
G. MURGOCI:

The Geological Synthesis of the South Carpathians

Extrait du Compte Rendu du XI:e Congrès Géologique International



The Geological Synthesis of the South Carpathians.

BY

G. MURGOCI,
Professor, Bukarest.

With one plate.

Contents: Character of the mountains and modern views. — Two groups of crystalline schists and their genesis. — The autochtone and overfolded mesozoicum; Sinaia schists; Tertiary layers. — Two critical moments of the folding: one cretaceous, the other miocene. The getic covering equivalent to UHLIG's "bukowinische" und "hochtatische Decke". — Root, frontal region, windows and remains of the getic covering. — Post-cretaceous folding in Banat; miocene overthrust in the Eastern Subcarpathians (ac. L. MRAZEC and I. POPESCU-VOITEȘTI). — The overfolding of S. and N. Carpathians and Alps; its origin in underthrust.

The South Carpathians consist of a great central zone, (a "Klippe" in the sense of UHLIG) formed by formations older than the meso-cretaceous, and surrounded, in the eastern part even covered up, by deposits beginning with the cenomanian and continuing through all the following ones down to the most recent.

The extension, from East to West, of this chain, also the bend southwards, towards the western Balkans, find their explanation in the direction of the ancient formations and foldings. The tertiary layers take only a small part in the constitution of the high mountain chain, viz. in the eastern part, eastwards of the Dâmbovița, where the central klippe descends and bends over to unite with another klippe, the Bistrița Mountains of the Eastern Carpathians. In the middle part (Oltu Valley and Hatzeg basin) the palæogene and neo-cretaceous sediments also take part, to a small extent, in the formation of the mountains.

In the rest of the South Carpathians the tertiary sediments fill up only ancient depressions and geosynclinals, or, being themselves slightly

folded, form a hill region round about the central klippe. Two important streams, the Danube and the Oltu, cut right through the South Carpathian chain, from one side to the other, and form valleys remarkable for their beauty and the range of problems which they afford.

As a result of the researches of L. MRAZEC and myself, and also of the able studies of Prof. F. SCHAFARZIK and other Hungarian and Servian geologists, on those parts of the Carpathians, which are included in their countries, I found myself forced, some six years ago, to adopt the hypothesis of the existence of a great overthrust in the central klippe of the South Carpathians. I have since then followed the problem with heightened interest, and last year I undertook a long series of excursions in the neighbouring countries, accompanied by my friend Professor F. SCHAFARZIK, and sometimes also by Professor S. RADOVANOVIC, Director L. v. LÓCZY and Director L. MRAZEC. The outcome of all our observations and discussions was to strengthen the case for my hypothesis and to throw much light on the remote past of the whole South Carpathians.

The researches on the tertiary formations published recently by I. POPESCU-VOITEȘTI¹ throw light on the tectonic of the sedimentary layers of the South and East Carpathians and complete the picture; accordingly, I am emboldened to lay before you a sketch of the geological synthesis of the South Carpathians, in connection with UHLIG's similar synthesis of the North Carpathians.

*

The eruptive rocks and the old crystalline schists of the South Carpathians are to be divided into two groups: Group I, which formed the core of the overthrust anticline, consists of highly crystalline schists in which the micaceous type of rocks predominates; as eruptive rocks belonging to this group, we may adduce Cozia gneiss, Cumpăna granite, Albești granite, diorite and peridotites, many veins of pegmatite, etc. According to the studies of the Bulgarian geologists this group is in the Balkan chain older than the silurian period.

¹ I. POPESCU-VOITEȘTI, Études stratigraphiques sur le Nummulitique de la Depression gétique. Anuarul Institutului Geologic. An. III. 2. 1910.

For less recent literature see my "Tertiarul Olteniei" in Anuarul Institutului Geologic, An. I, 1. 1907.

Group II, together with granite, gabbro and diorite, constitutes the basis, up to now considered as the autochtone, of the South Carpathians. The schists of this group are of the philito-chloritic type. Crystalline limestone, black graphitic schists, quartzite, etc. are found in both groups but sometimes with different facies.

The age of this second group of metamorphic schists is so far unknown; they may consist largely of palæozoic sediments of precarboniferous periods as has been shown by the Bulgarian geologists. Non-metamorphosed carboniferous sediments have been found lying directly on the schists of the autochtone at Secul and Eibenthal (BÖCKH), and even on the lower carboniferous at Poiana Preslopul (SCHAFARZIK). The Bulgarian geologists consider as carboniferous some anthracite- and coal-bearing sediments from Isker and West Balkans which have been taken in the Carpathians sometimes as permo-carboniferous, sometimes as lias (MRAZEC's Schela formation).

