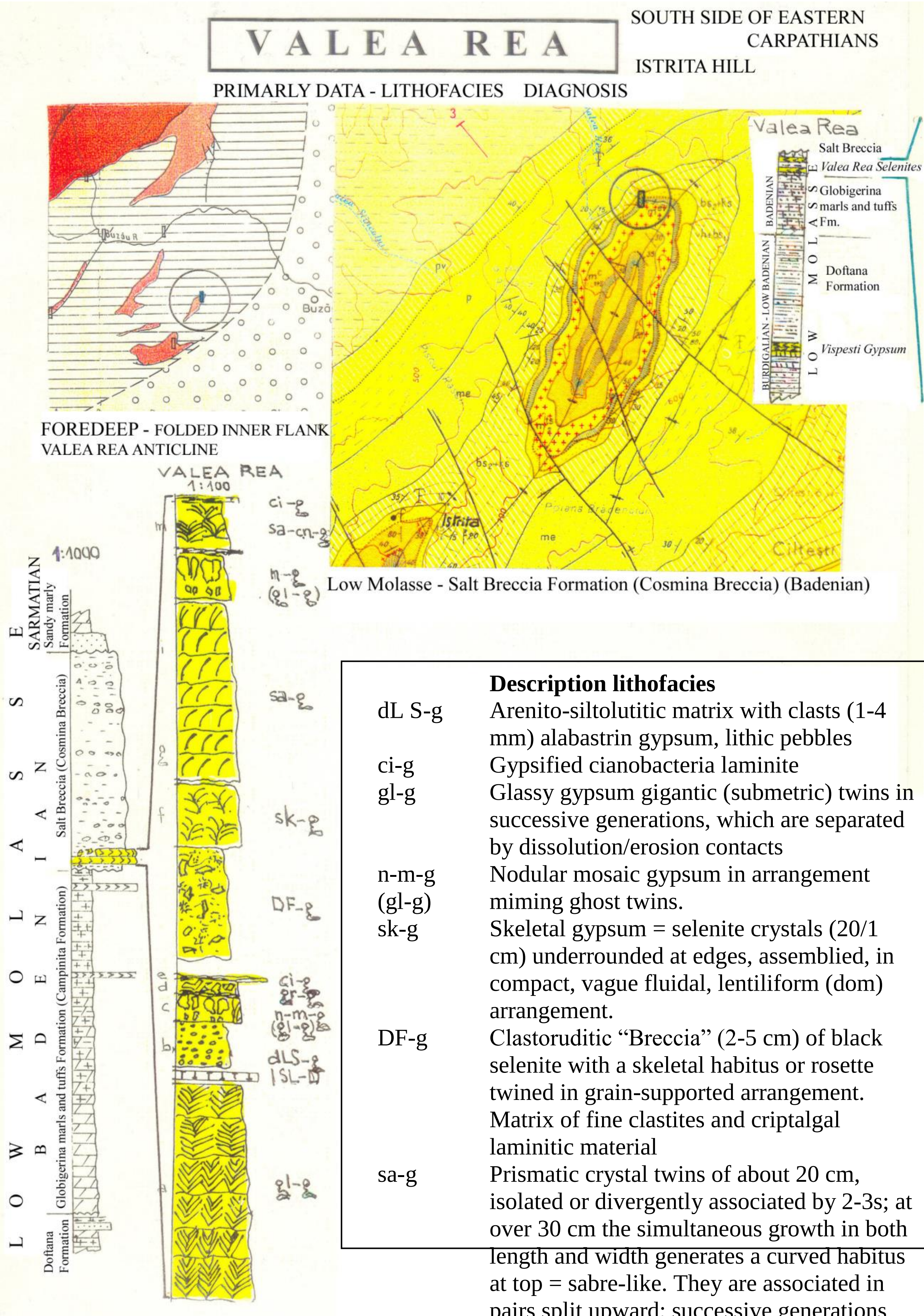



Fig. 1. Synthetic and detailed stratigraphic columns, with the notification of the identified litofacies

