Acta Mineralogica—Petrographica, Szeged, XXIII/1, 49—69, 1977

METAMORPHIC-GRANITOGENIC ROCKS OF THE BASEMENT COMPLEX OF THE GREAT HUNGARIAN PLAIN, EASTERN-HUNGARY

ÁRPÁD SZALAY

ABSTRACT

The metamorphic-granitogenic rocks of the Great Hungarian Plain showing a SW—NE trend have been uncovered by hundreds of hydrocarbon exploring boreholes. The central part is composed of polymetamorphic biotite-plagioclase gneisses, mica schists, amphibolites which gradually pass into migmatites and/or diatexites of granodioritic composition in the marginal parts of the deeply buried ranges involved. The polymetamorphic rocks are intersected by younger granites of medium grain-size. In some boreholes in the southern part of the Great Hungarian Plain mica-quarzites, chlorite schists belonging to the greenschist facies as well as staurolite-mica-schists belonging to the almandine-amphibolite facies have been found, all of them hit by a single metamorphism only. The formation of the metamorphic-granitogenic rocks is a result of three tectono-metamorphic cycles. The first one caused a regional metamorphism of the Proterozoic source rocks into the amphibolite facies and resulted in a synkinematic granodiorite formation. A regressiv metamorphism took place in the second cycle manifesting itself by milonitization and diaphtoresis along narrow zones. The regressive metamorphism resulted in mineral associations of the greenschist facies. These rocks show a limited regional extension until now. The final cycle caused some metasomatic transformations of considerable intensity as well, forming late kinematic granites.

INTRODUCTION

The metamorphic basement complex of the Great Hungarian Plain has been revealed by hydrocarbon exploring boreholes. After having intersected Cenozoic and Mesozoic sequences of different thickness, about 650 boreholes have reached the ancient crystalline rocks. A slightly curving line, connecting Újszilvás–Túrkeve–Hajdúszoboszló–Ártánd exploration areas, can be considered as a boundary north of which the metamorphic basement complex has not been discovered until now.

A comprehensive discussion of these metamorphic formations has been given by three studies [E. SZÁDECZKY-KARDOSS *et al.*, 1967, E. SZÁDECZKY-KARDOSS *et al.*, 1969, K. SZEPESHÁZY, 1973] so far. The petrological, stratigraphic and tectonic characteristics of the metamorphic rocks have been thoroughly discussed in these publications. The connection between the crystallin complexes of the Great Hungarian Plain and those of the Carpathian region has been outlined in the study of K. SZEPESHÁZY [1973]. The development of the metamorphic and granitogenic rocks in the Great Hungarian Plain has been ranged to some tectonomorphic cycles belonging to the Prae-Baykalian, Baykalian and Hercynian orogeny.

The chemical zonality of the garnets of metamorphic origin is considered by P. ÁRKAI *et al.*, [1975] as a proof of the polymetamorphism. By investigating some samples from the Great Hungarian Plain, they have stated that the original zoning of the garnets developed in the first phase of the recrystallization had been covered by a secondary zonal system formed later, during the regressive metamorphism.

METAMORPHIC AND GRANITOGENIC RANGES OF THE GREAT HUNGARIAN PLAIN

The metamorphic-granitogenic ranges forming the crystalline basement of the Great Hungarian Plain show a general SW–NE trend and a symmetrical arrangement. The central — *i.e.* largest — part of the Great Hungarian Plain is composed of polymetamorphic biotite-plagioclase gneisses hit by a regressive metamorphism and of plagioclase bearing mica-schists accompanied by amphibolite masses of local extension *(Fig. 1)*.

The mica-schist-gneisses range passes both towards the NW and towards the SE into granitogenic ranges surrounded by migmatites. The metamorphic-granitogenic basement forming ranges has been intersected by younger, granitogenic formations with SE–NW and/or SW–NE trends. Their common characteristic is that they are narrow, sometime show vein-like nature.

Naturally, the different ranges can not be distinguished without some kind of exploration. The areal distribution of the boreholes reaching the basement is highly uneven; in some areas data of 100 or even more boreholes can be taken into consideration, while in other areas data of some boreholes can be relied only.

Polymetamorphic crystalline rocks

Biotite-plagioclase gneisses

Biotite-plagioclase gneisses have been uncovered boreholes in several areas *(Sükösd, Érsekcsanád, Jánoshalma, Kiskunhalas, Tázlár, Szank, Kelebia, Forráskút, Sándorfalva, Üllés, Dorozsma, Algyő, Ferencszállás, Csanádapáca, Mezőkovácsháza, Végegyháza, Öcsöd, Szarvas, Endrőd, Füzesgyarmat, Komádi, Mezősas, Kőrösszegapáti* and *Ártánd)*.

As a result of a concentrated drilling activity the metamorphic basement complex is much better explored than usual *Jánoshalma–Kiskunhalas–Tázlár–Szank* (Danube–Tisza Interfluve), *Algyő* and in the NW part of the *Mezőhegyes–Mezőkovácsháza* arch (southeastern part of the Great Hungarian Plain).

The biotite-plagioclase gneisses are greenish-gray, medium or fine grained rocks with a schistosity of different intensity. As a result of the strong regressive metamorphism, their original structure had changed i.e. their structure characteristic of gneisses had disappeared and in many cases a secondary schistosity developed.

Their minerological composition is a simple one. The most important primary components are as follow: plagioclase, quartz and biotite. Accessories are garnet and apatite. K-feldspar of primary origin does not occur.

As a result of the regressive metamorphism the sericitization of the An_{28}-oligoclase of primary origin has taken place followed by a decomposition of variable intensity. The intensity of the biotite degradation os somehow different; a number of transitions beginning from the slight chloritization to the formation of chlorite-calcite-magnetite patches can be observed. The mineral assemblage of the regressive metamorphism is composed of chlorite, quartz, sericite, calcite, magnetite. A secondary mineral association consisting of younger K-feldspar, albite, quartz, muscovite frequently emerges and replaces the primary one.

