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THE ŢICĂU HILLS (NW TRANSYLVANIA — RUMANIA) — LITHOSTRATIGRAPHY AND PETROLOGY OF THE METAMORPHIC ROCKS

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Abstract: Ţicău Hills represent one of the crystalline islands of NW Transylvania, in which the pre-Variscan basement of the Tisia Domain outcrops. A lithostratigraphic sequence is described consisting of a lower, Magmatogene Stejera-Cheud Member with five subunits and an upper, Terrigenouse Chelinta Member, with three marker horizons. Three metamorphic phases were recognized: the first (main) phase developed progressively, the second, retrogressively and the final, progressively. Probably these metamorphic phases were related to the Caledonian and the Hercynian events. Late alterations are due to hydrothermal activity and intensive Paleogene weathering phenomena.

Key words: Transylvania, Someş Group, lithostratigraphy polymetamorphism, metaigneous rocks.

Introduction

The Ţicău Hills are situated in NW Transylvania (Rumania), approx. 30 km southward from Baia Mare. The Someş River cuts a large defile in its western side, collecting the water of the rivulets which originate in the hill. The metamorphic rocks and the sedimentary cover form clear and large outcrops along the valleys and the ridges of the hills, which permit a detailed geological mapping.

The Ţicău Hills are one of the NW Transylvanian Crystalline Islands (Fig. 1) which represent an uplifted blocks of the basement of the Tisia Domain — the major tectonic unit of the southern part of the Pannonian Basin (Szederkényi et al. 1995). Thus, a detailed lithostratigraphic succession of a limited area of this great domain, may be useful for interpretation of the structural approach of the sediment-covered areas, known only by deep-drilling data.

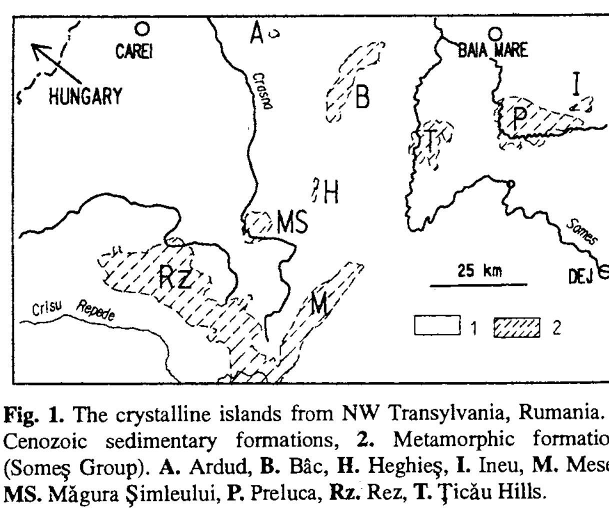

Fig. 1. The crystalline islands from NW Transylvania, Rumania. **1.** Cenozoic sedimentary formations, **2.** Metamorphic formations (Someş Group). **A.** Ardud, **B.** Bâc, **H.** Heghieş, **I.** Ineu, **M.** Meseş, **MS.** Măgura Şimleului, **P.** Preluca, **Rz.** Rez, **T.** Ţicău Hills.

The first cartographic and petrographic information on the Ţicău metamorphics was provided by Hauer & Stache (1863), Hofmann (1887) and Koch (1898). After the First World War, the Ţicău Hills were studied by Szádeczky (1925) and Kräutner (1938). Modern petrographic data from this area were supplied by Dimitrescu (1963), Kalmár (1969, 1972a, 1986) and by Zincenco et al. (1990). The Paleogene and Neogene sedimentary cover was studied by Saulea & Bărbulescu (1957), Marele-Ioniţa (1960), Ghiurca (1970) and Patrulius et al. (1979).