| | **Description lithofacies** |
|---|---|
| dL S-g | Arenito-siltolutitic matrix with clasts (1-4 mm) alabastrin gypsum, lithic pebbles |
| ci-g | Gypsified cianobacteria laminite |
| gl-g | Glassy gypsum gigantic (submetric) twins in successive generations, which are separated by dissolution/erosion contacts |
| n-m-g (gl-g) | Nodular mosaic gypsum in arrangement miming ghost twins. |
| sk-g | Skeletal gypsum = selenite crystals (20/1 cm) underrounded at edges, assemblied, in compact, vague fluidal, lentiliform (dom) arrangement. |
| DF-g | Clastoruditic “Breccia” (2-5 cm) of black selenite with a skeletal habitus or rosette twined in grain-supported arrangement. Matrix of fine clastites and criptalgal laminitic material |
| sa-g | Prismatic crystal twins of about 20 cm, isolated or divergently associated by 2-3s; at over 30 cm the simultaneous growth in both length and width generates a curved habitus at top = sabre-like. They are associated in pairs split upward; successive generations are separated by dissolution/erosion contacts. |
| sa-cn-g | Radial sabre-like gypsum arrangement as nucleation cone (10-40 cm) |

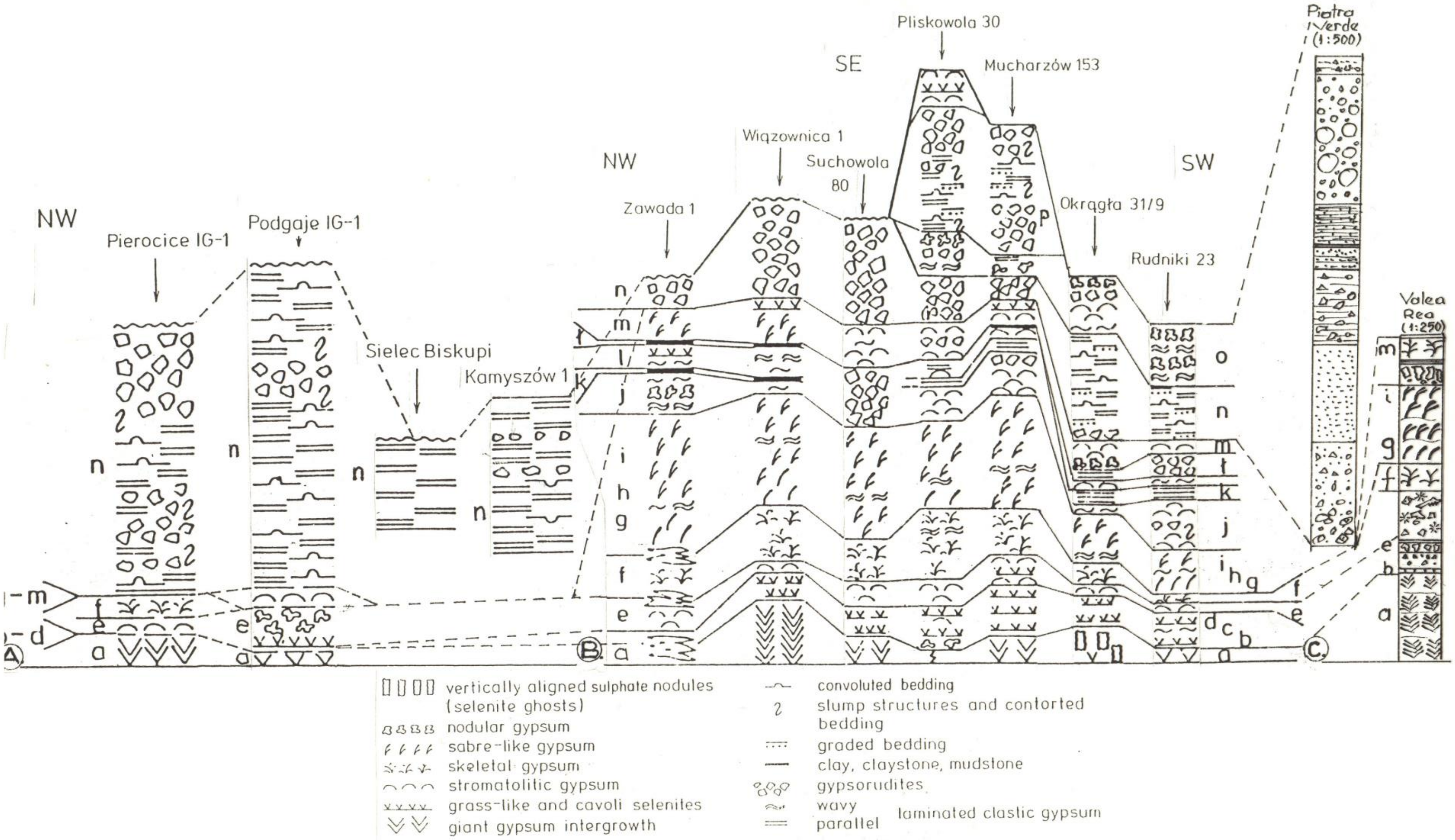



Fig. 2. Correlation between sedimentologic columns of Badenian gypsum from different sectors of Carpathian Foredeep. A. Northern Sector, central (Dziatoszyce trough –Poland); B. Northern Sector, exterior (South of Holy Cross); Southern sector of Eastern Carpathians (Piatra Verde inner side and Valea Rea – exterior side)

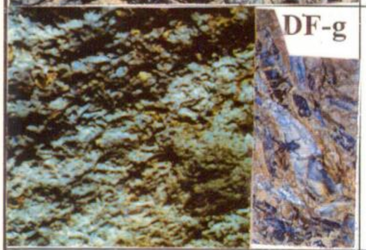
| VALEA REA | Description | Litofacies interpretation |
|---|---|---|
|  | Arenito-siltolutitic matrix with clasts (1-4 mm) alabastrin gypsum, lithic pebbles | Deposit of underwater/aeolian rework of algal mats (with sulphatic crust) in salinas, in the last filling stages with low batimetry and climatic vulnerability of salinity residence. |
|  | Gypsified cianobacteria laminite | Coastal plain setting which lies under flooding surface, affected by salinic fluctuations. |
|  | Glassy gypsum gigantic (submetric) twins in successive generations, which are separated by dissolution/erosion contacts | Floor basin precipitation with a reduced batimetry (<10 m), but a large brine body with long salinity residence. The halocline fluctuation determines growth perturbations or even dissolution and siliciclastic deposition. |