The chemical analyses of the rocks have been summarized in four regional groups according to the possibilities offered by the sampling. The following statistical parameters are given for each rock type and for each area in the Table 1: mean

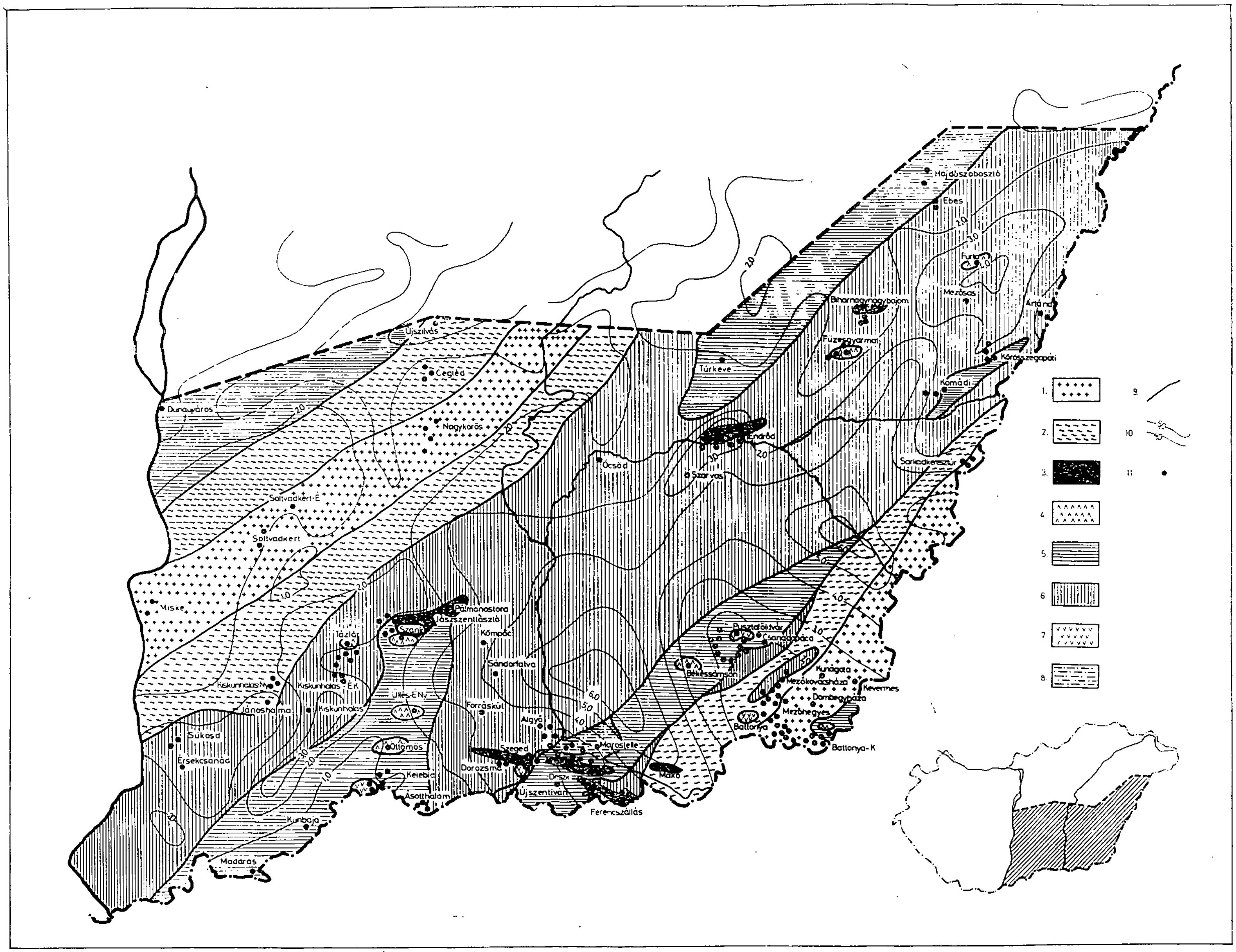

Fig. 1. Metamorphic-igneous rocks in the Great Hungarian Plain

Legend: 1. Granodiorite; 2. migmatite; 3. granite; 4. amphibolite; 5. mica-schist; 6. gneiss; 7. quartz-porphyry; 8. chlorite schist; 9. boundary of the formation; 10. contour on the top of the crystalline basement complex; 11. borehole; 12. boundary of the explored area value (x), standard deviation (S_x), mean standard deviation ($S_{\bar{x}}$) as well as number of the analyses. In the order to select the different petrological families independently of the sampling areas, STUDENT- (or "t"-) test was done. On the basis of this a correlation can be shown up between the know occurrences of the biotite bearing plagioclase-gneisses. Consequently, the chemical composition of the rocks can be given as a mean characteristic of the whole Great Hungarian Plain (Table 1).

Muscovite-biotite-plagioclase mica-schist

The overwhelming majority of the mica-schists uncovered in the area under consideration are of polymetamorphic nature.

Mica-schists hit by a single metamorphism are know scattered in small patches only. According to our information having acquired until recently, mica-schist-like rocks can be followed in SW–NE trending zones which wedge into or paralell with the central gneiss-range at *Madaras, Kunbaja, Kelebia, Ásotthalom, Algyő, Újszilvás, Ferencszállás, Kiszombor, Pusztaföldvár, Csanádapáca* areas. More scattered occurrences around *Turkeve, Hajdúszoboszló* testify to the existence of a northern mica-schist zone.