We can form now no idea of the character and extent of the hercynian foldings in this region; an intense denudation in permian and earlier times destroyed the palæozoic layers, eroded quite deep down and obliterated the folded mountains, sometimes right down to the granite core.

At the beginning of the palæozoic era I assume that there was in this region a wide geosynclinal accompanied by two anticlinal plications, one on each side. The western fold was of the diapiric type (MRAZEC), the eastern one of the normal type, being in fact a very wide geanticlinal. Igneous magmas were compressed and consolidated in these two folds, though in a different manner in each fold. In the diapiric fold the injection of magma and mineralisers along the lines of schistosity was greatly favoured by the structure of the fold; owing to the intense metamorphism thus arising, schists of well marked crystalline character took their origin, viz. Group I. In the big normal basin the direction of injection of magma and mineralisers was across the lines of schistosity, thus the schists of Group II took their origin. This explanation of the origin of the two groups of crystalline schists indicates a tendency towards a vertical movement of the masses of the South Carpathians in early palæozoic times; this would be also the commencement of the overfolding, occurring at a posterior date, of Group I and its mesozoic sediments, over Group II and its sediments.

The non-metamorphosed sedimentary covering of the autochtone schists is formed by layers similar to, and in general with the same facies as those of the overfolded anticline, viz. verrucano, with porphyric massives and tuff layers with schistous, sandy and conglomeratic facies; lias as sandstones, white arcoses, black and gray argillaceous schists; dogger as black sandstones and red fossiliferous limestones with intercalations of diabase and tuffs; titon-neocomie limestone and baremian marls up to urgo-aptian. This series is not complete everywhere; very often one or more substages or even a whole stage may fail.

The character of the layers in both series, in autochtone and covering, show us that in the South Carpathians there was only a single mesozoic covering which was folded and overthrust with its crystalline basis in the mesocretaceous times. The same fact has been stated recently by Dr. St. BONTSCHER¹ in East Serbia; in West Balkan he has described two independent overthrust folds. As a matter of fact in the South Carpathians we have to do, not with an overthrust only, but with an overfolding; for besides the fact that there is a well characterised frontal fold (*charnière frontale*), we can recognize the overturned median flank in many places such as Boletin and Dobra (Serbia), in the Cerna Valley, at the Iron Gates, in the Sarcu and Gugu Mountains, Lapusnic Valley, Mount Soarbele, in Petroșani basin, Lotru Valley, at Mount Fouqué, etc., then in Turcinu, Târnove and Repedea, etc.

In the overturned flank the mesozoic layers are sometimes very well developed, and they appear in all the windows above the titonic limestones in connection with lentiles and blocks of crystalline schists. As a rule these sediments are folded and dislocated in so complicated a way that it is very difficult to divide them into horizons and separate them from the autochtone layers. They contain numerous intrusions of diabase and more especially serpentine, which has metamorphosed the argillaceous strata very intensely. The so called Sinaia schists, marly or sandy, dark-coloured or black, occasionally purple or red, traversed by numerous veins of calcite, must be considered as the uppermost layers of the autochtone and overfolded covering. These schists have been attributed sometimes to neocomian or barremanian (UHLIG, POPOVICI-HATZEG), sometimes to senon and identified with Ropianka schists. In some places they are very similar to the dogger schists

¹ St. BONTSCHER, Die Leitlinien der geologischen Bau des westlichen Balkan. Sofia 1910.

and sometimes contain intrusions of diabase just like the dogger layers, so that some of them may be of the jurassic age and belong to the overturned flank.

These Sinaia schists are very well developed in the southern and eastern part of the central klippe; they take a good part in the constitution of the Eastern and Northern Carpathians, and according to the interpretation of UHLIG they form the foundation of the "bukovinische and tatriscche Decke" and even of the "pieninic" one. The upper cretaceous (meso- and neo-cretaceous) is so far unknown in the windows, and also in the autochtone of the South Carpathians. On the sedimentary layers of the root region of our overfolding, on the carapace and on the frontal fold, we find however the cenomanian lying transgressively with a littoral facies (in general cones of dejection), the senonian with a littoral and neritic facies, and the danian with a littoral and lacustrine facies as has been described by NOPCSA in the Hațeg basin. The neo-cretaceous is more frequent and appears as a continuous layer in the north and east of the South Carpathians. The inferior eocene is not known either here or elsewhere in the Carpathians, but the other horizons of the nummulitic lie transgressively either on the layer of the covering, or on the neo-cretaceous; they are restricted almost exclusively to the sedimentary covering of the east half of the klippe.

