On the age of Vitoša Pluton and some problems of Srednogorie Zone — a reply

The criticism and contra-interpretations by G o č e v (1988) concern several important and differing aspects of the problem. On the one hand, Gočev accepts the new facts and makes some attempts to adapt accordingly his own concepts; on the other, he is atacking some interpretations of mine, and is accusing me in "re-discovering of some well-known facts". Both the criticism and the new interpretations are very contradictory thus requiring a detailed answer.

I wish to emphasize again that the short (6 pages) communication of Z a g o r č e v & M o o r b a t h (1987) aimed to supply some new radiogeochronological information obtained by a method not applied to that moment; that the petrological and geological background of the neointrusions was necessarily not discussed, a detailed look upon them being given by B o y a d g i e v (1979); that the interpretations of more general character I made (Fig. 4; p. 47) aimed simply to show how the new data may eventually fit to an already existing model. I am grateful to Dr. Gočev for this opportunity to make clearer our viewpoints.

1. Vitoša Pluton — geological and petrologic problems

As demonstrated by Д и м и т р о в (1942) and later specified by other authors, Vitoša Pluton is built up at least from 3 separate intrusive phases: 1) gabbros; 2) monzonites and leucosyenites (the latter initially considered as a separate phase); 3) vein leucogranosyenites. I wish not to enter in a description of the shape of the intrusive body and its constituents a detailed description by Ž e l e v (1988) being now in print in the same journal.

The age of the Pluton is considered as post-andesitic, the monzonites cross-cutting the Senonian andesites of the Srednogorie Zone and having a contact effect (uralitization) upon the latter (Д и м и т р о в, 1942, 1951). The age of the andesites has been considered for a long time as Maastrichtian, and consequently, the age of Vitoša Pluton (including the first, gabbroic phase) and of the other Srednogorian neointrusives, as Laramide (Danian—Paleocene) (cf. Д и м и т р о в, 1942).

G o č e v (1988) is right about the omission by me in Z a g o r č e v & M o o r b a t h (1987) of two or three important references concerning the age of the volcanic activity in the Srednogorie Zone. Thus Г о ч е в et al. (1970) were the first to plead for a probable Campanian — Lower Maastrichtian age of the volcanism in the Western Srednogorie, and they reported a volcanic activity (tuffaceous sandstones) also in he Lower Turonian of the same region. D i m i t r o v a et al. (1981) defined a volcanogenic-sedimentary geocomplex with proven Lower Senonian (Coniacian—Campanian) age covered by a "regressive limestone-clay-sandstone geocomplex" of Maastrichtian age. However, the authors cited by me in Z a g o r č e v & M o o r b a t h (1987) were the first to refute the Laramide age of the Srednogorian neointrusives, Vitoša Pluton included, and to refer volcanics, gabbros, monzonites and other intrusive rocks to a single Upper Cretaceous (Lower Senonian) volcano-plutonic association. Members of this association were intruded or extruded in several phases but mostly before the Maastrichtian. This new concept has not been accepted as fast and unanimously as G o č e v (1988) now pretends. Thus Г о ч е в et al. (1970, Fig. 1, pp. 297, 298) wrote that "Vitoša Pluton is a fissure-core intrusion emplaced into a syncline after the Laramide folding"; Г о ч е в (1973, pp. 132, 136) concluded that the pluton "should be considered as an accordant core intrusion synorogenic to the Laramide tectonic phase yet post-kinematic to the main structure process". B o y a d g i e v (1979) also supported the view for a Laramide age of the Srednogorian neointrusions, and outlined the following phases in the development of the Srednogorie (p. 84): "extension with initial prolonged subsidence accompanied by synchronous polycyclic rupturally predestined volcanism; Laramide inversion with compression and partial intrusion of neoplutons; new uplift with compression. . . and penetration of aschystic magma. . . which determined also the recurrency of the dyke formation". Only later (Б о я д ж и е в, 1981) the same author admitted a "Late Subhercynian age. . . between 80.5 and 72.5 Ma". D i m i t r o v a et al. (1981) already considered the regressive geocomplex which covered the neointrusives also, as Maastrichtian, and the neointrusives themselves, as Late Campanian. However, G o č e v (Г о ч е в, 1983, p. 13, 14) described Plana Pluton as synkinematic in respect to the Subhercynian Golo-Bârdo Thrust, and Vitoša Pluton, as post-nappe and "postkinematic to the Upper Senonian deformation in the end of the Campanian or in the beginning of the Maastrichtian (Resen phase?) which led to a general change in the tectonic regime in the Western Srednogorie". Ž e l e v (1988) considered that all Ca-alkaline volcanic and intrusive rocks are a part of a Vitoša palaeo-volcano of Coniacian — Santonian age, and the late K-alkaline volcanics and dykes are bound to another (Campanian) tectonomagmatic stage. These are in brief the main points in the evolution of the ideas about the age of Vitoša Pluton and its surrounding.