The mica-schist-like schists of varying appearance are mostly stressed, folded rocks with greenish shade. In thin sections the following charactereistics can be observed: lamination fabric, unidirectional arrangement of the fairly elongated mafic components, a separation of the mafic and salic minerals in form of systematic alignement of these crystals. The polymetamorphic character of the rocks is referred to by a multi-generation mineral association. Their primary mineralogical composition is rather uniform. The main components are muscovite, biotite, quartz, plagioclase, garnet. Accessories: cordierite, epidote, tourmaline, magnetite, titanite. There are two plagioclase modifications. The original mineral was oligoclase from which recently sericitized, silicified xenomorphs aligned in streaks exist only. The phenoblasts of the younger plagioclase generation are fresh albites. The quartz shows a remarkable varying fabric. It consists of grains showing undulose extinction and forming mosaic-like contacts arranged into streaks and vein. The muscovite is the most frequent mineral of this rock-group. The primary and the younger generation could hardly be distinguished. Forming tress-like masses it separates itself from the salic components. Its young variations developed by transformation of biotite and felspar can frequently be observed. The primary biotite crystals are mostly decomposed to different extent. Most frequent phenomenon is the chloritization of the biotite crystals and/or their transformation into calcite-magnetite-muscovite. Small crystals of the newly formed biotite generation hardly occur in the mica-schist-like rocks. The garnet graine are decomposed in all of the cases. A number of transformation processes can be observed beginning from the chloritization along clefts to the garnet pseudomorphs filled by calcite and by chlorite.

Originally, the mica-schist-like rocks were mica-schist, gneisses composed of quartz, plagioclase, muscovite, biotite, garnet. The regional metamorphism of the source rock of dominantly sedimentary origin exceeded the degree of metamorphism in the greenschist facies. On the basis of the anortite content of the plagioclase (over 15%) and a widespread occurrence of the almandine garnet, these rocks could be ranged into the Barrow-type staurolite-almandine subfacies of the amphibolite facies. As a result of a younger regressive metamorphism, the primary mineral association has transformed and a secondary mineral assemblage consisting of

TABLE 1

Chemical compositions of the biotite-plagioclase gneiss occurrences

1. Mezőhegyes, Mezőkovácsháza, Végegyháza
2. Szank, Tázlár, Jánoshalma
3. Algyő, Ferencszállás
4. Endrőd, Kőrösszegapáti
5. Average chemical composition of the central biotite-plagioclase gneiss belt

	1			2			3			4			1—2	1—3	1—4	2—3	2—4	3—4	5
	$\bar{X}_{N=19}$	S_x	$S_{\bar{x}}$	$\bar{X}_{n=30}$	S_x	$S_{\bar{x}}$	$\bar{X}_{n=20}$	S_x	$S_{\bar{x}}$	$\bar{X}_{n=5}$	S_x	$S_{\bar{x}}$	$t_{0,95=2,01}$	$t_{0,95=2,09}$	$t_{0,95=2,07}$	$t_{0,95=2,01}$	$t_{0,95=2,04}$	$t_{0,95=2,06}$	$\bar{X}_{n=74}$
SiO_2	63,65	3,65	0,84	62,54	3,39	0,62	61,48	7,05	1,58	62,73	3,05	1,36	−1,09	−1,20	−0,52	−0,72	−0,11	−0,36	62,55
TiO_2	0,60	0,21	0,05	0,59	0,21	0,04	0,54	0,23	0,05	0,65	0,26	0,12	−0,06	−0,17	−0,42	−0,16	−0,55	−0,49	0,59
Al_2O_3	17,21	1,15	0,26	16,41	1,42	0,26	16,12	1,56	0,35	15,07	1,67	0,75	+2,45	+2,45	+3,37	−0,83	−1,92	−1,34	16,45
Fe_2O_3	0,63	0,41	0,09	1,02	0,98	0,18	1,06	0,78	0,17	0,94	0,19	0,08	−1,54	−1,72	−1,67	−0,13	−0,18	−0,32	0,91
MnO	0,09	0,04	0,01	0,12	0,40	0,10	0,11	0,08	0,02	0,08	0,02	0,01	−1,67	−0,59	−0,83	−0,51	−1,99	−0,81	0,10
MgO	1,66	0,63	0,14	2,10	0,67	0,12	2,48	1,40	0,31	2,00	0,39	0,17	+2,55	+2,37	−1,18	−1,22	−0,39	−0,72	2,09
CaO	2,30	1,04	0,24	1,97	1,05	0,19	2,80	1,81	0,41	2,93	2,56	1,14	−1,11	−1,06	+2,25	+2,05	+3,05	−1,15	2,14
K_2O	2,59	0,50	0,11	3,34	0,92	0,17	2,12	0,90	0,20	1,84	1,07	0,48	+3,30	+2,10	+2,33	+4,78	+3,32	−0,47	2,71
H_2O	2,72	0,98	0,22	2,74	0,74	0,14	3,12	1,24	0,28	2,20	0,68	0,30	−0,05	−1,10	−1,13	−1,37	−1,51	−1,59	2,80
H_2O	0,18	0,09	0,02	0,17	0,13	0,02	0,17	0,25	0,05	0,16	0,10	0,04	−0,75	−0,47	−0,96	−0,36	−0,23	−0,10	0,17
P_2O_5	0,30	0,17	0,04	0,17	0,08	0,01	0,17	0,17	0,04	0,13	0,04	0,02	+4,63	+2,77	+3,10	−0,01	−1,10	−0,48	0,14
CO_2	1,27	1,26	0,29	1,69	1,70	0,31	1,51	1,49	0,33	3,42	1,72	0,77	−0,90	−0,86	+3,14	−0,36	+2,11	+2,49	1,65
Σ	99,60			99,84			99,89			99,51									99,51

