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TECTONOMETAMORPHIC AMALGAMATION: FIELD EVIDENCE FROM SOUTH BULGARIA

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ABSTRACT
The term "tectonometamorphic amalgamation" is proposed to designate a process of tectonometamorphic recycling when rocks and rock formations of different age and composition are tectonically mixed and metamorphically homogenized in such a manner that a new complex is formed, and the primary elements are recognized with difficulty. Several examples from South Bulgaria are discussed, and they concern both insertion of higher-grade metamorphics into a lower-grade metamorphic or a non-metamorphic cover or insertion of non-metamorphic cover beds into additionally sheared basement rocks. Large parts (Prerhodopian and/or Ograzhdenian Supergroup, Osogovo Formation, Lisets complex) of the Precambrian high-grade metamorphic basement in Bulgaria may be regarded as products of Cadomian recycling and tectonometamorphic amalgamation of pre-Cadomian and Cadomian metamorphic and igneous rocks.

INTRODUCTION

The term "amalgamation" is used in geology in terrane analysis, and "is defined as tectonic combination of two or more terranes into a single larger tectonic unit prior to their attachment to a craton" (definition by L. Parfenov, A. Khanchuk and W. Nokleberg). Another application of the term is used in modern sedimentology, – relative to merging of two or more beds (usually, turbidites) into a single bed.

The first and most popular meaning of the word implies the production of a single and more or less homogenous product from two or more clearly defined and essentially different initial components, as, e.g., in the case of obtaining a metal alloy of mercury.

Another most appropriate application of the term could concern cases when essentially initially different rocks or rock associations (complexes) are tectonically mixed, and due to strong deformations and metamorphism, reach a homogeneity that makes the recognition of the initial elements very difficult or even impossible. When molten and homogenized, such mixtures give birth to anatectic magmas. Even without reaching such a stage, the degree of homogenization might be sufficiently high thus allowing for the term "tectonometamorphic amalgamation" to be used.

Several cases of tectonometamorphic amalgamation have been observed in South Bulgaria. Although not covering the whole possible range of amalgamation phenomena they may serve as a source for a future classification. The principal cases may be related to: (1) insertion of higher-grade metamorphics into lower-grade metamorphics or non-metamorphic cover rocks that suffer a low-grade metamorphism together with the inserted diaphthorised high-grade rocks; (2) insertion of lower-grade metamorphics or initially non-metamorphic rocks and formations into sheared higher-grade metamorphics or sheared igneous rocks; (3) progressive metamorphism of thick shear zones or thrust zones; (4) polydeformational and polymetamorphic processes in high-grade complexes, with consecutive adding of new igneous material (as sill-like bodies, dykes, etc.), and a partial homogenization during subsequent deformations and metamorphism.

TECTONIC INSERTION OF HIGHER-GRADE ROCKS INTO A SEDIMENTARY COVER

Tectonic insertion of higher-grade (amphibolite facies) basement lenticular bodies into a sedimentary or volcano-sedimentary cover has been observed in a number of cases in South Bulgaria. They have been described with a different degree of detailization. The presence of coeval and later homogenization through deformational and metamorphic overprint gives the ground to designate some of these cases as tectonometamorphic amalgamation.

The tectonic insertion of basement inliers (*Fig. 1*) built up of diaphthorized mica gneisses, migmatites and amphibolites (Ograzhdenian Supergroup) into the covering (tectonic or primary depositional contact) diabases, tuffs and phyllites (Frolosh Formation) has been first described in the Vlahina Mountain, near the western edge of the Lisiya basement fragment (Zagorchev, 1974, 2001). Gneisses, migmatites and amphibolites have been transformed into greenschist-facies blastomylonites grading into chlorite-sericite schists and phyllonites. The resulting sericite-chlorite-actinolite phyllonites are often undistinguishable from the green schists and metadiabases of the Frolosh Formation. The deformational and metamorphic (greenschist facies syntectonic metamorphism) homogenization of the resulting complex (Lisiya strip of inliers) proceeded during multiphase folding. Several possible mechanisms of the insertion include the formation of first-phase anticline(s) near the edge of the fragment that have been consequently tightened and refolded. Another possible origin may be related to early Cadomian thrusting pre-dating or coeval with the greenschist-facies metamorphism of the Frolosh Formation.