*

The neogene in an almost complete series surrounds the central klippe and covers both the ancient geosynclinals in the front of the covering and also the depressions of the central zone which, at an epoch anterior to the first Mediterranean Sea, were hollowed out right down to the autochtone and even as far as the basal granite. The palæogene and neogene of the Southern Carpathians have a different tectonic character in the getic depression from that of the Eastern Carpathians. In the getic depression there are only some small folds with several faults; in the eastern part POPESCU-VOITEȘTI has distinguished in the sedimentary layers an intense folding with several coverings¹; overthrust one over the other and all together overthrust over

¹ Recent investigations by L. MRAZEC and I. POPESCU-VOITEȘTI have shown only two chief coverings: one internal, the other marginal, with several scales; in the first 4, in the second 2 scales. Nouvelles données sur le flysch des Carpathes, Comptes rendus des séances de l'Institut géologique de la Roumanie III. 1912.

the miocene (salt formation) of the moldo-valachian Subcarpathians. Accordingly we must assume two important periods of folding in the past of the South Carpathians, the older ending with the inferior cretaceous; and the younger postcretaceous which continues up to the present. The phenomenon of overfolding in the central klippe is due to the first period of folding. The beginning of the process is lost in the night of the first geological periods; only an exhaustive study based on the law of HAUG, concerning the ingression and regression of seas (as has been tried by RADOVANOVIC) and on that general law concerning the displacement of the geosynclinal towards the vorland, can give us any information concerning the overfoldings in the remote past of the Carpathians. Some tectonical researches of S. BONTSCHEF in West Balkan throw light on the beginning of the overfolding and support my conjectures on this subject; there, in the West Balkan, we have the first step towards overfolding (l. c.).

According to the very instructive and evident facts, which the study of the tectonic of the neogene coverings of the Subcarpathians demonstrate, we must assume that the folding was continuous throughout all the past of the earth; it had begun already in precarboniferous times, it was continued sometimes with great, sometimes with very slight intensity, right up to the mescretaceous, when there is a critical moment, that of the overthrust, the sudden release of the pressure in the earth's crust.

Thus in the constitution of the central klippe of the South Carpathians we can distinguish only one single covering, which was overfolded and overthrust over the neocomian Sinaia schists in the mescretaceous times, it corresponds to UHLIG's "bukovinische Decke" of the Eastern Carpathians and the "hochtatische Decke" of the Northern Carpathians. However we shall call it *getic covering* ("getiche Decke"), as MRAZEC has named the mountains between Dâmbovita and Timok valleys "gêtic" chain.

Even if the "siebenbürgische Decke" (UHLIG), corresponding to the "subtatische Decke", has existed in the Eastern Carpathians, it certainly has not left its traces in the Southern Carpathians; perhaps we must look for its prolongation in the Western Mountains of Transsylvania, where UHLIG has shown already some indications of its existence, according to the investigation of LÓCZY, PAPP, etc.

In the autochtone of the South Carpathians, as well as in the overturned flank, we observe numerous scales, but it is not possible to individualise any one of them as a separate covering.

*

My most recent researches, confirmed by the ideas and observations of Prof. F. SCHAFARZIK, S. RADOVANOVIĆ etc., have done much to define the nature and extent of the overfolded covering (see the plate).

Peku Mountains and those of the West Banat, Poiana Rusca, Mount Sebes, and the Fagaras mountains constitute the root region of the covering. The Mountains of Bucegi and Leaota, of Cozia, of the Lotru, of Godianu, etc. constitute a country of overfolding. The Mountains of Mateiașu, of the Bistrița and the east part of the Mehedinți-Miroci plateau form the frontal region, covered by sedimentary deposits dating from the cenomanian to the most recent. Throughout the whole extent of the frontal region it rests on a thick layer of Sinaia schists. The rest of the South Carpathians form a window country, with remains of the overfolded covering between windows. The accompanying sections show clearly the character and extent of the overfolding.

