Variscan Granitoid Magma Generation Processes in the Greater Caucasus Collisional Orogen

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Introduction

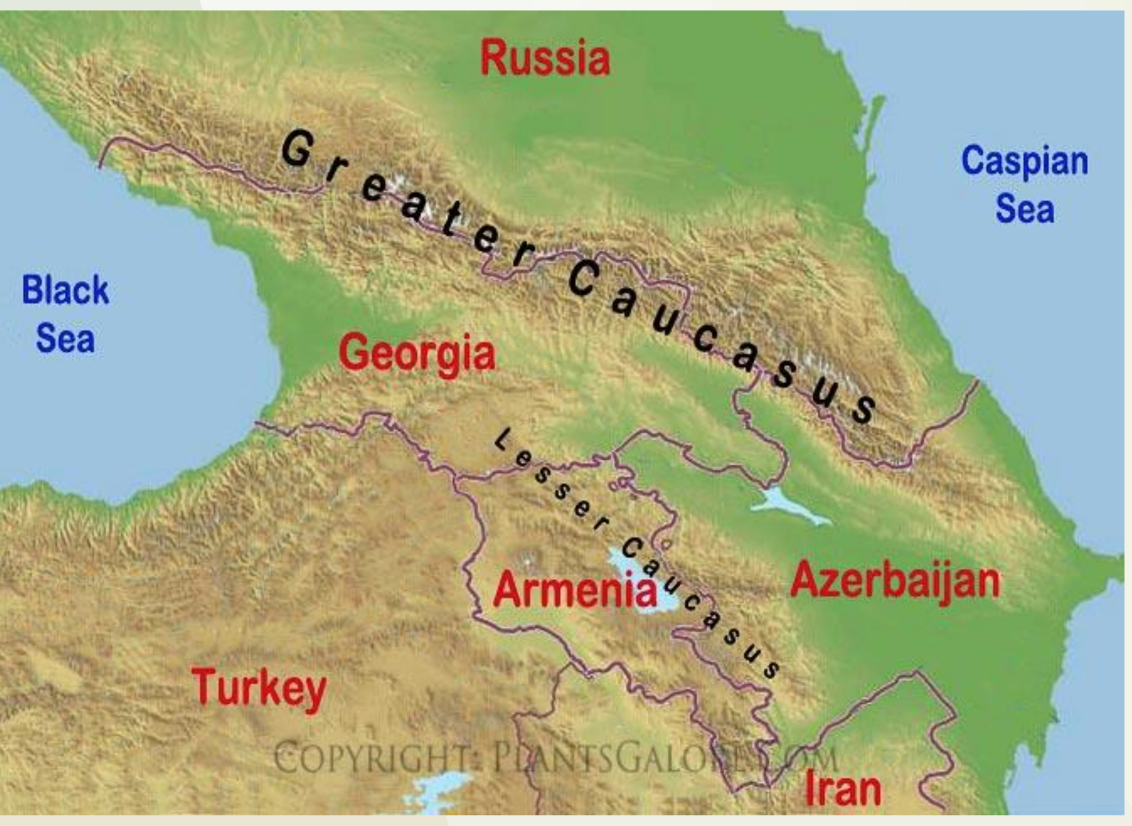

Fig.1. Schematic map of Caucasus

The Greater Caucasus represents a Phanerozoic collisional orogen formed along the Euro-Asian North continental margin and stretches on 1200 km, from the Black to the Caspian seas (Fig.1). Currently, it is an expression of continental collision between the Arabian and Eurasian lithospheric plates. Two major stages are distinguished in its construction: Pre-Alpine crystalline basement and Alpine volcanic-sedimentary cover. Crystalline basement complex (200 km x 40 km) is mainly constructed of Precambrian and Paleozoic crystalline schist, amphibolites, gneisses, migmatites and granitoids .

Tectonic Settings

Paleomagnetic and geological data indicate that within the oceanic area of Tethys, which separated Afro-Arabian and Eurasian continental plates, there were relatively small continental or subcontinental plates (terranes) having various geodynamic and geological histories (Gamkrelidze 1997; Somin 2007; Stampfli et al. 2002; Roumer et al. 2003). During the Neoproterozoic, Paleozoic and Early Mesozoic, these terranes underwent horizontal displacement within the oceanic area of Proto-, Paleo- and Meso-Tethys, followed by accretion and, ultimately, merging with the Eurasian continent. The Arabian and Eurasian lithospheric plates are separated by the Greater Caucasian, Black Sea-Central Transcaucasian, Baibut-Sevanian and Iranian-Afghan terranes (Gamkrelidze 1997) that in geological past represented island arcs or microcontinents (Fig. 2).