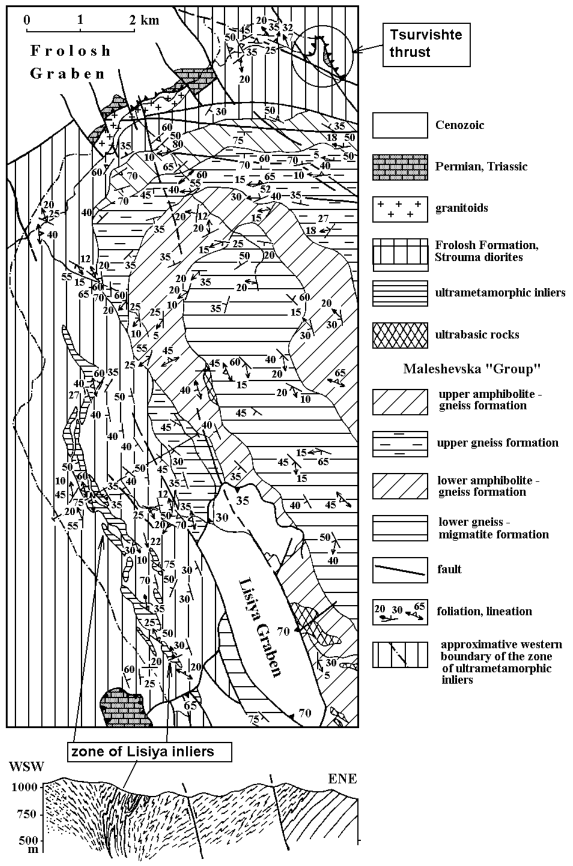

Figure 1. Zones of Cadomian? tectonometamorphic amalgamation (inliers) and of Alpine amalgamation of Triassic rocks into sheared Strouma diorites. After Zagorchev (1974)

The insertion of basement (Frolosh Formation, Strouma diorite formation) lenticular bodies of metadiabase, gabbro or diorite into the cover (with a primary depositional unconformable contact) of Permian and Triassic rocks (Skrino Formation, Gurbino Formation, Mogila Formation, Bosnek and Radomir Formation) has been described (Загорчев, 1984; Загорчев *et al*., 1999) along the Poletintsi-Skrino fold-thrust zone (*Fig*. 2) characterized with very high strains. Coeval or consequent amalgamation through high strains and greenschist facies metamorphism with chemical interchange of components and incipient or partial recrystallization has been recently observed, too.

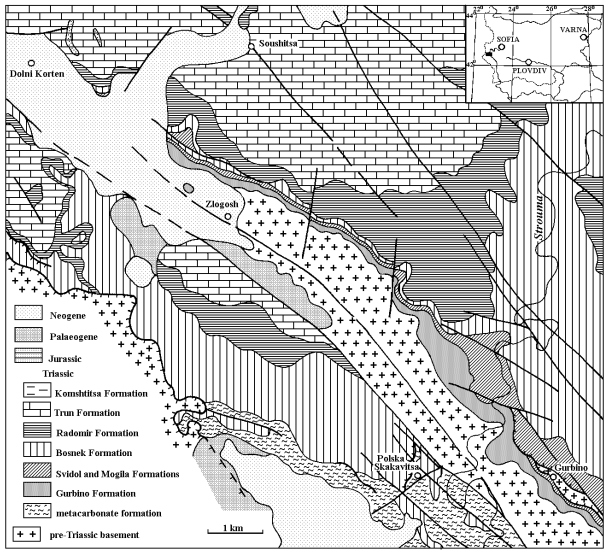

Figure 2. Insertion of basement rocks into the Triassic of Gurbino and Svidol Formation. After Загорчев et al. (1999)

TECTONIC INSERTION OF LOW-GRADE ROCKS INTO SHEARED HIGH-GRADE METAMORPHICS OR IGNEOUS ROCKS

A typical example of this phenomenon is the insertion of a series of lenticular Triassic rock bodies (red beds of Murvodol Formation, and limestones and dolomites of the Mogila and Bosnek Formation) along the thrust surface (Tsurvishte thrust) into sheared diorites of the Strouma diorite formation (*Fig. 1*). This event probably occurred when the lower south-western limb of a tight to isoclinal fold (Tsurvishte anticline) has been sheared and reduced into a series of lenses, and the core (built up of Strouma diorites) has been intensely sheared and thrusted (*Fig. 3*). The whole tectonometamorphic mixture has been syntectonically transformed into a greenschist – marble – phyllite-like sequence (Zagorchev, 1996).

Figure 3. Tsurvishte thrust in the road cutting near the village of Tsurvishte. Lenses of MiddleTriassic dolomites inserted into the Strouma diorites sheared and transformed into mylonites

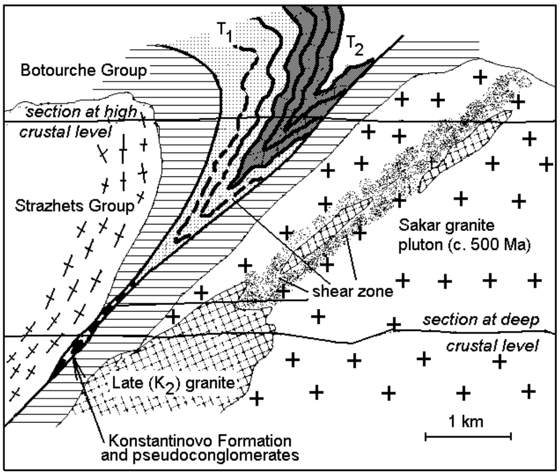

Figure 4. Lisovo syncline and shear zones in the southern slope of the Sakar Mountain. After Zagorchev (1994).