The thickness of the overfolded anticline cannot be exactly determined; the mesozoic covering, alike of the carapace and of the autochtone, rarely exceeds 1000 m in thickness, so that, owing to the processes of overfolding and of crushing together of folds, the total thickness may attain 2000 m; where the Sinaia schists are crushed together, they may attain an even greater thickness, but in many places slipping and lamination has caused the flanks to be reduced to a few metres (for example West Orsova). Judging by the region Făgăras-Bucegi, we can assume that the old overturned fold must have had in its middle part a thickness of some 6 kilometres.

The folds which have continued to be formed in the klippe after this overfolding have modified very much the form, thickness and undulations of the old folds, which have been further changed, to some depth, by intense erosion especially in the cenomanian and the eocene. According to the nature of the rocks which constitute the conglomerates of these stages, and according to the rocks on which they lie, viz. the limestones of the carapace or the crystalline schists of Group I, it would appear that not, until the miocene, had the erosion reached

as far as the autochtone. At present, the overthrust covering is found in the Southern Carpathians only in the eastern part of the klippe, in the Lotru and Făgăras Mountains, where it persists, because the folds of the overthrust covering were almost vertical (as B. v. INKEY proved some time ago); in this way we can explain the fact that the central klippe of the Carpathians is so much reduced in width. In the western region we have large windows along a great bunch of anticlines, viz. Parîngu, Retezatu, Mount Bătrânu, which towards the south-west fits in between other anticlines and scales (Schuppen), viz. three in Mehedinți and five in the Krassoszőreny Mountains, etc. In the synclinals, fragments of overthrust remain invaded afterwards by miocene seas.

*

The movements of the klippe do not end with the phenomenon of overfolding in cretaceous times. All the sedimentary basins, from the cenomanian up to the sarmatic, are folded and dislocated, thus for example the basin of Rucăr, the basins Titești, Brezoi, Petroșani, Temeș, Bozovici and Bahna-Milanovaț, Liebkova and the other Servian ones. In some places, we can even see the overthrust of the crystalline over the miocene deposits, as for example at Bahna, Liebkova (Servia), etc. It must however be noted that while the basins to the west and south of the klippe have undergone a very slight folding or dislocation, those of the centre are much more disturbed (Brezoi-Titești); whilst the tertiary layers of the frontal regions are very much disturbed indeed.

The conclusions of I. POPESCU-VOITEȘTI based on the researches of MRAZEC and others give us a picture of the phenomenon, very complicated indeed, but very interesting. Here we have overfoldings in which we can distinguish three coverings of overthrust besides that of the conglomerates of Bucegi which rest on Sinaia schists. Overthrust and out-thrust are met with even in the youngest deposits, the levantine, which in the west of Oltenia is hardly bent. A period of intense folding is still obvious in pleistocene times.

As the palæogene and miocene deposits rest in some places on the crystalline schists of the overthrust covering, it is not to be wondered at, that in these intense movements the miocene of the interior basins should be overthrust by the crystalline schists as at Bahna, Liebkova, Brezoi and in the valley of the Argeș, etc.

It can be further shown in detail that, while the direction of the folds in east Muntania is with the overturned fold towards the south or east, the direction of those of west Oltenia and Banat is with the overturned fold towards the west. It is as if in miocene and pliocene times the Carpathians had undergone a torsion in the western region, but in a direction contrary to that once assumed by E. SUSS.

We come now to the tectonic of the eastern Subcarpathians. I. POPESCU-VOITEȘTI distinguishes a first covering formed by the layer of the Sinaia schists upon which lies Group I with the mesozoic of the frontal getic fold, and the conglomerates of Bucegi which lie progressively on the frontal region of that main fold. In the southern part, from underneath this covering (from the autochtone palæogene), there emerges the "marginal covering", equivalent to the sub-beskidic covering of UHLIG, this marginal covering being overthrust over the saliferous miocene (autochtone) of the Subcarpathians. A second internal covering of overthrust (Siriu and Fusaru) in intimate relationship with the layer of the schists of Sinaia, and corresponding to the "beskidic covering" of UHLIG, has slipped over the marginal covering. Finally, an other covering of overthrust, that of the senonian marls (similar to the silesian cretaceous covering of UHLIG), was forced to assert itself in Prakova valley. The critical moment of the tertiary overfolding occurred in the miocene after the mediterranean. The movements, which have continued in all their intensity right up to the levantine, have completely changed the aspect of this fold, in some places overthrusting the Fusaru covering over that of the senonian marls; but a great erosion has wiped out the frontal margin obscuring the relations between the different coverings.