Lithostratigraphy of the metamorphic basement

The metamorphic basement of the Ţicău Hills was asigned by Dimitrescu (1960, 1963) to the Someş Group (Seria de Someş), a large lithostratigraphic unit which comprises the meso-metamorphic rocks of the northern Transylvanian Midmountains (Munţii Apuseni) and the metamorphic formations which outcrop in North-western Transylvanian Crystalline Islands. The last ones were called the "Sylvania Unit" by Zincenco et al. (1990). According to Szederkényi (1984), the Ţicău, Preluca, Bâc and Ardud islands, represent the easternmost outcrops of the Autochthone Unit continuing towards the east the structural pattern of the basement of the Southern Great Hungarian Plain.

As there are no data concerning the undoubted correlation between the Ţicău and the other islands, we propose, for the metamorphic sequence which outcrops in this area, the term "Ţicău Formation".

The Ţicău Formation may be subdivided in two members: the lower, Magmatogene Stejera-Cheud Member and the upper, Terrigenous Chelinţa Member (Fig. 2).

The Magmatogene Stejera-Cheud Member

This member partly surrounds the Ţicău Hills, being best developed on the eastern side of the hills. Following the most

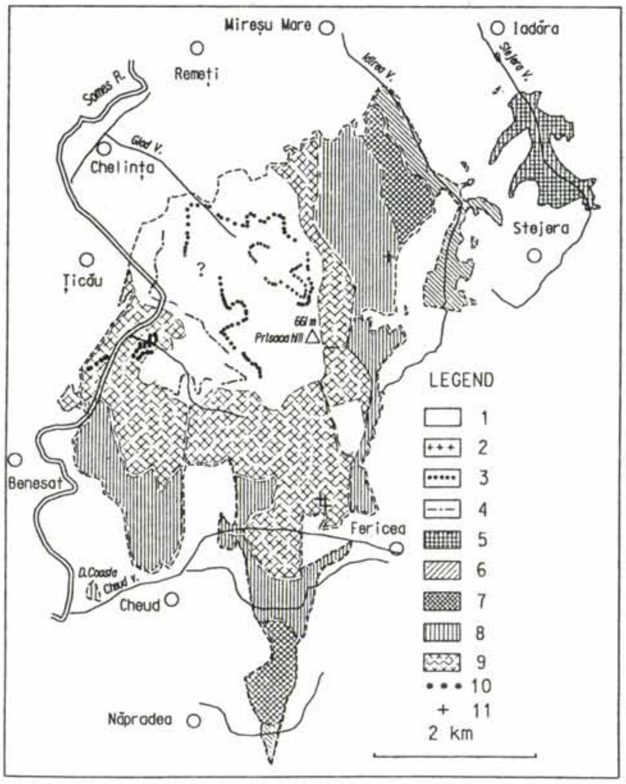

Fig. 2. Lithostratigraphic units of the Ţicău Hills. **1.** Chelinţa-Hagău Terrigenous Member, **2.** Porcăreţ Leptinite Horizon, **3.** Glod-Hagău Mica-Schist Horizon, **4.** Valea Morii Mica-Schist Horizon, **5.** Stejera Gneisses, **6.** Idirea Mica-Schists, **7.** Plescuţei Gneisses, **8.** Ti-holţ Main Mica-Schists, **9.** Secătura Gneisses, 5-9. Stejera-Cheud Magmatogene Member, **10.** Amphibolite lenses, **11.** Biotitic metagranodiorite bodies.

important gneiss and mica-schist intercalations, a complex, metamorphosed volcano-sedimentary sequence was recognized. Five lithostratigraphic subunits were mapped formed of more or less thick terrigenous rocks (paragneisses, mica-bearing quartzites, quartzose mica-schists) in the lower part and by one or more gneiss or garnet-bearing mica-schist intercalations, thin amphibolite, graphitic quartzite or marble lenses in the upper part. On the basis of the chemical composition and mineralogical-petrographical data, we assume that this rock assemblage represents metamorphosed acid volcanites (dacites, rhyolites), tuffs and accompanying products of their alteration (red clay, chert, chemically precipitated limestone).

The igneous origin of the feldspar-rich gneisses was discussed by Kalmár (1986).