|  | Nodular mosaic gypsum in arrangement miming ghost twins. | Initial deposition of glassy selenite gypsum from large brine bodies that after being buried suffer a process of anhidritization through a chlorides hydroscopic effect (suprajacent, afterwards dissolved). Through rehidratation nodular habitus alabastrin gypsum appears. |
|  | Skeletal gypsum = selenite crystals (20/1 cm) underrounded at edges, assemblied, in compact, vague fluidal, lentiliform (dom) arrangement. | 1. Salinas floor precipitation, close to water/air interface; stable brines; high salinity; reduced batimetry; high energy. 2. Reworks: clastorudite of broken rounded selenite by the process of dissolution/erosion from previous environments |
|  | Clastoruditic "Breccia" (2-5 cm) of black selenite with a skeletal habitus or rosette twined in grain-supported arrangement. Matrix of fine clastites and criptalgal laminitic material | Debris-flow rework with a high batimetry setting (salinas slope) of the initial material, deposited at a low batimetry. The rosette forms can be incipient nucleation cones which are developed within algal laminites, wept and deposited as lowstand fan (tectonic-eustatic cause) |
|  | Prismatic crystal twins of about 20 cm, isolated or divergently associated by 2-3s; at over 30 cm the simultaneous growth in both length and width generates a curved habitus at top = sabre-like. They are associated in pairs split upward; successive generations are separated by dissolution/erosion contacts. | Sea floor precipitation under air/water interface from concentrated brines of batimetry that is low in comparison to the one of glassy gypsum (several metres). The halocline fluctuation determines dissolution at the top of one generation. At reduced batimetry by lake sediment filling climatic vulnerability of brine residence increases, and the crystallization is blurred. The high energy determines the top curving. |
|  | Radial sabre-like gypsum arrangement as nucleation cone (10-40 cm) | Growth settings of inconstant reduced batimetry and of fluctuant salinity: at refreshening –algal laminate, at concentration – nucleation cones. Resedimentation by slump/debris flow determines the piling of different oriented cones. |