TABLE 2

Chemical composition of the biotite-plagioclase gneisses

1. Pusztaföldvár
2. Algyő, Ferencszállás, Újszilvás
3. Ásotthalom, Kelebia
4. Chemical composition of the southern mica-schist range

	1			2			3			1—2	1—3	2—3	4
	$\bar{X}_{n=25}$	S_x	$S_{\bar{x}}$	$\bar{X}_{n=35}$	S_x	$S_{\bar{x}}$	$\bar{X}_{n=28}$	S_x	$S_{\bar{x}}$	$t_{0,95=2,00}$	$t_{0,95=2,01}$	$t_{0,85=2,0}$	$\bar{X}_{n=88}$
SiO_2	54,23	6,85	1,37	56,56	6,29	1,06	54,78	6,29	1,19	−1,33	−0,36	−1,03	55,36
TiO_2	0,59	0,28	0,06	0,98	0,41	0,07	0,55	0,17	0,03	+4,13	−0,66	+5,17	0,73
Al_2O_3	20,64	6,05	1,19	20,85	4,13	0,70	22,40	3,63	0,69	−0,88	−0,51	−1,46	21,67
Fe_2O_3	0,91	0,71	1,14	1,51	0,69	0,12	1,20	0,61	0,12	+3,71	−1,95	−1,87	1,23
FeO	6,18	2,85	0,57	6,24	1,60	0,27	4,92	1,19	0,22	−0,18	+2,06	+3,64	5,79
MnO	0,16	0,08	0,02	0,21	0,32	0,05	0,10	0,05	0,01	−0,12	+3,45	+2,76	0,14
MgO	1,90	0,63	0,13	2,21	1,07	0,18	1,82	0,53	0,10	−1,34	−0,50	−1,78	2,00
CaO	0,82	0,56	0,11	1,30	1,02	0,17	0,77	0,43	0,08	+2,18	−0,26	+2,55	1,00
Na_2O	1,07	0,54	0,11	1,29	0,61	0,10	0,81	0,51	0,10	−1,42	−1,80	+3,28	1,07
K_2O	4,58	0,81	0,16	4,20	0,97	0,16	4,13	1,24	0,23	−1,67	−1,56	−0,20	4,28
$+H_2O$	3,77	0,92	0,18	3,73	0,97	0,16	4,35	0,78	0,15	−0,17	+2,42	−2,73	3,95
$-H_2O$	0,13	0,07	0,01	0,15	0,12	0,02	0,15	0,07	0,01	−0,20	−0,82	−0,44	0,14
P_2O_5	0,10	0,05	0,01	0,12	0,07	0,01	0,14	0,15	0,03	−1,31	−1,36	−0,87	0,12
CO_2	3,43	2,10	0,42	0,65	0,81	0,14	3,44	1,55	0,29	+6,89	−0,04	+9,01	2,34
Σ	98,51			100,00			99,56						99,82

albite-chlorite-calcite-muscovite-quartz, and belonging to the greenschist facies has developed.

Chemical analyses are available from the rocks of the southern mica-schist range only. According to the sampling frequency of the boreholes, mica-schist-like rocks of three different areas have been compared (Table 2).

The Al_2O_3 content (exceeding 20%), the K_2O/Na_2O ratio (heavly exceeding 1.0), the high FeO content refer to a sedimentary origin. The areal heterogenity of the source rock, the degree of the metamorphism, the selectiv effects of the secondary transformations have been studied by "t"-test. The author is of the opinion, that a significant difference could not be stated among the mica-schist locations. That is why a comprehensive mean is also given here.

Amphibolites

Amphibolites with a relatively limited areal extension and subparalell to the trend of the polymetamorphic formations have been uncovered at *Tázlár, Szank, Füzesgyarmat,* and — south of the zone above — at *Öttömös, Üllés, Algyő, Békés-sámson, Battonya.* These amphibolites are compact, finely-crystallized, dark-green rocks of slightly schistose or non-schistose character. In addition to green-hornblende and plagioclase, epidote, quartz, titanite, rutile, apatite, garnet can be found as accessories.

The green hornblende crystals are mostly decomposed, transformed — in many cases into biotite. The majority of the amphibolites has supposedly been formed by metamorphism of very old ophiolites and bear traces of secondary transformations. There is not a significant difference among the chemical composition of the scattered amphibolite bodies (Table 3).

TABLE 3

Chemical composition of the biotite-plagioclase gneisses

1. Békésssámson, Battonya-E
2. Algyő
3. Szank
4. Üllés-NW, Öttömös

	1		2		3		4	
	$\bar{X}_{n=4}$	S_x	$\bar{X}_{n=4}$	S_x	$\bar{X}_{n=7}$	S_x	$\bar{X}_{n=4}$	S_x
SiO_2	47,82	1,33	45,35	3,21	49,32	2,16	50,90	2,08
TiO_2	1,07	0,35	1,37	0,76	2,16	0,78	1,56	0,45
Al_2O_3	16,67	2,82	15,10	0,69	15,67	1,56	14,88	2,20
Fe_2O_3	2,56	1,36	3,87	1,50	3,87	1,53	4,20	3,43
FeO	7,80	2,29	6,09	2,57	8,19	1,91	7,99	2,62
MnO	0,19	0,13	0,17	0,04	0,24	0,09	0,26	0,08
MgO	7,35	1,38	8,04	2,26	5,00	1,03	5,16	0,65
CaO	7,17	2,42	11,69	2,34	8,30	0,82	6,44	1,55
Na_2O	3,23	0,21	2,27	1,09	3,42	0,70	3,63	0,99
K_2O	0,51	0,27	0,59	0,76	0,85	0,20	1,14	0,49
$+H_2O$	3,59	1,46	2,64	1,77	2,05	0,48	2,61	1,55
$-H_2O$	1,19	1,31	0,04	0,04	0,31	0,21	1,01	1,80
P_2O_5	0,15	0,12	0,24	0,28	0,44	0,28	0,17	0,12
CO_2	0,51	0,17	2,82	4,81	0,14	0,20	0,32	0,30
Σ	99,81		100,28		99,96		100,27	