2. Radiogeochronological data

The re-interpretations of G o č e v (1988) are provoking also a new look upon the existing radiogeochronological evidence.

Most of the data have been obtained by K-Ar method on biotite, K-feldspar, hornblende and whole-rock samples (Б о я д ж и е в, 1981). It should be noted that they represent mainly cooling ages for the corresponding mineral and reflect the time of cooling under the threshold temperature (about 300°C for biotite);

therefore they are minimum ages for the intrusion itself. They cannot be treated statistically together because of different threshold temperatures for the different minerals studied, and capture of radiogenic argon by minerals (except for hornblende) as Бояджиев (1981) suggested, is doubtful. Бояджиев (1981) even treated statistically together data obtained by different laboratories using different constants (unfortunately, not cited in his article), and obtained a "reliable Late Subhercynian age" of ca. 75.4 Ma the separate plutons and phases being intruded in the time span 80.5—72.5 Ma. However, dates by G. P. Bagdasarian, L. L. Shanin and M. M. Arakeliants cited by the same author include K-Ar ages on biotite of 84 Ma (Vitoša Pluton; equal to previously obtained age by Boyadgiev&Lilov, 1981, recalculated to 85.3 Ma in Zagorčev & Moorbath, 1987), 75 Ma (Plana Pluton) and 79 Ma (Elšica—Bošulja Pluton). It should be emphasized that samples from innermost parts of a given pluton would yield younger cooling ages; therefore, the date of ca. 85 Ma should be considered as a reliable cooling age for Vitoša Pluton. These data have been also confirmed by Мончев & Друбецкой (1987) who obtained K-Ar dates on biotite within the range 78—83 Ma, and on K-feldspar, between 69 and 79 Ma. Dates on hornblende obtained by the same authors are between 84 and 94 Ma and may be due to excess argon.

Data obtained by Pb-He method cannot be used in modern geology (as Gočev, 1988, did) this method being proven as unreliable during the last 30 years.

Rb-Sr whole-rock isochron data supply new important evidence. Unfortunately, data cited by Zagorčev & Moorbath (1987) have been arbitrarily interpreted by Gočev (1988) thus requiring some additional explanations. In the meantime, preliminary information on Rb-Sr studies appeared in Реферативный журнал (April issue of 1987), and P. Mončev (Geochemical Laboratories of the Committee of Geology, Sofia) was kind to supply to me his data (unpublished Ph. D. Thesis; Leningrad, 1986; Institute for Geology and Geochronology of the Precambrian) not included in the short communication of Амелин et al. (1986). Both in the thesis of Mončev and in Амелин et al. (1986) a single isochron of 79±2 Ma and initial $^{87}Sr/^{86}Sr$ ratio of 0.7046 has been calculated on all samples from the pluton: 1 gabbro of the first phase (with very low $^{87}Rb/^{86}Sr$ ratio but with comparatively high $^{87}Sr/^{86}Sr=0.7048$); 6 monzonite samples; 1 syenite, aplitoid granite, 1 pegmatite. I recalculated all data in different combinations (Table 1), and it turned out

Table 1

Compararison of Rb-Sr whole-rock studies

Phase of the pluton	Number of samples	Age, Ma	$(^{87}Sr/^{86}Sr)_0$	Source
Monzonitic (+syenites)	8	91±10	0.7042	Zagorčev, Moorbath
	7	92±8	0.7043	Mončev
Monzonitic and leucogranosyenitic (incl. pegmatite)	11	84±5	0.70435	Zagorčev, Moorbath
	10	79±2	0.7046	Amelin et al.; Mončev
Leucogranosyenitic (incl. aplite-granites and pegmatites)	6	79±6	0.7043	Zagorčev, Moorbath; Mončev

that results of both laboratories are almost coinciding (within analytical error). The single gabbro sample has been excluded from computation by obvious reasons; if included, its higher $^{87}Sr/^{86}Sr$ ratio is incompatible with the lower $^{87}Sr/^{86}Sr$ initial ratio computed on the basis of all other samples. The isochron on all whole-rock samples of Амелин et al. (1986) is strongly influenced by a single aplite-granite sample with a very high $^{87}Rb/^{86}Sr$ ratio. Therefore, the age calculated by these authors coincides with the age calculated only on the isochron from the late phase (leucogranosyenites, aplite-granites, pegmatites etc.). The following conclusions may be drawn on this stage of research:

The age of the monzonitic phase is determined within very broad confidence limits (2σ). The limit (beginning of Cenomanian) is geologically unrealistic. The geologically realistic (Dimitrova et al., 1981) time interval for the intrusion of the monzonitic phase is Coniacian—San onian, and the probable cooling time is given by the K-Ar date on biotite: 85 Ma. However, having in mind the Rb-Sr data for this phase, a more precise field work on the contacts with faunistically determined formations is needed (possible Turonian age of the intrusion?).