**Fig. 3. Description and interpreting of sulphatic lithofacies from Valea Rea**

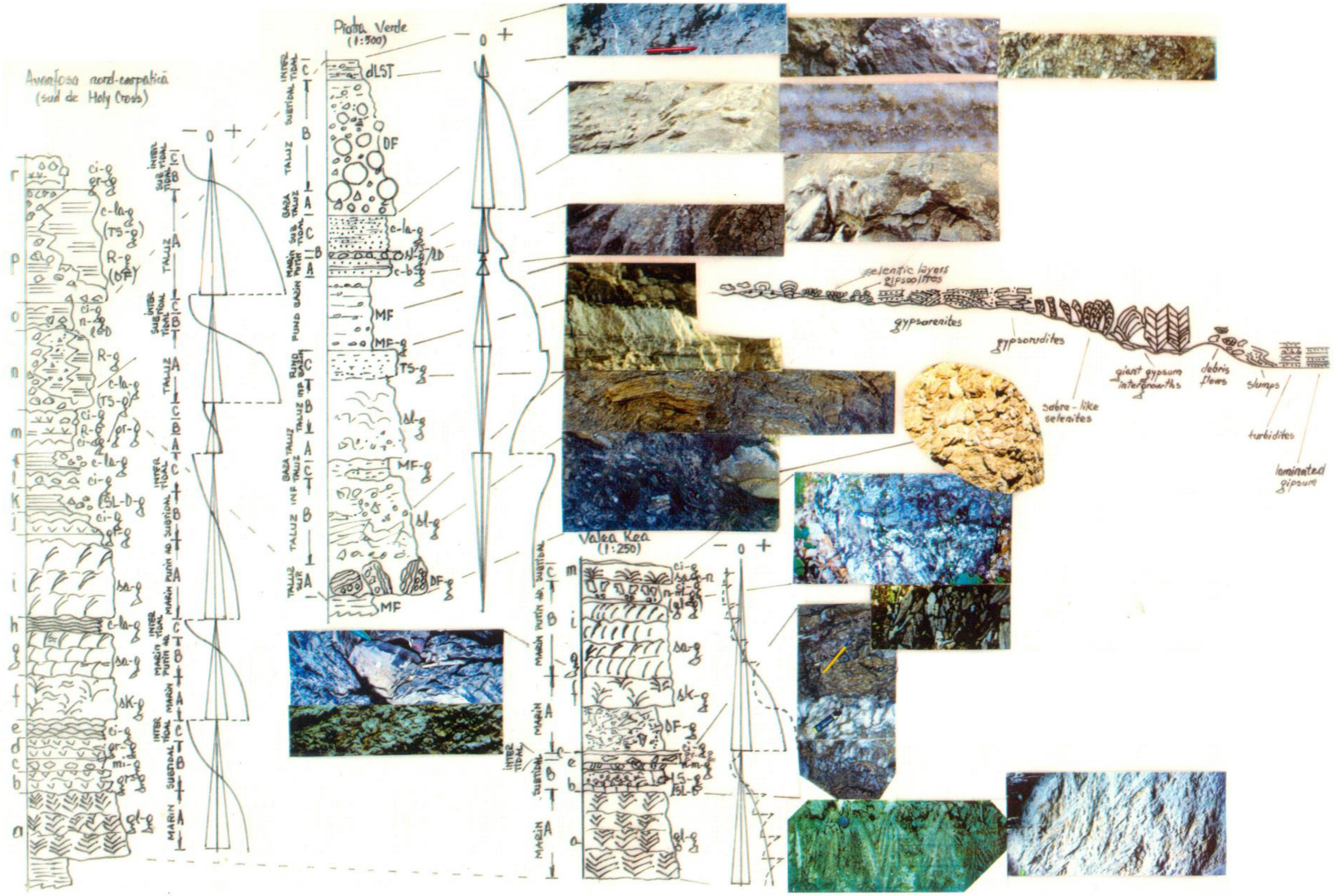



Fig. 4. Succession of facies. Typical Parasequences of Badenian gypsum and the depositional correspondent of component litofacies