Stejera Gneisses

This subunit outcrops in the easternmost part of the Ţicău Hills, along the Stejera Valley and its affluents. Due to the research works for the Stejera kaolin deposit, it was studied in detail and its lithological column is known at a 1-5 m precision (Fig. 3). It consists of 5 large and another 10 small biotite gneiss lenses, 2 garnet-bearing mica-schist lenses, 3 leptinite intercalations, a 2-3 m thin graphitic quartzite layer and a small amphibol-gneiss lens (the last is known only in boreholes). The term "leptinite" describing feldspar-rich and mica-poor gneisses, derived from acidic igneous rocks or/and tuffs was used according to Winkler (1973).

The chemical study of gneiss samples obtained from boreholes and mining works shows the acid, calc-alkaline composition of the protolith (Kalmár 1986). The relation of calcium to alkali oxides emphasize two main trends, corresponding to dacitic (biotite gneisses) and to rhyolitic (leptinites) compositions. In Tab. 1 we present 14 chemical analyses of typical metavolcanic rocks. Presuming an isochemical metamorphism, the petrochemical diagrams (Fig. 4) show, that these rocks originate from alkali-rich and intermediate, salic and semisalic, granite-granodiorite type (rhyodacitic-dacitic) igneous rocks.

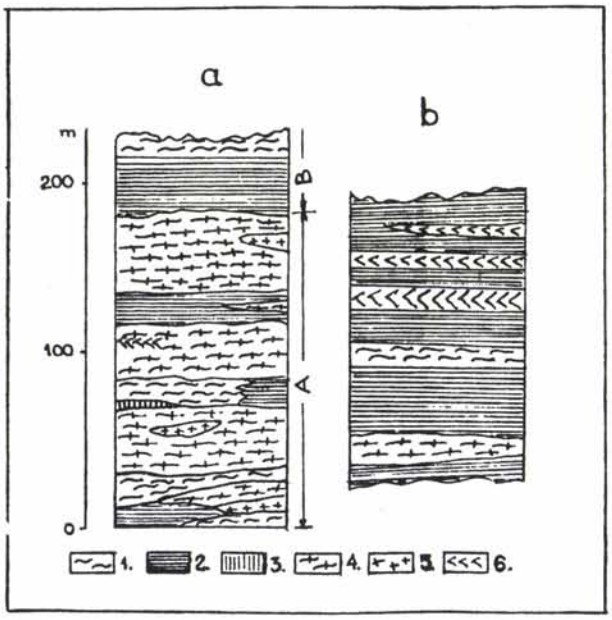

Fig. 3. Lithological columns. **a.** Detailed column of Stejera Gneisses, Stejera Valley; **b.** Amphibolite lenses in Secătura Gneis Level, Ingustului Valley, right slope of the Szamos Defile. **1.** Garnet-rich muscovito-biotitic mica-schists, **2.** Quartzitic mica-schists and two-mica paragneisses, **3.** Graphitic quartzites, **4.** Biotitic gneisses, **5.** Leptinites, **6.** Amphibol-gneisses, amphibolites. **A.** Stejera Gneisses, **B.** Idirea Mica-Schists.

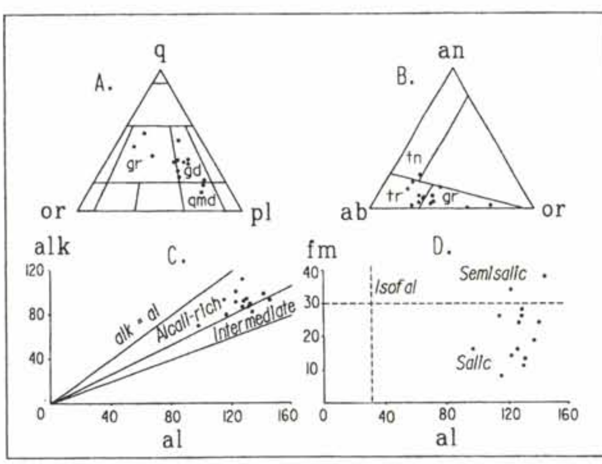

Fig. 4. Petrochemical diagrams. **A.** q-pl-or classification diagram (IUGS, 1973), **B.** ab-an-or diagram (O'Connor 1965), **C.** alk-al diagram and **D.** m-al diagram (Burri & Niggli 1945). **gr.** Granites, **gd.** Granodiorites, **qmd.** Quartz-monzodiorites, **tn.** Tonalites, **tr.** Trondhjemites.