The age of the last (leucogranosyenitic) phase of the pluton is probably Campanian. Therefore, the radiogeochronological evidence favours the idea about a single volcano-plutonic complex and the time of intrusion and cooling of the monzonitic and leucogranosyenitic phases lasted for about 10 Ma. The study of the interrelations between the different sedimentation, volcanic, intrusive and tectonic events is a complex task, and it cannot be solved by isolated radiogeochronological results.

3. Plate-tectonics ideas and interpretations

The criticism of Gočev (1988) on the illustrated by Zagorčev (in Zagorčev & Moorbath, 1987) model of Boccaletti et al. (1974, 1978) for the Late Cretaceous geodynamic environment in the Srednogorie Zone is based upon some very broad but not sufficiently proven ideas about possible Subhercynian and/or Laramide "charriages" and "retrocharriages" in the Rhodope Region, and on the idea (Гочев, 1983) about a pre-nappe or synchronous to the Golo-bârdo Thrust intrusion of Plana Pluton, a post-nappe intrusion of Vitoša Pluton.

A new fact obtained by the Rb-Sr isotopic studies is the very low (0.7042 after Zagorčev & Moorbath, 1987; 0.7046 according to Амелин et al., 1986) initial $(^{87}Sr/^{86}Sr)_0$ ratio for the Vitoša Pluton, and for the monzonitic phase. As far as I am informed, this is the lowest such ratio for a given rock complex or pluton on the Balkan Peninsula. Pb isotopic data for K-feldspars from all phases, and He isotopic data for the hornblende from the gabbroic phase (Амелин et al., 1986) are also in favour of the opinion that the primary magma of Vitoša Pluton derived from a mantle source, and had been further subjected to differentiation, crustal contamination and fractionation at different level. In my interpretation this fact is combined with 1) the model of Boccaletti et al. (1974, 1978) taking into account also Myiashiro (1971), Myiashiro et al. (1979) and other authors; 2) the petrological evidence (e. g. Boyadgiev, 1979; Želev, 1988); and 3) data for the Late Cretaceous granitoid (with quartz-monzonite tendency) activity in the western part of the Rhodopes (Загорчев et al., 1987) which possess high (0.710—0.712) initial $(^{87}Sr/^{86}Sr)$ ratios. The Late Cretaceous intrusive igneous activity in the Western Rhodopes was evidently of a crustal origin, primary magmas being formed by anatexis of Rhodopian-type metamorphics (Zagorčev & Moorbath, 1987, Fig. 3) in the beginning of the Late Cretaceous (see also Загорчев & Мурбат, 1986). If we agree as Boyanov et al. (1987) and Gočev (1988) do that the principal Alpine tectonic mechanism in SE Europe was related to a subduction along the NE margin of Vardar Zone under the Rhodope Region, it should be accepted that in the time of the Late Cretaceous magma generation the actual crustal thickness distribution already existed, i. e. a crustal thickening in the Rhodope Region vs. a crustal thinning in the Srednogorie (see Zagorčev & Moorbath, 1987, p. 47, Fig. 4, and their Russian abstract). Surprisingly, Gočev (1988) is accusing me in the opposite (crustal thinning in the Rhodopes and crustal thickening in the Srednogorie) which proves only how superficially he read the 6 pages of the criticized article.

The argument whether the Late Cretaceous volcanic island arc was situated in the Srednogorie (Boccaletti et al., 1974, 1978) or in the Rhodopes (Gočev, 1988) has an academic and phraseological character. Thus in the full text of Boyanov et al. (the abstract — Boyanov et al., 1987, is cited by Gočev, 1988 in support of his idea) is written, that the origin of the Srednogorie Zone is still not well understood: "three main groups of hypotheses have been proposed: a volcanic island arc in combination with back-arc rifting (Boccaletti et al., 1974, 1978; . . .) in geodynamic relations to subduction of Vardar oceanic crust under the Rhodopes; an inter-arc trough (Nachev, 1978. . .) likewise genetically related to Vardar Zone; a continental rift (Bončev, 1976, 1978; Гочев, 1979; Boyadgiev, 1979; Dabovski, 1980; Popov, 1981)". In the same paper it is suggested that the Late Cretaceous granitoids in Pirin and West Rhodopes "may be relics of another, deeply eroded Late Cretaceous volcanic arc". It should be said that Boyadgiev (1979) also wrote that "the magmatism. . . shows also the features of island-arc type", and that "in geodynamic respect this magmatism is probably related to a posterior activization of the Vardar Zone". It is well-known that in the southern margin of Srednogorie Zone (northern margin of Rhodope Region and Ljubaš monocline) the Upper Cretaceous is represented in a carbonate facies and is avolcanic, and in the Rhodope Region itself the Upper Cretaceous granitoid activity is related to several centers and is only intrusive. Therefore I believe that it is more logical to look for a volcanic island arc (combined with back-arc rifting) in the rich in volcanics Srednogorie Zone until Gočev (1988) is looking for it in the devoid of Cretaceous volcanics continental crust of the Central and Western Rhodopes.