A similar case is the so-called Lisovo graben-syncline (or Konstantinovo shear zone) in the southern slope of Sakar Mountain (*Fig. 4*). A tight and pinched-in syncline is built up of Triassic metasedimentary rocks initially covering with a depositional contact the Precambrian complex (Кожухаров *et al.*, 1968). Intense Alpine synmetamorphic (amphibolite facies) shear transformed the Triassic carbonate-terrigenous sequence into garnet- and staurolite-bearing micaschists and amphibolites, their foliation becoming parallel to the reoriented foliation of the Precambrian metamorphics. Some geologists questioned the Precambrian age of the basement pretending that the whole sequence was conformable without taking into account the complex depositional and tectonic history. At deeper structural levels, the complex synmetamorphic shear led to formation of blastomylonites and pseudoconglomerates (Zagorchev, 1994) possibly partially formed at the expense also of a Palaeozoic Konstantinovo Formation (Кожухаров, 1991). Later Ivanov *et al.* (Иванов *et al.*, 2001) named the zone as "Konstantinovo shear zone" still not fully elucidating its origin, age and tectonometamorphic evolution.

PROGRESSIVE METAMORPHISM OF THICK SHEAR ZONES OR THRUST ZONES

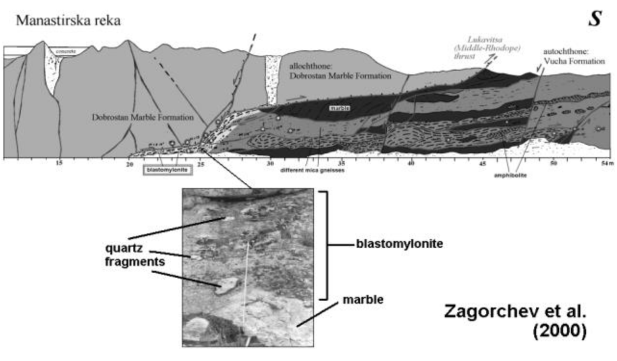

Figure 5. Blastomylonites in the zone of the Lakavitsa thrust

This mechanism is considered as a possibility based on observations in different localities of the Rhodope massif. Some of the major fault structures underwent a prolonged evolution, with several major events with different kinematics recorded. Thus, the West-Pirin fault belt is up to 2 – 3 km wide, and contains more than 10 – 12 individual fault zones (thrusts, upthrusts, wrench faults and normal faults) activated in Palaeogene, Neogene and Quaternary times. The related very low-grade to greenschist-facies mylonites obliterate the older structures of the basement, and have been locally considered by some inexperienced geologists as a normal progressive metamorphic sequence. In the Central Rhodope area, the low-grade to greenschist-facies mylonites along the Lakavitsa thrust (*Fig. 5*) have been formed at the expense of gneisses, marbles, amphibolites and foliation-parallel or oblique aplite and quartz veins during consecutive south-verging thrusting and later normal faulting (Zagorchev *et al.*, 2000). The purely tectonic amalgamation of these rocks induced some inexperienced geologists to consider them as sedimentary ones (conglomerates, sandstones, limestones), and even to seek (and "find") microfossils. In case such a blastomylonitic sequence would suffer a more intense metamorphic event, and the amalgamation would have a tectonometamorphic character, the resulting mixed and amalgamated rock could be considered as a completely new rock type (schist or metaconglomerate), and the origin and evolution of the whole sequence could be entirely misunderstood.

POLYDEFORMATIONAL AND POLYMETAMORPHIC PROCESSES IN HIGH-GRADE COMPLEXES

High-grade metamorphic complexes are usually characterized by a polydeformational and polymetamorphic evolution. Penetration of intrusive rocks (usually dykes) that belong to a later tectonomagmatic cycle or event may be followed by subsequent deformations common for host and intrusion that may efface any differences between the older and younger rocks thus forming a new amalgamation complex. This is the case of many high-grade polymetamorphic complexes, the classical examples coming from the Scottish Highlands, the Alps, and elsewhere.