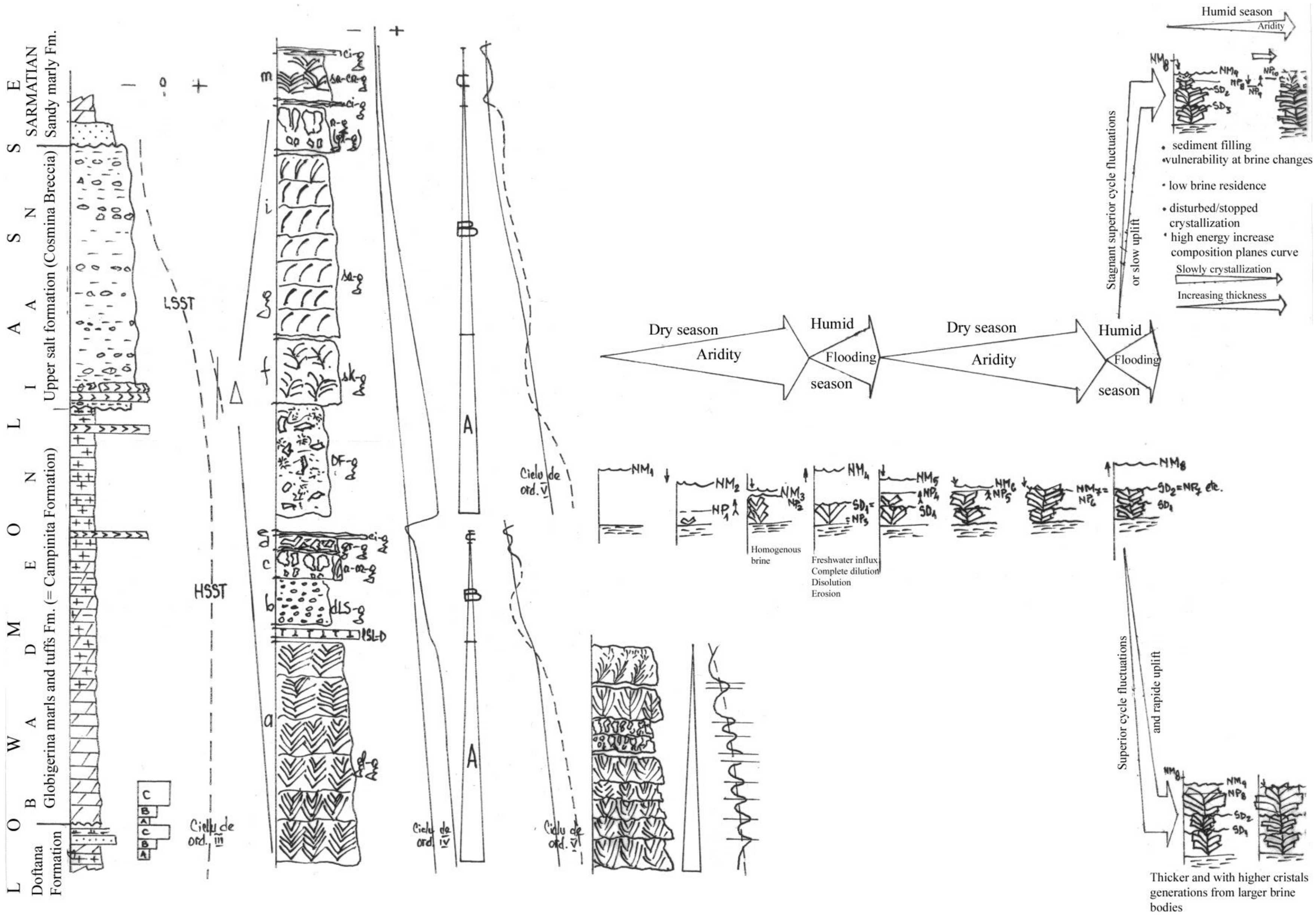



Fig. 5. The cycle hierarchy of a basin evaporitic environment of Salinas coastal type from Valea Rea Badenian