The rock types of the granitogenic ranges

Metatexites

The southeastern migmatite zone can be traced along a SW–NE trend at *Mezőhegyes, Dombegyháza, Mezőkovácsháza–SE, Kunágota.* The migmatite zone of Danube–Tisza Interfluve is less known. The boreholes finished recently uncovered the southern part of the migmatite zona in the environs of *Kiskunhalas,* while its northern zone became know at *Cegléd* and *Újszilvás.*

The rocks of the migmatite zones are metamorphites hit by a partial anatexis and in which the textural and mineralogical relicts and characteristics of the parent rock (=paleosome) are still identifiable, but — simultaneously — the new, re-melted part (=neosome) also appears. The neosome consists of the components of the leucosome. (The nomenclature of the migmatites and granitoids is used here according to MEHNERT [1968].)

The fabric of the metatexites is of lineation character. In the paleosome the original, oriented and schistose nature of the fabric has been preserved. The neosome frequently took the adventage of this inherited schistose, stromatic character of the paleosome and developed along the schistosity. The leucosome mobilizates are separated by melanosome streaks from the paleosome. The paleosomes in the Great Hungarian Plain are mostly biotite-plagioclase gneisses, rarely mica-schists. The leucosome mobilizates are composed of plagioclase, quartz, biotite. Their fabric is coarsely crystallized and slightly oriented. The most common components of the leucosome are subhedral plagioclases with a generally uniform optical appearance. The An-content of the plagioclase amounts to 15–20%. Another plagioclase generation also appears, showing a lower An-content and replacing the above mentioned plagioclase generation. Apart from the plagioclase, the other important mineral is the quartz. Being crystallized after the feldspars it occurs in form of xenomorphic crystals among those. Its recrystallization leads to replacement and resorption phenomena. The only mafic component is chloritized biotite.

The leucosome-paleosome contact is considered as a genetical feature. This contact shows an abrupt change in the mineralogical composition. In thin sections this contact is of more diffuse character. The amount of the biotite crystals in the leucosome increases towards the contact. The main component of the melanosome is the biotite. The melanosome bands consist of biotite, plagioclase, quartz and titanite crystals. The proportion of the biotite may amount to 40–50% of the rock part involved. The plagioclase is of 15—20% An-content, being in accordance with that of the plagioclase in the leucosome mobilizates is summarized in the Table 4.

Diatexites

In the southeastern part of the Great Hungarian Plain *(Battonya, Battonya–East, Dombegyháza–South, Kevermes, Sarkadkeresztúr)* and in some central parts of the Danube–Tisza Interfluve *(Soltvadkert, Soltvadkert–North, Nagykőrös, Kecskemét)* the crystalline basement complex is composed of granodioritic diatexites.

Being homogenized towards the granodioritic zone, the metatexites gradually pass into diatexites of granodioritic composition. Sometimes inclusion-like paleosome relicts still can be observed in the diatexites, the homogeneous rock, however, could not be devided into leucosome and paleosome anymore. The overwhelming majority of the rock mass has melted. The diatexites of the both zones mentioned above are granodiorites consisting of plagioclase, quartz, K-feldspar and biotite. The accessories are: apatite, zircon, epidote.

TABLE 4

The neosome differentiates of the migmatite range in the southeastern part of the Great Hungarian Plain

	1. Leucosome			2. Melanosome		
	$\overline{X}_{n=9}$	S_x	$S_{\bar{x}}$	$\overline{X}_{n=7}$	S_x	$S_{\bar{x}}$
SiO_2	69,14	4,26	1,42	50,08	5,03	5,90
TiO_2	0,27	0,18	0,06	0,96	0,43	0,16
Al_2O_3	16,75	1,89	0,63	15,85	2,25	0,85
Fe_2O_3	0,23	0,22	0,07	1,13	0,60	0,23
FeO	1,49	0,83	0,28	7,59	4,09	1,55
MnO	0,04	0,05	0,02	0,19	0,09	0,03
MgO	0,62	0,31	0,10	4,26	0,99	0,37
CaO	2,11	0,80	0,27	4,73	2,14	0,81
Na_2O	4,54	0,77	0,26	1,90	0,93	0,35
K_2O	2,41	0,92	0,31	3,89	1,42	0,54
$+H_2O$	1,26	0,40	0,13	3,15	1,20	0,45
$-H_2O$	0,12	0,05	0,02	0,85	0,74	0,28
P_2O_5	0,28	0,16	0,05	0,72	0,65	0,25
CO_2	0,52	0,65	0,22	4,68	4,27	1,62
Σ	99,78			99,98		

The hypidiomorphic plagioclase crystals are oligoclases of 15–20% An-content, being heavly sericitized, sometimes kaolinitized. The resorption of the oligoclase crystals at the rims is a phenomenon of common occurrence. At the rims of some oligoclase crystals fresh albite overgrowths developed being strikingly different from the sericitized inner part of the crystal. Besides this oligoclase generation composed of crystals with sericitized central part and albitic rims, appears a younger plagioclase generation characterized by blastic albite crystals of 2–7% An-content. Xenomorphic, hypidiomorphic crystals of this generation are generally fresh, sometimes slightly sericitized. The myrmekitic transformation has hit this plagioclase generation too. The young, acid plagioclase generation appears together with the blastic microcline, thus forming a joint association.