Table 1: Chemical analyses on some gneiss samples from Ţicău Hills.

SampleNo	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	SO_3	L.I.	Summa
1694	76.57	13.23	1.05	0.56	0.85	5.60	1.20	0.08	0.18	0.93	100.29
2191	77.80	13.34	0.82	0.84	0.25	2.60	3.35	0.03	0.08	0.64	99.80
2276	78.65	11.82	0.62	0.42	0.15	6.60	0.70	tr	0.23	0.75	99.94
2336	80.97	10.02	1.12	0.30	0.34	4.71	1.16	0.08	0.07	1.02	99.79
2399	76.68	13.52	1.48	0.18	0.15	5.10	2.00	0.20	0.60	0.58	100.49
2414	76.28	12.58	2.20	0.76	0.80	2.65	3.50	0.30	0.22	0.95	100.24
2445	75.92	12.93	1.70	0.66	0.20	4.00	3.90	0.32	0.21	0.66	100.50
2446	77.13	12.50	1.60	0.56	0.17	3.85	3.40	0.20	0.10	0.70	100.21
2468	77.09	11.78	2.30	0.93	0.09	3.31	3.33	0.06	0.21	0.60	99.62
2514	76.82	13.24	2.15	0.49	0.53	2.00	4.10	0.15	0.19	0.70	100.37
2522	76.87	13.09	1.90	0.35	0.48	2.15	3.90	0.18	0.26	0.91	100.09
2523	76.80	12.95	1.82	1.10	0.20	2.45	4.00	tr	0.09	0.90	100.39
2611	71.62	14.38	2.10	3.15	0.45	1.85	4.50	0.10	0.12	1.02	99.39
2677	69.55	14.75	2.63	4.30	0.86	2.08	3.95	0.12	0.05	0.95	99.74

Location of samples
1694-2336. Stejera Gneisses from mining works. 2399-2446. Ibidem from Stejera Quarry.
2468. Pleşcuţei Gneisses. 2514-2523. Secăturii Gneisses.
2611, 2677. Metagranodiorites from Carpănului Valley Mirşeu Mare.
Analysed by Building Raw Material Research Institute Cluj-Napoca, Rumania.

Idirea Mica-Schists

Along the Idirea Valley, a 150-200 m thick garnet-rich muscovitic-biotitic mica-schist level appears. This level continues southward, outcroping in Valea Rea, Năpradea. Its detailed structure can be observed in the Groşilor Valley: the sequence begins with grey paragneisses containing quartzite lenses and continues with mica-schists containing 1-10 cm thick leptinite ribbons. In the upper part, an alternation of garnet mica-schists and quartzose mica-schists, and thin grey and black quartzite lenses is developed.

The garnets of these rocks are pink or light purple-coloured and form anhedral grains 3-10 mm in size. In the Cerboaia Valley, on the right bank of the Idirea Valley, 1-5 mm long staurolite crystals occur.

Plescuţei Gneisses

It was mapped on the left side of the Idirea Valley and can be recognized southward, as far as Voinicului Hill (N of Năpradea). In the upper flow of the Idirea Valley three discontinuous biotite-gneiss intercalations with 5-10 m thick garnet-mica-schist inbeddings occur. In the Voinicului Hill the gneiss lenses constitute three horizons, with small mica-schist lenses. The host rock of the gneisses and mica-schists are quartz-rich paragneises and mica-bearing quartzites.