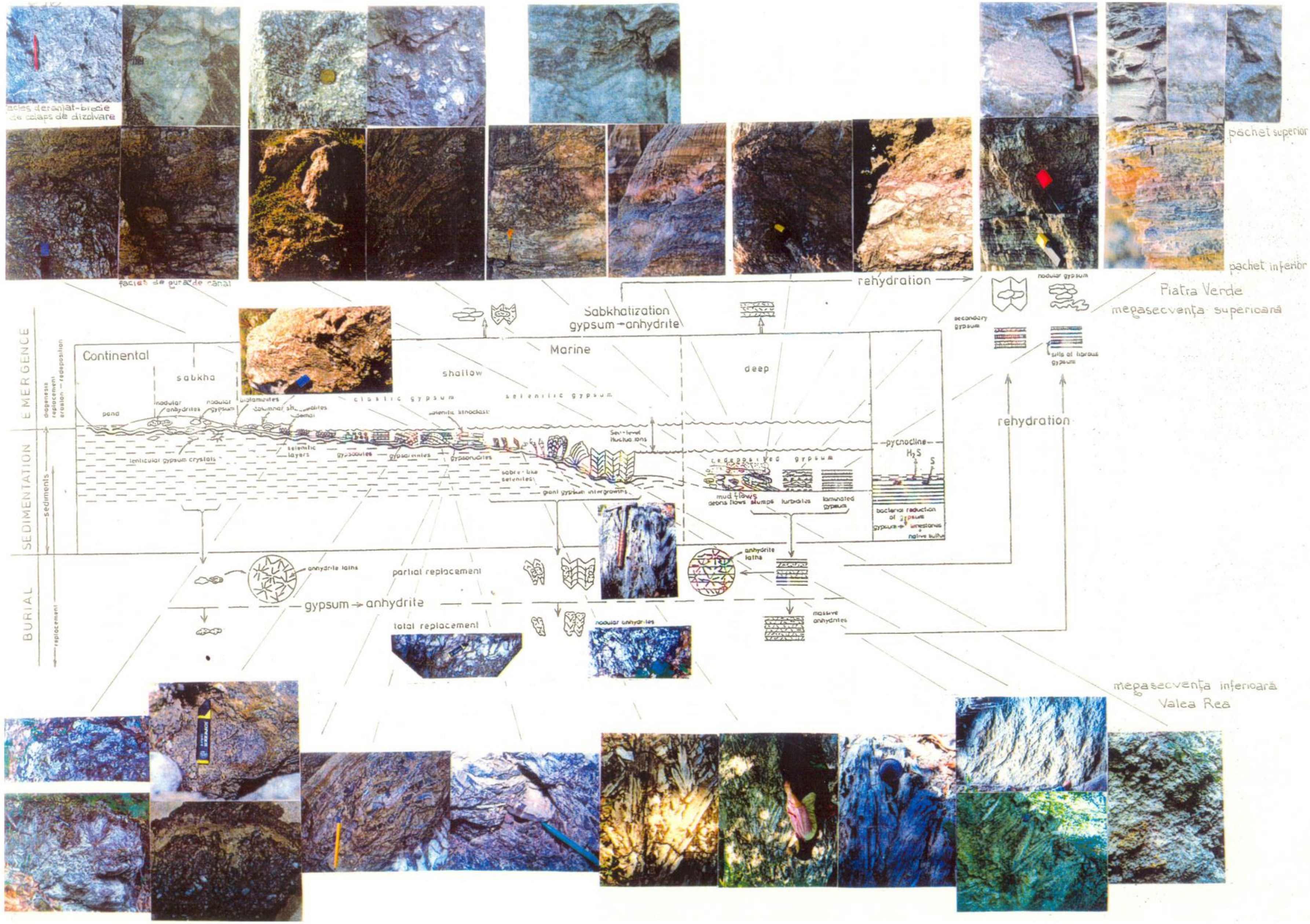



Fig. 6. Depositional settings and diagenetic changes of Badenian sulphatic sediment (up Piatra Verde, down Valea Rea).