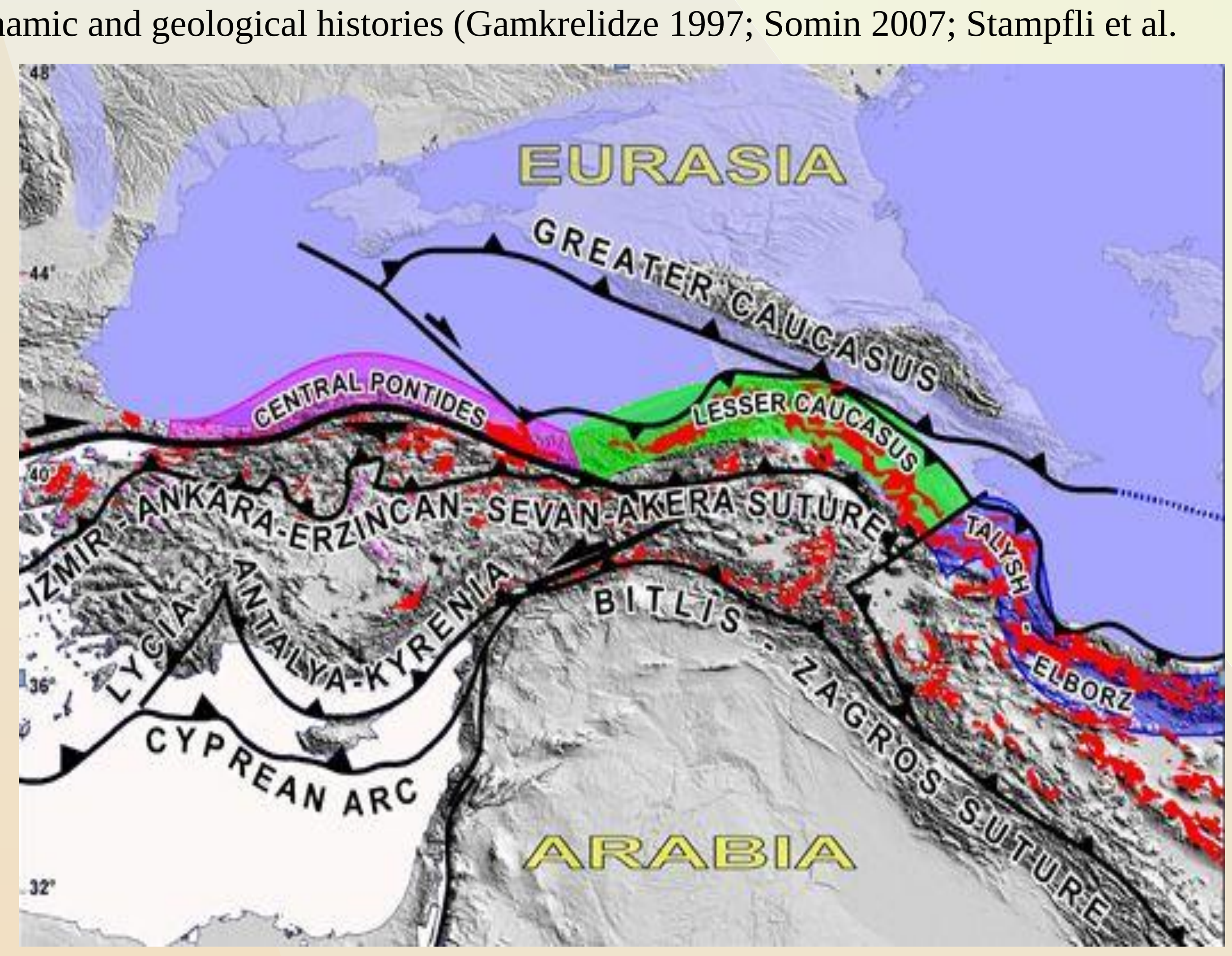

Fig.2. Scematic tectonic map of the Eastern Mediterranean

Field Relations & Petrography

The Variscan orogenic plutonic magmatism has played significant role in the formation of the Greater Caucasian crystalline basement complex. Field and petrographic investigations indicate that plutonic magmatism is represented by different types localized in distinct tectonostructural zones, or terranes. Four plutonic series (from the South to the North) have been distinguished: 1. gabbroplagiogneiss, 2. diorite-adamellite, 3. plagiogranite-granite, and 4. granodiorite-alaskite.