Tiholţ Main Mica-Schists

The Tiholţ Main Mica-Schists are exposed along the Tiholţ Valley, at the springs of Idirea (Fântâna Pintii), in the gorge of the Cheudului Valley, in the Icubula Hill and the Icubula Valley continuing westward, between Cheud and Benesat under the alluvial deposits of the Someş River (in the shallow boreholes from Benesat Gravel Quarry). The thickening of the level in this area is due to the increasing amount of terrigenous intercalations and to the isoclinal folding (see Dealul Coasta, Cheud). In the northern part, the level is built up by mica-rich quartzites with three or four, 10-30 m thick mica-schist layers, the thickness of which increases southward. In the Carpănului and Idirea Valley thin leptinite lenses and intercalations can be observed. Between the Cheudului Valley and Icubula Hill, the mica-schist occupies the whole section of the level, containing rare black quartzite lenses. A characteristic feature of the mica-schists from this level is the presence of idioblastic (rhombdodecahedral), quasi-opaque garnet porphyroblasts, which attain 2-2.5 cm in diameter.

In the Carpănului Valley and northward of the Cheudului gorge, two, 100-200 m large feldspar-rich, grano-porphyroblastic gneiss lenses were mapped, with oligoclase and biotite porphyroblasts and fine-grained microcline+oligoclase+quartz+biotite matrix, considered as small metamorphosed intrusions of granodiorite-porphyry.

Secătura Gneisses

The thickness of this stratigraphic subunit constantly increases from 100-150 m in the north to 300-500 m in the southern and western part of the Ţicău Hills. This thickening is due to both, thickening of the gneissic intercalations and appearance of new intercalations, as well as to folding. Southward of the Cheudului Valley, the Secătura Gneisses show an intra-formational unconformity, which cross-cuts the lithological subunits from the upper part of the Main Mica-Schists.

In the northern part (Poienii and Ruginoasa valleys), the gneissic intercalations are thin and represent less than 10 % of the level. In the Stânei Valley, Kalmár (1972b) described a sequence of leptinite, biotitite and graphitic quartzite, with 1 m thick intercalation of almandinite ("kinzigite"). The maximal development being attained in the Secătura Valley; where also a 5-8 m thick marble lens appears. In both slopes of the Someş defile, three amphibole-gneiss intercalations were found (Fig. 3). In the left slope of the defile, also a quartz-poor, dark biotite- and titanite-rich plagioclasic gneiss lens, of intermediate (andesitic) composition was mapped.

The Terrigenous Chelinţa-Hagău Member

Above the last leptinite layer, a monotonous sequence of paragneisses, quartzose mica-schists, mica-bearing quartzites occur. It is disposed in an asymmetrical brachi-syncline, the western wing of which is complicated by few short, imbricated and faulted folds. The detailed structure of the Terrigenous Chelinţa-Hagău Member is shown by three, 5-20 m thick marker horizons.

— The Valea Morii Garnet Mica-Schist Horizon. It occurs between the gipsy camp of the Chelinta village and the upper flow of the Morii Valley. The lack of this horizon in the western and southern wings of the syncline suggests either an intraformational sedimentary unconformity (ingression?) between the Terrigenous and Magmatogene Members, or a metamorphic shearing on the schistosity.

— The Glod-Hagău Mica-Schist Horizon with discontinous development was identified in both wings of the syncline. It is represented by two-mica and garnet-bearing mica-schist lenses with 5-10 cm thick leptinite ribbons (Glodului Valley and NE of the Hagău Peak).

— The Porcareţ Leptinite Horizon. It was mapped in the central part of the Ţicău Hills, between the Hagău and the Prisaca Peaks. The leptinite is constituted by feldspars and quartz, having massive and aplite-like texture.

Metamorphism and post-metamorphic transformations

Three phases of the metamorphism have been recognised in the rocks of the Ţicău Hills (Kalmár 1972a).

The first (main) metamorphic event is characterized by the associations biotite + almandine + plagioclase (An20) + staurolite and hornblende + plagioclase (An35). In the Barrovian type metamorphism, this association corresponds in Winkler's P-T diagramm (1973) to T = 500-600 °C and P = 4-6 kb. It is assumed, that the corresponding S_1 schistosity follows the former lithological stratification of the sequences. The above mentionned mineral assemblages and the S_1 surfaces were preserved during the later events, therefore a reconstruction of the former (pre-metamorphic) stratigraphic sequence seems to be possible.