Figure 6. Boudinage and shear of aplites and pegmatites in the Ograzhdenian Supergroup (Mikrevo, SW Bulgaria) later refolded and amalgamated into the complex

Stoyanov *et al.* (1997) observed such amalgamation of diorites, basic dykes and quartz porphyries in the eastern parts of the Republic of Macedonia, where later deformations and metamorphism transformed the complex into interlayering granite-gneisses and amphibolites.

Zagorchev (1976) reported different generations of igneous and metamorphic markers within the Ograzhdenian and Prerhodopian Supergroup in the Ograzhden unit and the Madan-Davidkovo dome. In both cases, the presence of markers and the lack of a complete homogenization allow for at least a partial recognition of the sequence of igneous and metamorphic events; thus, the amalgamation has not been completed. For example, aplites and pegmatites near the village of Mikrevo had intruded the folded tourmaline-bearing gneisses of the Ograzhdenian Supergroup, and were later transformed into leptitoid gneisses boudinaged and refolded together with the host rocks (*Fig. 6*) in Cadomian times. This is obviously not the case in the strongly sheared polymetamorphic and polydeformational pre-Cadomian Osogovo-Lisets gneisses intruded by the Cadomian Lisets granitoids: they have undergone together a profound tectonic and metamorphic homogenization.

AMALGAMATION ENVIRONMENTS

The geodynamic environments that can host tectonometamorphic amalgamation phenomena, may vary but are certainly mostly related to island arcs and subduction zones where high strains and shear are associated with increased geothermal gradient. Possible depths vary but the estimates are that the phenomena may be related to the whole range of greenschist to amphibolite facies conditions. Partial melting may usually accompany the process in lower amphibolite facies conditions. Amalgamation of docked terranes would certainly lead to tectonometamorphic amalgamation of their rock complexes within the suture zone, and intra- and intercontinental collision would also favor such phenomena. First indications for a tectonometamorphic amalgamation may be sought in the isotopic homogenization that finally reaches a "resetting of the isotopic clock" to the time of this reworking (Загорчев, Мурбат, 1986).

REFERENCES

Stojanov, R., Zagorchev, I., Dumurdzhanov, N., Aleksandrov, M. 1997. Palaeozoic correlations in the border areas of Macedonia and SW Bulgaria. - Boev, B., Serafimovski, T. (eds.) *Proceeding, Magmatism, metamorphism and metallogeny of the Vardar Zone and Serbo-Macedonian Massif,* Stip; 209-214.

Zagorcev, I. 1974. Ultrametamorphic inliers within the diabas-phyllitoid complex, Vlahina block, SW Bulgaria. - *C.-r- Acad. bulg. Sci.,* 27, 9; 1255-1258.

Zagorcev, I. 1976. Tectonic, metamorphic and magmatic markers in the polycyclic ultrametamorphic Ograzdenian complex. - *Geologica Balcanica*, 6, 2; 17-33.

Zagortchev, I. 1994. Alpine evolution of the pre-Alpine amphibolite-facies basement in South Bulgaria. – *Mitt. Oesterr. Geol. Ges*., 86 (1993); 9-21.

Zagorchev, I. 1996. Tectonic sites of special scientific importance (TSSSI) in Southwest Bulgaria. - *Geologica Balcanica,* 26, 2; 63-80.

Zagorchev, I., Katskov, N., Kozhoukharov, D., Kozhoukharova, E., Marinova, R. 2000. The Lukavitsa (Middle-Rhodope) thrust (Central Rhodope Mts., Bulgaria): facts, interpretations and ideas. – *Geological Conference, 11-13 October 2000, Sofia, Book of Abstracts*; 156-157.

Загорчев, И., С. Мурбат. 1986. Проблемы метаморфизма в Центральных Родопах в свете Rb-Sr изотопных данных. - *Geologica Balcanica*, 16, 6; 61-78.

Загорчев, И., А. Чаталов, Е. Трифонова, Е. Кожухарова, Е. Горанов, П. Пемов. 1999. Нови данни за триаската стратиграфия в Скакавишката антиклинала (Кюстендилско Крайще, Югозападна България). - *Спис. Бълг. геол. д-во,* 60, 1-3; 73-81.

Иванов, Ж., Герджиков, Я., Кунов, А. 2001. Нови данни и съображения за строежа и тектонската еволюция на Сакарската област. – Год. Соф. У-тет, Геол-геогр. фак., 91, кн. 1 – Геол.; 35-80.

Кожухаров, Д. 1991. Константиновская метаконгломератовая свита в Сакар планине и Марицской зоне между Симеоновград и Димитровград, Хасковская область. – *Geologica Balcanica*, 21, 4; 73-81.

Кожухаров, Д., Боянов, И., Савов, С. 1968. Геология на областта между с. Клокотница и р. Марица, Хасковско. – *Юбилеен геол. сборник*; 37-50.

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