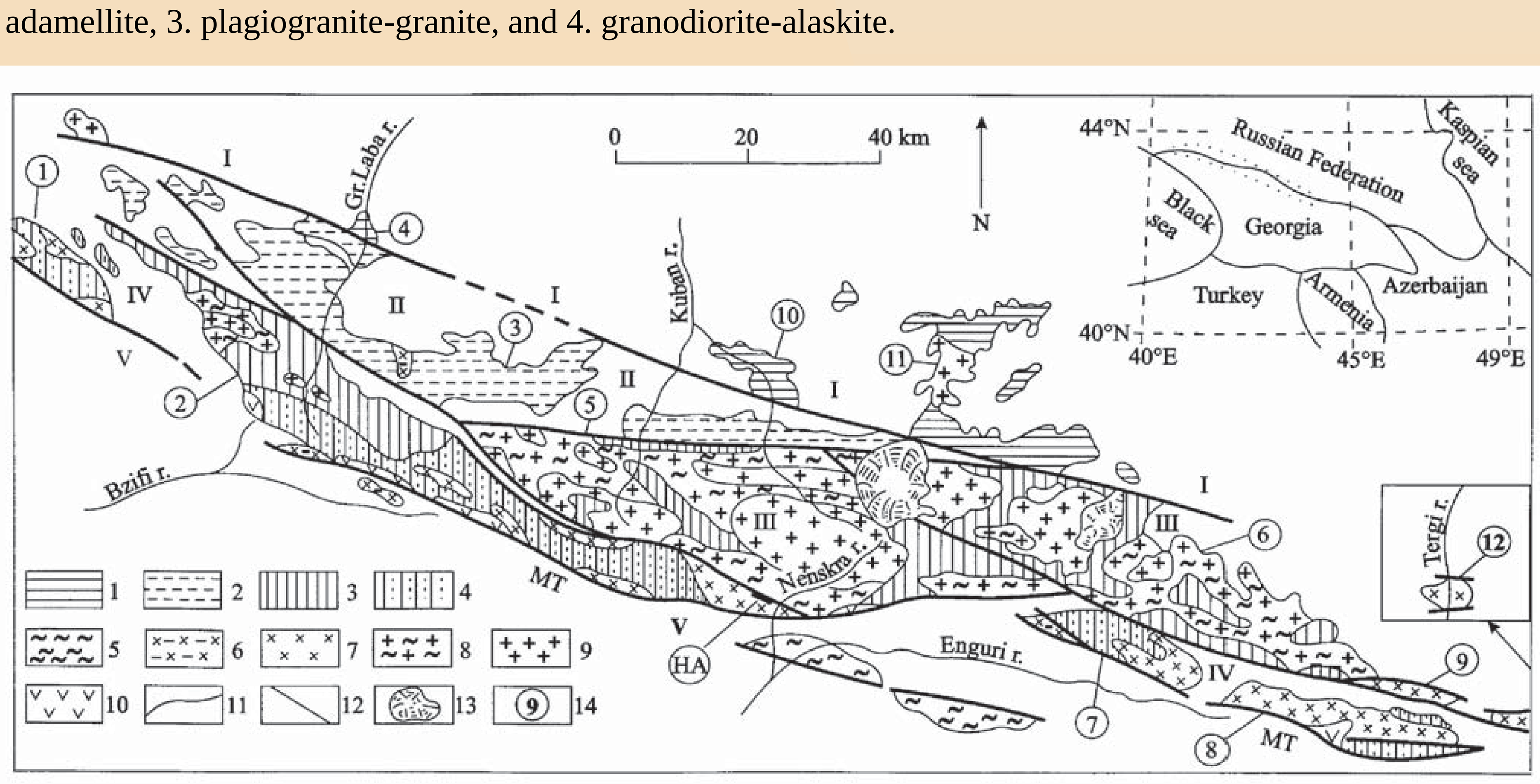

Fig.3. Schematic geological map of the crystalline basement of the Greater Caucasus and its geographical position (marked dotted line). Structural zones: I. Bechasyn; II. Front Range; III. Elbrus Subzone of Main Range; IV. Pass subzone of Main Range; V. Southern Slope. Conditional mean of exposes: 1 – Bechasyn zone; 2 – Front Range zone; 3 – Elbrus subzone of Main Range; 4 – Pass subzone of Main Range; 5. Sothern Slope zone; Variscan plutonic series (6-9): 6. Gabbro-plagiogneiss, 7. Diorite-adamellite, 8. Plagiogranite-granite, 9. Granodiorite- alaskite, 10. Middle Jurassic granitoid intrusive, 11. Stratigraphic and magmatic boundary, 12. Fold systems (MT -main trust); 13. Glaciers, 14. Number in the circle-the main tectonic uplifts: 1. Chugushi, 2. Sofia, 3- Blibi, 4. Beskes, 5. Teberda, 6. Digori, 7. Shkhara, 8. Adaikhokh, 9.Unal, Kuban, 11. Kislovodsk, 12. Dariali. (The Dariali tectonic uplift transfers from East); HA- Hokrila-Achapara (Sakeni) goldfield

Petrochemistry

Petrochemistry was based on various method investigations of magmatic system. The method gives an opportunity of systematization of great number of chemical and petrochemical data and, at the same time, shows graphically their variation tendencies. Chemical analysis are divided into I, II, III, IV and V groups of acidity, where I<57,00% $_{SiO_2;}$ II=57,00- 61,99% $_{SiO_2;}$ $^{III=62,00-67,99\%}$ $_{SiO_2;}$ IV=68,00-75,00% SiO_2; V>75,00% SiO_2 (Velikoslavinsky et al. 1994). For each oxygen group chemical and petrochemical parameters (Tables 1, 2) are calculated as average statistic data.