The 2nd metamorphic event caused the partial breakdown of biotite, garnet, plagioclase and hornblende resulting in phengite, albite, epidote, actinolite and calcite. The P-T conditions decrease to 450 °C and 3 kb (Winkler's P-T diagramm). In isolated, more or less large portions of the rocks, but mainly in the vicinity of petrographic discontinuities, S_2 surfaces formed by shearing occur at an angle of 30-40° to S_1.

The last metamorphic recrystallization is marked by the appearance of the cross-biotite and new muscovite, rims in garnet, phaneroblastic ferrotremolite, and finally, albite and Mg-chlorite in pressure-shadow zones. The mean orientation of the newly formed micas shows a virtual surface S_3.

After the metamorphic changes, secondary mineral formation took place due to hydrothermal alterations at higher (smoky quartz, Fe-rich chlorite, albite, siderite, pyrite, chalcopyrite) and lower temperature (limpid quartz, calcite, adularia, marcasite, sphalerite, cinnabar, zeolite, and opal). By weathering of the gneisses and mica-schists during the Paleogene, the Stejera kaolinitic clay deposit was formed.

The sedimentary cover

The oldest sedimentary formation of the sedimentary cover is Senonian in age: in borehole No. 346 Iadara grey Globotruncana-bearing marls, a few m in thickness were observed. The old weathering crust of the crystalline rocks is covered mainly by Paleogene formations. In Ţicău and in its vicinity the Paleocene - Lower Eocene (Jibou, Valea Nadăsului, and Stejera formations) appear. The Upper Eocene (Priabonian) is represented by the Cozla Limestone Formation. After a stratigraphic gap during the Oligocene and Lower Miocene, Badenian detrital, pyroclastic and carbonatic sediments were deposited, followed by Sarmatian and Pannonian marls and sands.

Tectonics

The metamorphic basement forms a brachy-syncline, with asymmetrical wings (Fig. 2). Some of the folds deformed previously metamorphosed rocks, the mineral assemblage of which, i.e. the mica-rich layerlets, the amphibols and the feldspar phenoblasts were curved or crushed. Also, kink-type deformations affected the newly formed cross micas. Thus, deformations continued after the metamorphic recrystallization.

The disjunctive tectonics shows a complex pattern of directional, transverse and diagonal faults. Some of them affected the sedimentary cover up to the Pannonian deposits. The Ţicău Hills represent a horst limited by the Sălaj Basin in the west and the Baia Mare Basin in the north.

Concluding remarks

We have no data concerning the age of the initial sediments, the volcanic products or the metamorphic phases. It was considered that the rejuvenation of the K-Ar ages in the middle Cretaceous (90-110 Ma, Soroiu et al. 1985) may be related to the collision between the Tisia Microplate and the Transylvanian Ophiolitic Belt. Considering the Rb-Sr ages and the few Pb-Pb data from the basement of the Great Hungarian Plain and Transdanubia, it is probable, that the sediments are not older than Middle Proterozoic and the main metamorphic stage may be assigned to the Caledonian or Hercynian event (Árkai et al. 1985).

Despite the advanced metamorphic overprint the main primary lithological units are recognisable, thus it is assumed that the premetamorphic stratigraphic sequence can be reconstituted. The lithostratigraphic sequence of the Ţicău Hills includes magmatogene and terrigenous rocks. The magmatic activity had a bimodal character, acid products previal, but basic and intermediate metavolcanics are known as well.

The sequence of metamorphic events present remarkable similarity with those described in the pre-Variscan basement of the Great Hungarian Plain ("Autochthone Unit", Szederkényi 1984).

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References

Árkai P., Nagy G. & Dobosi G., 1985: Polymetamorphic evolution of the South-Hungarian crystalline basement, Pannonian Basin: Geothermometric and geobarometric data. *Acta Geol. Hung.*, 28, 3-4, 165-190.

Burri C. & Niggli P., 1945: Die junger Eruptivgesteine des mediterranean Orogens. I. *Publ. Vulkaninstitut Immanuel Friedlaender*, Zürich, 3.