* * *

Late Cretaceous processes in the Srednogorie Zone have been evidently so complex that attempts to incorporate them into the rigid frame of a desired plate-tectonic scheme would lead to an impoverishment of our knowledge. Therefore I noted in Zagorčev & Moorbath (1987) that new isotopic data are compatible with the known model of Boccaletti et al. (1974, 1978) introducing interesting new elements about possible mantle generation of the primary magma, about Late Cretaceous crustal thickness distribution, and that they refute the still not outlived ideas about a Laramide age. These considerations are fully supported by the results of Амелин et al. (1986) unknown to us at that time, and giving both Rb-Sr, Pb and He^3/He^4 isotopic data. It is also evident that both studies contained new evidence and a new look upon some tectonic problems which has been noted in the introduction of Gočev (1988) and has nothing in common with his final accusations for incompetent "sample gathering for isotopic or other radiometric analyses" or for "re-discovering of known facts".

References

Boyanov, I., Dabovski, C., Gočev, P., Harkovska, A., Kostadinov, V., Shanov, S., Tzankov, T., Zagorčev, I. 1987. A new view on the Alpine tectonic evolution of Bulgaria. — In: *Geology and physical geography of the Rhodope Massif*, First Bulg.-Greek Symp., Kliment Ohridski University Press, Sofia; 32-33.

Dimitrova, E., Ganeva, N., Jolkičev, N., Milanova, J., Nachev, I. 1981. Upper Cretaceous stratigraphy in Western Srednogorie. — *Geol. Balc.*, *11*, 1; 51-66.

Gočev, P. 1988. On the age of Vitoša Pluton and some problems of the Srednogorie — a remark. — *Geol. Balc.*, *18*, (in press).

Zagorčev, I., Moorbath, S. 1987. Rubidium-strontium isotopic data for Vitoša Pluton, Srednogorie Zone. — *Geol. Balc.*, *17*, 6; 43-48.

Želev, V. 1988. Vitoša central-magmatic structure. — *Geol. Balc.*, *18*, 5.

Амелин, Ю. В., Друбецкой, Е. Р., Мончев, П., Неймарк, Л. А., Овчинникова, Г. В., Левский, Л. К. 1986. Генезис Витошского плутона (НРБ) по изотопным данным. — В: *11 Всесоюзн. симп. по геохим. изотопам, М.*, 1—3 дек. 1986 (цит. по *Реферативный журнал*, Москва, 1987, № 4; 4 В 128).

Гочев, П. 1973. Структура на Витошкия плутон. — *Изв. Геол. инст., Сер. геотект.*, *21—22*; 105—136.

Гочев, П. 1983. Субхерцински алохтон в Западното Средногорие. — *Геотект., тектонофиз. и геодинам.*, *15*; 3—16.

Гочев, П., Костадинов, В., Матова, М., Велинов, И. 1970. Структура на южната ивица на западното Средногорие. — *Сп. Бълг. геол. д-во*, *31*, 3; 289—301.

Дабовски, Хр. 1974. Микроструктурни изследвания във Витошкия плутон. — *Изв. Геол. инст., Сер. геотект.*, *23*; 141—164.

Димитров, Стр. 1951. Върху уралитизацията и нейното значение като показател за контактната метаморфоза в Средногорската еруптивна област. — *Изв. Геол. геогр. и хим. инст. БАН, 1* (В: Димитров, С. 1961. *Научни трудове, т. 2*; Изд. БАН, София; 292—312).

Мончев, П. Б., Друбецкой, Е. Р. 1987. Возраст Витошского плутона по данным K-Ar метода. — В: *Геохронология и геохимия изотопов*, Л., Наука; 77—85.

Ivan Zagorčev
Geological Institute of the Bulgarian Academy of Sciences
1113 Sofia