Gr	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	CaO	MgO	K_2O	Na_2O	N
Gabbro-Plagiogneiss series											
I	50.47	0.68	16.57	3.70	6.52	0.17	7.88	6.50	1.02	3.16	15
II	59.5	0.42	15.69	3.48	3.68	0.11	6.28	4.84	0.75	3.74	25
III	65.3	0.32	15.41	2.39	3.12	0.1	4.00	2.25	0.66	3.76	30
IV	71.33	0.25	14.03	1.15	2.14	0.06	2.70	1.13	0.81	4.03	35
V	77.28	0.11	12.94	0.42	0.65	0.03	1.78	0.60	0.39	4.85	20
Diorite-adamellite series											
I	52.87	0.92	16.93	3.56	4.87	0.17	7.60	5.43	1.66	3.16	17
II	60.02	0.67	17.35	3.29	4.60	0.12	5.60	2.39	1.97	2.77	30
III	64.6	0.58	16.55	2.33	3.26	0.14	3.86	1.96	3.09	3.43	38
IV	71.09	0.30	15.28	1.29	1.40	0.07	1.89	0.86	3.57	3.65	47
Plagiogranites of Plagiogranite-granite series											
III	65.05	0.74	16.14	1.60	3.29	0.11	3.32	2.09	2.06	3.25	12
IV	72.18	0.30	14.71	0.73	1.72	0.07	2.12	0.95	1.48	4.25	35
V	75.56	0.18	13.48	1.13	0.05	1.34	0.90	1.35	1.35	4.07	25
Granites of Plagiogranite-granite series											
III	66.06	0.58	16.30	1.81	2.12	0.06	2.10	1.51	4.92	3.01	20
IV	70.70	0.32	15.01	1.06	1.18	0.05	1.67	0.81	5.2	3.27	45
V	75.95	0.05	12.77	0.27	0.77	0.03	0.57	0.43	5.92	2.6	25
Granodiorite-alaskite series											
III	67.55	0.61	15.66	1.66	2.54	0.07	2.59	1.50	2.81	3.58	8
IV	71.85	0.25	14.97	0.87	1.22	0.04	1.21	0.65	4.55	3.48	120
V	75.75	0.15	13.14	0.67	0.77	0.02	0.79	0.51	2.87	3.80	7
Late Caledonian granite-gneisses											
II	60.53	0.60	17.81	2.17	3.77	2.24	3.12	2.98	2.92	2.78	5
III	65.53	0.70	16.38	1.87	2.99	0.12	1.72	2.18	3.27	3.36	15
IV	70.94	0.45	15.49	1.12	2.02	0.06	1.32	1.16	3.83	3.55	15