The diatexites contain two generation of K-feldspar. The older one — which had crystallized from melt and later was slightly transformed — is composed of microclines of medium triclinity. The younger generation consists of microclines with maximum triclinity, which developed in low-temperature and filled the intergranular space. It has been stated by optical measurements on universal stage [GY. BUDA, 1970] that the K-feldspars of the granodiorites in the Great Hungarian Plain show dual-triclinity similar to those in the granodiorites of the Mecsek Mts. The older generation is composed of intermedier microclines of medium triclinity, while the younger one does of microclines of maximum or almost maximum triclinity. The homogeneously distributed scales of the biotite are mostly chloritized.

The microfabric of the diatexites are characterized by a joint occurrence of several mineral associations by the abundant occurrence of replacement structures caused by the younger generations as well as by the presence of secondary mineral associations and mineral transformations caused by low-temperature metasomatism [Á. SZALAY, 1975].

The chemical composition of the two granodioritic zones shows a significant difference in the SiO_2, FeO, MgO, Na_2O content. The FeO, MgO proportion is higher, the Na_2O/K_2O ratio is lower in the granodiorites of the Danube–Tisza Interfluve than those in the granodiorites of the southeastern part of the Great Hungarian Plain (Table 5).

TABLE 5

The chemical composition of the granodiorite ranges in the southeastern part of the Great Hungarian Plain and in the Danube—Tisza Interfluve

1. Battonya, Battonya-E, Mezőhegyes
2. Kecskemét, Nagykőrös

	1			2			1—2
	$\bar{X}_{n=17}$	S_x	$S_{\bar{x}}$	$\bar{X}_{n=3}$	S_x	$S_{\bar{x}}$	$t_{0,95=2,10}$
SiO_2	68,08	1,00	0,24	65,45	1,80	1,04	+3,72
TiO_2	0,53	0,28	0,07	0,42	0,07	0,04	−0,58
Al_2O_3	15,90	0,77	0,19	15,55	0,22	0,12	−0,78
Fe_2O_3	0,61	0,20	0,05	0,75	0,23	0,13	−1,12
FeO	2,03	0,39	0,10	3,02	0,17	0,10	+4,23
MnO	0,10	0,05	0,01	0,04	0,01	0,01	−1,86
MgO	1,12	0,48	0,12	2,17	0,24	0,14	+3,87
CaO	1,76	0,46	0,11	1,97	0,47	0,27	−0,72
Na_2O	3,65	0,41	0,10	2,73	0,49	0,28	+3,51
K_2O	3,76	0,56	0,14	3,92	0,59	0,34	−0,48
$+H_2O$	1,61	0,31	0,07	1,96	0,37	0,21	−1,78
$-H_2O$	0,14	0,11	0,03	0,14	0,10	0,06	−0,01
P_2O_5	0,25	0,08	0,02	0,23	0,03	0,02	−0,32
CO_2	0,62	0,81	0,20	1,19	1,92	1,11	−0,95
Σ	100,16			99,54			

The diatexites are transversed by pegmatites. The anatectic rocks are interlaced by 10–50 cm thick, coarse-grained, pink pegmatite veins, consisting mostly of K-feldspar phenoblasts, quartz and muscovite. The pegmatites show a diffuse boundary zone without any mafic rim towards the country rock.

The pegmatites of the diatexites in the south-eastern part of the Great Hungarian Plain and in the Danube–Tisza Interfluve are characterized by the mean chemical compositions given in the Table 6. The chemism of the two pegmatite types is significantly different. The pegmatites in the Danube–Tisza Interfluve are more K-rich.

Crystalline schists hit by a single metamorphism

Mica-quartzites

Some boreholes have uncovered mica-quartzites in the *Ferencszállás* area and in the southern and southeastern part of *Ásotthalom* and *Pusztaföldvár* areas, respectively. These are pale-gray, schistose, frequently strongly folded, rigid rocks. Its dominant minerals are elongated quartz crystals with very undulose extinction. Besides muscovites and tiny biotites the rock contains a large quantity of sericite. These have developed by the decomposition of feldspars of sedimentary origin now being observed in form of hardly identifiable relicts. Rarely, fresh albite crystals can also be found in the rocks formed by the metamorphism of a psammitic sediment mass in the greenschist-facies. It is considered as an important genetic feature that this rock-type does not show any sign of polymetamorphism.

The mica-quartzites of quite different areas are of the same chemical composition and shows definite relationship in their composition (Table 7).

TABLE 6

The chemical composition of the pegmatites in the southeastern part of the Great Hungarian Plain and in the Danube—Tisza Interfluve

	1. SE Great Hung. Plain			2. Danube—Tisza Interfluve		
	$\bar{X}_{n=4}$	S_x	$S_{\bar{x}}$	$\bar{X}_{n=2}$	S_x	$S_{\bar{x}}$
SiO_2	63,12	2,75	1,38	64,99	0,18	0,13
TiO_2	0,14	0,07	0,03	0,02	0,01	0,00
Al_2O_3	17,49	1,40	0,70	14,77	0,18	0,13
Fe_2O_3	0,20	0,14	0,07	0,05	0,02	0,01
FeO	1,28	0,34	0,17	0,09	0,01	0,00
MnO	0,04	0,04	0,02	0,02	0,01	0,00
MgO	0,96	0,67	0,33	0,32	0,08	0,06
CaO	2,20	1,44	0,72	0,62	0,13	0,09
Na_2O	2,99	0,83	0,41	1,70	0,13	0,09
K_2O	8,47	1,71	0,86	13,52	0,38	0,27
$+H_2O$	0,95	0,28	0,14	0,41	0,01	0,01
$-H_2O$	0,10	0,03	0,01	0,05	0,03	0,02
P_2O_5	0,92	0,67	0,34	0,02	0,01	0,00
CO_2	1,02	0,25	0,13	—	—	—
Σ	99,88			96,58		