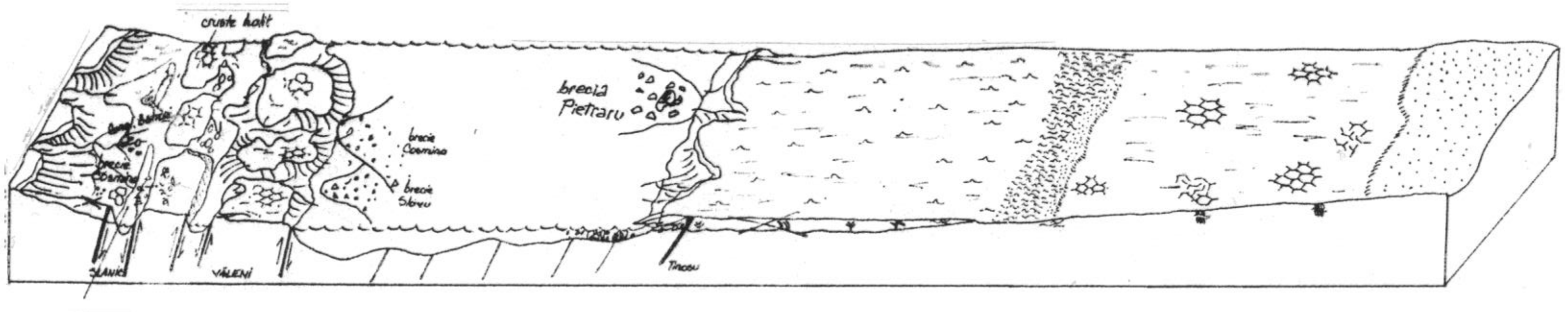



Fig. 7. Paleogeographic aspects of Badenian Foredeep basin

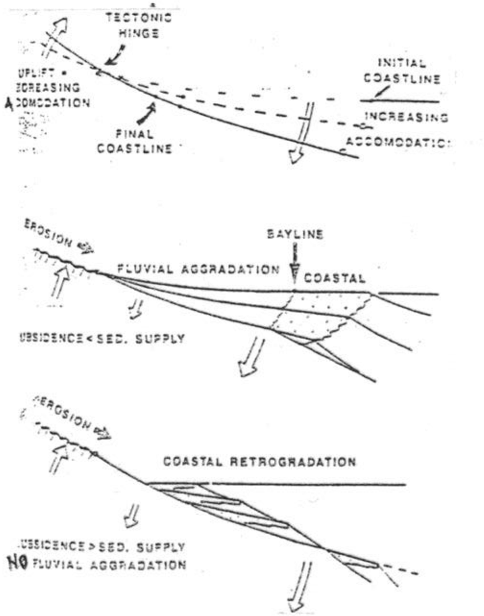



Fig. 8. Tectonic balance with erosion effect upward of tectonic hinge and lowstand accumulation at increasing batimetries in downward (with progradational stocking at slow subsidence and retrogradational stocking at rapid subsidence)

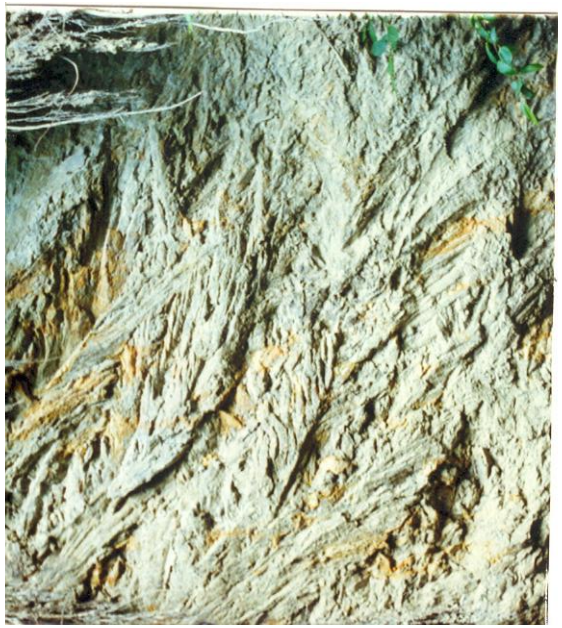


Fig. 9 .Bended assemblages under conditions of stream increase (curved assemblage plan surface); upward crystals become indistinct and disordered function of the growth of salinity variations)