Table 1: *The average chemical analyses (mass %) of Variscan plutonic series and Late Caledonian granite-gneisses of the Greater Caucasus, according to acidity groups (N-amount of analysis)*

Gr	A	F	M	CaAl	SiAl	R1	R2	A/CNK	K	f	N
Gabbro-Plagiogneiss series											
I	17.3	52.6	30.01	29.5	79.5	19.78	14.86	0.81	11.5	53.5	15
II	22.2	49.6	28.01	27.3	82.4	22.64	12.14	0.85	10.4	49.8	23
III	35.7	43.5	20.8	22.5	89.8	26.00	8.36	1.04	9.6	56.7	42
IV	59.2	29.6	11.2	19.6	94.3	27.14	6.16	1.09	10.2	55	34
V	76.5	14.1	9.4	17.7	96.6	29.49	4.60	1.1	4.8	52.2	30
Diorite-adamellite series											
I	27.3	51.6	21.1	28.7	81.5	17.80	14.10	0.82	35.5	46.5	22
II	37.3	44.2	28.5	27.5	87	22.12	10.61	1.04	38.3	57.5	35
III	47.6	38.2	14.8	24.9	90.4	23.22	8.28	1.04	34.7	64.1	44
IV	57.8	31.6	10.6	21.5	94	25.30	5.38	1.12	45.4	67.3	54
Plagiogranites of Plagiogranite-granite series											
III	42.7	40.6	16.7	23.7	89.1	25.14	7.74	1.20	29.5	52.4	57
IV	59.3	25.5	15.2	20.2	94.5	27.90	5.56	1.20	20	68.5	79
V	68.4	20.3	11.3	18.1	96.5	29.44	3.20	1.29	19.1	52.7	27
Granites of Plagiogranite-granite series											
III	57.6	31.6	10.8	20.6	94.0	23.06	6.14	1.16	46.6	62.5	42
IV	78.4	15.3	6.3	19.5	96.5	26.38	5.42	1.11	52.3	60.5	63
V	87.6	9.4	3.0	17.21	98.7	27.50	3.54	1.11	63.0	66.5	47
Granodiorite-alaskite series											
III	58.1	30.8	10.1	22.0	93.11	24.51	6.74	1.12	37	60.6	42
IV	70.2	21.5	8.7	20.2	96.5	25.12	4.98	1.19	38.3	67.5	49
V	76.6	26.2	7.2	16.8	97.6	28.87	3.64	1.20	34.2	53.3	22
Late Caledonian granite-gneisses											
II	37.9	43.6	18.5	38.8	58.7	25.5	88.1	27.9	37.5	34.6	35
III	47.6	37.4	15.0	37.1	58.7	22.7	91.7	25.7	34.6	39.7	20
IV	62.3	27.2	10.5	38.0	59.0	21.1	95.2	24.0	36.4	39.6	15

Table 2: *The average petrochemical parameters according to acidity groups of Variscan plutonic series and Late Caledonian granite-gneisses of the Greater Caucasus (N-amount of analysis)*

Diagram-model represents (Mg-Fe)O-CaO-2Al_2O_3- SiO_2 tetrad projection (Fig. 3) and gives an opportunity to discuss according to a single diagram the fractioning of multi-component magma systems. It is known that on a TiO_2-(TiO_2+FeO) diagram co-magmatic rocks are distributed on a straight line, and hybrid and metasomatic rocks are distributed on unstraight line (Evrard 1947). This conformity is greatly revealed in the Greater Caucasus variscan plutonic series and represents good criteria for their genetic separation. Analyzing Fig. 3, it is evident, that different plutonic series start forming in different magmatic sources. Gabbroplagiogneiss represents magmatic system which is formed in the area rich in aluminous and femic elements and they trend to eutectic zone. Diorite- adamellite series is also formed in the area rich with these elements, but in their formation the processes of assimilation and hybridization was important.