Dimitrescu R., 1963: About the crystalline islands from NW Transylvanie. *Societatea de Ştiinţe Naturale i Geologie, Comunicări de Geologie. II.* Bucarest, 23-32 (in Rumanian).

Hauer Fr. & Stache G., 1863: Geologie Siebenbrgens, Wien.

Hofmann K., 1887: Geologische Notizen ber die kristallinische Schieferinsel von Preluka und das nördlich and südlich anschliessende Tertiärland. *Magy. Királyi Földt. Intéz. Évi Jelent., 1886*; separatum, Budapest.

Kalmár J., 1969: Geological prospections for feldspar- and mica-bearing pegmatites in Lăpusului Mts., Remecioara zone and in Ţicău Mts. (Maramureş and Sălaj districts). *Manuscript, Archive of the MMPG*, Bucarest.

Kalmár J., 1972a: Stratigrafy of the metamorfic and sedimentary terrains from the crystalline islands Inău, Preluca and Ţicău. *Ph.D. thesis, Oil, Gas and Geology Technical University*, Bucarest (in Rumanian).

Kalmár J., 1972b: About the presence of the kinzigite in the Ţicău Hill. In: *Studii şi Cercetări de Geologie*, 17. 2, Bucarest, 414-417 (in Rumanian).

Kalmár J., 1986: About the feldspar-rich gneisses from Stejera - Ţicău, mineralogical and petrochemical study. *Acta Univ. Babeş - Bolyai*, 31, 2, 156-172.

Koch A., 1898: Gaura and Galgó. A Magyar Korona országainak 1:75000-es léptékű földtani térképe. MÁFI, Archive of the Geologic Maps (in Hungarian).

Kräutner Th., 1938: Recherches géologiques et pétrographiques dans les massifs cristallins du NW de la Transilvanie. *Comptes Rendus, Institute Géologique Roumaine (Bucuresti)*, XXII., 133-138.

Patrulius D., Popescu B. & Baltreş A., 1979: Paleogene and Mesozoic carbonate rocks of the Transylvanian Basin and northern Apuseni Mountains. *Guidebook for the Field works of 3.5. Group, IGCP, Institutul Geologic Român*, Bucarest.

O'Connor J. T., 1965: A classification for quartz-rich igneous rocks based on feldspar ratio. *U. S. Geol. Survey Prof. Paper 525-b*, 79-89.

Saulea E. & Bărbulescu A., 1957: Contributions for knowledge of the Miocene from Ţicău - Iadăra Area. *Anuarul Universitătii "C. I. Parhon" Seria Ştiinţe Naturale*, 15., 26-38 (in Rumanian).

Soroiu M., Balintoni I. & Vodă A., 1985: A model of the basement of the Transylvanian Basin as revelated by K-Ar dating. Rev. Roum. *Géol. Géophys. Géogr.*, 29. Bucarest, 29-35.

Szádeczky Gy., 1925: Metamorphic rocks of the Crystalline Islands Cicău - Preluca. *Dări de Seămа ale Institutului Geologic al României (Bucuresti)*, XIV, 35-41 (in Rumanian).

Szederkényi T., 1984: The crystalline basment of Alföld and its geological relations. *Academic Doctor Dissertation, JATE Szeged* (in Hungarian).

Szederkényi T., Kalmár J. & Nicolici A,. 1995: The evolution of the north-eastern border of Tisia-realm. *XV. Congr. CBGA, Spec. Publ. of the Geol. Soc. of Grece*, 4/1. Athens.

Winkler H.G., 1973: Metamorphic Petrology. *Elsevier*, Lond., Amst., N. Y., Tokio.

Zincenco D., Soroiu M. & Cuna S,. 1990: Cretaceous thermal front on pre-mesozoic continental crust, documented by K-Ar data: on exemple, the Sylvanic belts, NW Transylvania, Romania. *Rev. Roum. de Géol., Géophys. Géogr., Ser. Géol.*, 34., 95-105.