TABLE 7

The chemical averages of the mica-quartzites

1. Pusztaföldvár
2. Ferencszállás, Kiszombor
3. Ásotthalom

	1			2			3			1—2	1—3	2—3
	$\bar{X}_{n=9}$	S_x	$S_{\bar{x}}$	$\bar{X}_{n=6}$	S_x	$S_{\bar{x}}$	$\bar{X}_{n=6}$	S_x	$S_{\bar{x}}$	$t_{0,95=2,16}$	$t_{0,95=2,16}$	$t_{0,95=2,22}$
SiO_2	71,68	3,38	1,13	72,70	0,83	0,34	72,78	3,06	1,25	−0,61	−0,64	−0,06
TiO_2	0,36	0,19	0,06	0,51	0,37	0,15	0,44	0,19	0,08	−1,05	−0,84	−0,40
Al_2O_3	13,57	2,18	0,73	14,51	1,93	0,79	12,27	2,00	0,82	−0,88	−1,20	−2,01
Fe_2O_3	0,50	0,25	0,08	1,26	1,36	0,55	0,91	1,15	0,47	−1,67	−1,04	−0,17
FeO	3,21	0,83	0,28	2,07	1,37	0,56	3,41	0,91	0,37	−2,02	−0,44	−2,00
MnO	0,11	0,02	0,01	0,04	0,03	0,01	0,10	0,04	0,02	+5,25	−0,80	+2,81
MgO	1,03	0,25	0,08	1,02	0,52	0,21	1,38	0,54	0,29	−0,32	−1,27	−1,18
CaO	0,67	0,28	0,09	0,32	0,26	0,11	0,58	0,14	0,06	−0,33	−0,73	−0,36
Na_2O	0,87	0,55	0,18	1,30	0,81	0,33	0,29	0,07	0,03	−1,21	+2,54	+2,99
K_2O	2,95	0,58	0,19	3,59	1,17	0,48	1,98	0,46	0,19	−1,42	+3,41	+3,22
$+H_2O$	2,27	1,04	0,35	2,23	0,79	0,32	2,55	0,70	0,29	−0,07	−0,09	−0,74
$-H_2O$	0,13	0,09	0,03	0,03	0,03	0,01	0,13	0,02	0,01	+2,62	−0,59	+6,64
P_2O_5	0,09	0,05	0,02	0,13	0,08	0,03	0,13	0,08	0,03	−0,37	−1,23	−0,59
CO_2	2,03	0,94	0,31	0,13	0,06	0,03	2,60	0,67	0,27	+4,88	−1,28	+9,03
Σ	99,47			99,84			99,52					

Chlorite schists, epidote gneisses

In the Tisza–Maros (rivers) junction (south part of the Great Hungarian Plain) unique rock-types were found in the basement complex of the Great Hungarian Plain. These two types could be genetically correlated.

The chlorite schists are greenish, fine-grained, compact schistose rocks. Their dominant mineralogical composition are: quartz, chlorite, albite, pyrite. Accessories are: calcite, muscovite, epidote. Their fabric is very characteristic one consisting of quartz grains and chlorite fibres aligned in one direction. The albite crystals link up with the quartz grains in an oriented way. The texture seems to be fresh the minerals belong to a single generation.

The quartz grains fitting together in a chain-like way form stripes of slightly undulose extinction. The plagioclase of albite composition is a fresh mineral being as clean as the water. The chlorites showing a greenish-brown colour under crossed nicols seem to be the dominant mafic component. Their fibrous appearance gives a strongly lineated character to the texture.

Inside the chlorite-schist sequence more coarse-grained rocks containing epidote and K-feldspar also appear. On the basis of their mineralogical composition and texture, these are considered as gneisses formed by K-metasomatism. The oriented character of their texture is less definite than that of the chlorite schists and becomes blastose. The effect of the blastesis manifests itself even in the chemical composition of the rock: the amount of the SiO_2 and K_2O has significantly increased than these of the chlorite schists (Table 8). The main mineralogical components of the epidote gneisses are as follow: quartz, plagioclase, epidote, muscovite, K-feldspar. The accessories are: pyrite, calcite, chlorite.

TABLE 8

The chemical composition of chlorite-schists and epidote-gneisses

1. Chlorite-schists (Algyő)
2. Epidote-gneisses (Algyő)

	1		2	
	$\overline{X}_{n=15}$	S_x	$\overline{X}_{n=13}$	S_x
SiO_2	60,59	5,07	71,61	3,52
TiO_2	0,07	0,10	0,11	0,11
Al_2O_3	15,13	1,98	13,74	1,93
Fe_2O_3	1,73	1,24	1,32	0,90
FeO	5,59	2,61	2,34	0,85
MnO	0,11	0,08	0,09	0,04
MgO	4,38	1,83	1,55	0,71
CaO	2,35	1,51	2,12	1,53
Na_2O	3,47	0,99	3,68	1,42
K_2O	0,50	0,29	1,23	0,64
$+H_2O$	4,01	1,45	2,13	0,48
$-H_2O$	0,11	0,07	0,06	0,05
P_2O_5	0,12	0,17	0,05	0,03
CO_2	1,45	1,65	0,25	0,34
Σ	99,61		100,28	

The mica-quartzites, chlorite-schists, epidote-gneisses and staurolite-mica-schists are products of a younger regional metamorphism in greenschist and/or amphibolite facies. These rocks were produced by a single metamorphism only. The epidote-gneisses bear marks of K-metasomatism.

Staurolite-mica schists

Staurolite-mica schists unknown structural position surrounded by granodiorites have been found in *Battonya–East* (SE–Hungary). These rocks are pale-gray, fine grained, slightly pressed metamorphites showing joints of schistosity with a silky shade. The lineated fabric of these rocks consists of isometric quartz grains as well as biotite and muscovite scales. The staurolite grains of 0.5–1.0 cm are scattered in the fabric of the rock. Accessories are as follow: magnetite, pyrite, zircon. Their chemical composition is characterized by a higher SiO_2 and CaO content as well as by a lower K_2O content than these in muscovite-biotite mica-schists (Table 9).