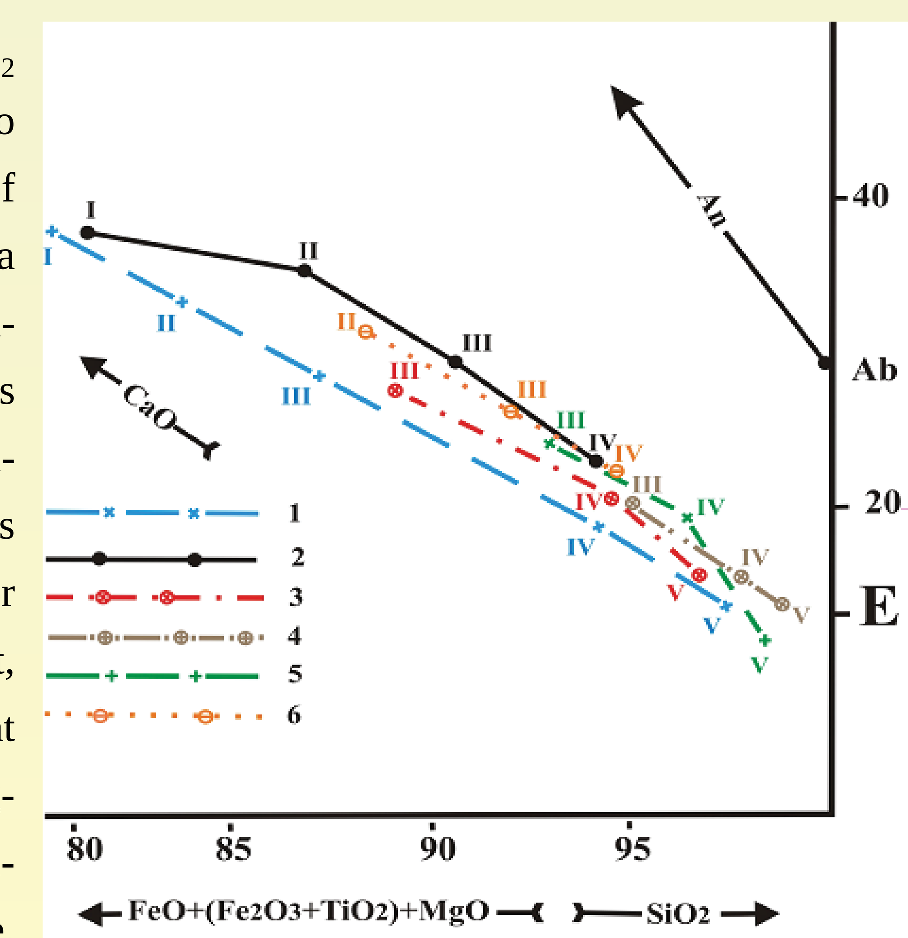

Fig.4. *The(Mg-Fe)O-CaO-2Al_2O_3-SiO_2 diagram-model for Variscan plutonic series of the Greater Caucasus, Trends: 1-Gabbro-plagiogneiss series, 2-diorite-adamellite series, 3-Plagiogranites of plagiogranite-granite series, 4-Granites of plagiogranite-granite series, 5-Granodiorite-alaskite series, 6-Late Caledonian granite-gneisses, E-Eutectic zone.*