According to the recent researches of ST. BONTSCHEF and S. RADOVANOVİČ in E. Servia, it is very probable that in the Southern part of the getic covering there is a tectonic, in the sedimentary (cretaceous and tertiary) layers, similar to that which has been described by L. MRAZEC and I. POPESCU-VOITEȘTI for the E. part of the getic covering.

*

The tectonic of the South Carpathians being as above described, the phenomenon of overfolding is the resultant of a movement which began in palæozoic times, continued almost without interruption through all the epochs right down to the present and which shows

two important critical periods, viz. in the meso-cretaceous and miocene, when the overfolding ends. Now about the cause and mechanism of this imposing phenomenon. The formation of the South Carpathians differs from that of the Alps and Northern Carpathians in the intensity of the phenomenon at the critical moments, and in the character and age of the coverings. It is assumed that the coverings of the Alps and the Northern Carpathians were brought "in situ" in miocene times; the Southern Carpathians are interesting scientifically as showing us how the movements to form mountains can be divided into two series: one older, the overthrust of the central klippe, precenomanian; another younger, the formation of sedimentary (cretaceous and tertiary) coverings of overthrust, in miocene. I do not wish to generalize on too large a scale, but still I think that if we look upon the Northern Carpathians and Alps in the light afforded by the Southern Carpathians, we shall arrive at conclusions, which hold for the formation of whole Alpine chains. We may look upon them as the resultant of all the movements which they have undergone; if we could distinguish every critical movement in their past, the phenomenon of overfolding would not appear so astonishing. Overfolding is an ordinary phenomenon of earth movements, and is part of the ordinary processes of the life of the earth.

It would be of interest to know, to what these movements in this part of the earth are due, what generates the energy which causes these movements?

The idea of E. SUSS à propos of Alpides is not only suggestive but full of genius: Alpides are plicated regions in compartments with a consolidated external boundary; the foldings of the upper carboniferous up to now are limited only to these spaces. If we consider the direction of the pressure which the fixed boundary exercises, which, being in intimate connection with the interior of the earth, is forced to take part in the contraction of the interior of the earth, thus movements of masses occurred inwards towards the centre. This phenomenon is called underthrust (*Unterschiebung*) by L. MRAZEC, and in the underthrust of the Russian plain, Dobrogea and Prebalkan we find the explanation of the overfolding of the Southern Carpathians, which has followed as the waves of a viscous substance over a body which is thrown in that substance (*poussé ou rappellé au vide*).

Discussion:

Le professeur **É. Haug** (Paris) rend hommage à l'œuvre considérable qui a déjà été réalisée dans les Carpathes roumaines sous l'impulsion du Professeur **MRAZEC** et de ses excellents collaborateurs, parmi lesquels **M. MURGOCI** tient une place si éminente. Dans la remarquable synthèse que celui-ci vient de nous présenter le difficile problème des relations tectoniques entre les Carpathes septentrionales et méridionales est en partie résolu, mais **M. HAUG** pense que des études sur le terrain sont encore nécessaires en Bukowine pour arriver à plus de précision dans la corrélation des nappes.

Professor **L. von Lóczy** (Budapest) findet die Schlüsse und auch die Ausführungen in der Verallgemeinerung verfrüht. **LÓCZY** hat eine Reihe von Daten aus dem Bihargebirge und dem Siebenbürgischen Erzgebirge vorgeführt, welche nicht im Einschlag stehen mit den schönen und fleissigen Arbeiten vom Herrn **MURGOCI**. Es müssen viele weitere Forschungen abgewartet werden, bis über die Tektonik der Ost- und Süd-Karpathen ein treues Bild entsteht.

M. Murgoci remarque, répondant à l'observation de **M. Lóczy**, que les faits ont été déjà pris en considération par **V. UHLIG** lequel pense que, dans cette partie de la Transylvanie, nous avons à faire à une nappe qu'il rapporte à la »subtatische Decke« et qu'il appelle la nappe transylvaine (siebenbürgische). Cette nappe s'est peut-être étendue jusqu'en Bukowine et Maramures, mais elle n'est pas venue jusque dans les Carpathes méridionales où nous avons seulement la nappe de Bukowine qu'on rapporte à la nappe haut-tatique.