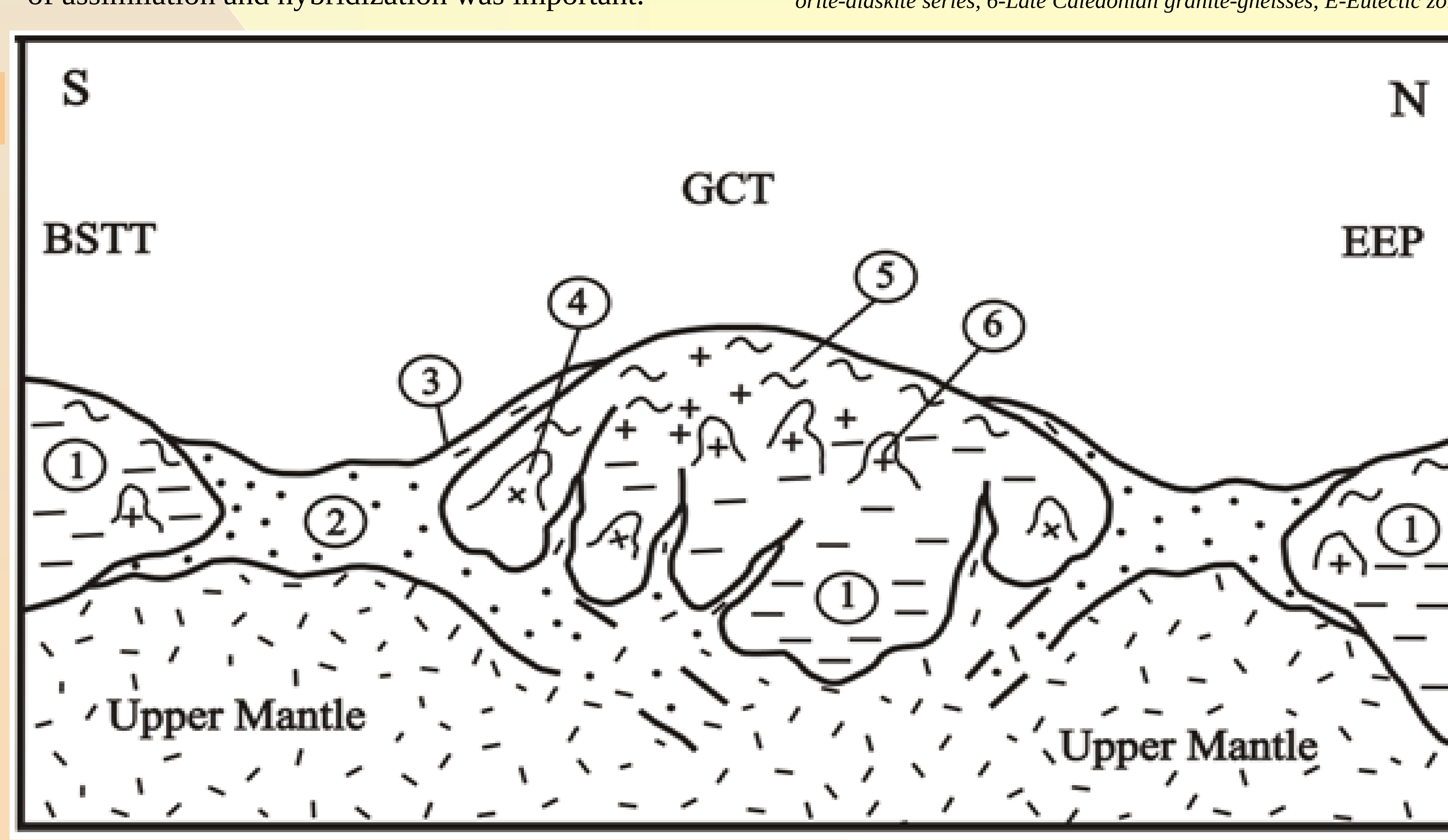

Fig.5. *Hypothetical geological cross section through the Greater Cauca-sus Orogen and of the Variscan Tectonic-thermal events (Late Carbonife-rous –Early Permian). It is shown on the figure how Great Caucasus Ter-rane (GCT) go through collision between Black Sea Central Transcauca-sian terrane (BSTT) and East European Platform (EEP). Pre-Variscan rocks (1) undergo intensive reworking. In subduction zones gabbro-pla-giogneiss associations (3) are formed, over subducted oceanic crust (2) hybrid dioriteadamellite plutons (4) undergo generation, as a result of metapelite anatexis plagiogranite-granite series (5); Pre-Variscan Caledonian granite-gneisses recycling results in the formation of the diorite-alaskite (6) plutonic associations undergo.*

Conclusion

Evolution of plutonic magmatism is clearly observed in the Greater Caucasus Variscan tectonic-thermal events. Mantle origin gabbro-plagiogranite series is formed (355±15 Ma) at the initial stage of the process in subduction zone at the orogen south margin. During 320±8 Ma mantle-crust generated gabbro-adamellite series formed just above the subduction zone. Much later (315±7 Ma; 310±5 Ma) crustal anatectic plagiogranite-granite series started formation in the arched part of collision structure. The Greater Caucasian Variscan plutonic magmatism is ended by granodiorite-alaskite series (300±5 Ma), which formed at the expense of the upper Caledonian granite gneisses as a consequence of the East-European platform felsic rock recycling.

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