TABLE 9

The chemical composition of the staurolitic mica-schists discovered in Battonya-East

	$\overline{X}_{n=5}$	S_x
SiO_2	62,27	5,10
TiO_2	0,73	0,32
Al_2O_3	18,07	3,35
Fe_2O_3	1,30	1,04
FeO	3,81	0,80
MnO	0,16	0,06
MgO	2,14	1,08
CaO	1,60	1,10
Na_2O	1,14	0,90
K_2O	3,10	1,19
$+H_2O$	3,00	0,99
$-H_2O$	0,22	0,21
P_2O_5	0,08	0,05
CO_2	2,39	1,84
Σ	100,01	

Metasomatic rocks

Granites

The rocks of granitic chemical composition in the crystalline basement complex of the Great Hungarian Plain occur in forms of streaks and veins. In the diatexite-zones of granodioritic composition they are fine-grained, pink rocks with an aplitic appearance. Their fabric is fresh without any sign of secondary transformation. The rock is composed of quartz, K-feldspar, plagioclase and muscovite. The plagioclase is small, fresh albite. The K-feldspar is microcline of maximum triclinity. The aplites are of chemical composition being closest to that of granitic rocks (Table 10).

Medium-grained, pale gray granites have become know in the narrow belt from *Kiszombor* to *Kiskundorozsma* via *Ferencszállás–Algyő–Szeged*, at *Pálmonostora* as well as in the northern part of the *Szank* arch, and/or in the environs of *Endrőd*. Migmatite zone is not connected to these pale gray granites with slightly oriented fabric, wich are more coarse-grained than the aplites. In their environs the amount of the microcline-albite increases only. The rocks contain K-feldspar, quartz, plagioclase and muscovite. As accessories biotite, tourmaline, epidote and garnet can also be found.

TABLE 10

The aplitic rocks of the granodiorite range

1. Aplites of the Southeastern part of the Great Hungarian Plain
2. Aplites of the Danube—Tisza Interfluve

	1			2			1—2
	$\bar{X}_{n=17}$	S_x	$S_{\bar{x}}$	$\bar{X}_{n=3}$	S_x	$S_{\bar{x}}$	$t_{0,95=2,10}$
SiO_2	72,75	1,64	0,40	73,20	1,13	0,65	−0,27
TiO_2	0,30	0,32	0,08	0,34	0,10	0,05	−0,21
Al_2O_3	14,49	1,02	0,25	14,34	0,93	0,54	−0,24
Fe_2O_3	0,29	0,18	0,04	1,04	0,46	0,27	+5,25
FeO	1,33	0,54	0,13	0,29	0,05	0,03	+3,25
MnO	0,09	0,05	0,01	0,03	0,04	0,02	−1,41
MgO	0,46	0,31	0,07	0,46	0,16	0,09	−0,01
CaO	1,02	0,42	0,10	0,58	0,10	0,06	−1,76
Na_2O	2,96	0,64	0,16	2,71	0,53	0,31	−0,63
K_2O	5,06	0,92	0,22	5,37	0,54	0,31	−0,56
$+H_2O$	0,95	0,38	0,09	1,41	0,18	0,11	+4,86
$-H_2O$	0,06	0,02	0,00	0,15	0,07	0,04	−1,99
P_2O_5	0,14	0,09	0,02	0,13	0,07	0,04	−0,20
CO_2	0,19	0,21	0,05	0,17	0,25	0,14	−0,13
Σ	100,09			100,22			

The microcline is a mineral of maximum triclinity wich has formed at a low temperature. Their crystals are fresh, products of blastesis and fill the intergranular space. They frequently contain graphic quartz and albite lamellae. The plagioclase is a mineral of two generations in this rock. The old plagioclase crystals are relicts of the source rock. The dominating plagioclase, however, is albite forming the younger generation. Big phenoblasts show a "chessboard-like" albite twinning. The microcline, quartz, albite, muscovite crystals belonging to the younger generation are of simultaneous origin and can be easily distinguished from the primary association composed of oligoclase, biotite and garnet.

The young granites are characterized by a high SiO_2 content and K_2O/Na_2O and/or K_2O/CaO ratios exceeding 3 (Table 11).

Albitites

The pale gray granites are accompanied by coarse-grained fresh albitites. The majority of the rockmass is composed of plagioclase crystals with 2–5% An-content showing "chessboard-like" twinning. The rocks contain quartz, K-feldspar and muscovite too. Apart from the young mineral association the transformed relicts of the source rock can also be observed.

In accordance with the mineralogical composition the Na is the dominant alkali. The SiO_2 content exceeds 70 w% (Table 12). The proportion of the TiO_2, MnO, Fe_2O_3, MgO is very low.

Albitic gneisses

Gneisses containing young mineral association are known in many areas, systematically in those wich are close to granites, albitites. Albeit the effect of developing new albite — microcline generation becomes already dominant, these

Table 11

The general composition of medium-grained granites

1. Deszk, Ferencszállás, Dorozsma
2. Szank, Pálmonostora, Jászszentlászló

	1			2			1—2
	$\overline{X}_{n=15}$	S_x	$S_{\bar{x}}$	$\overline{X}_{n=5}$	S_x	S_x	$t_{0,95=2,10}$
SiO_2	73,09	1,98	0,51	72,00	1,49	0,67	−1,12
TiO_2	0,15	0,25	0,07	0,27	0,23	0,10	−0,92
Al_2O_3	14,66	1,52	0,39	15,18	1,41	0,63	−0,61
Fe_2O_3	0,35	0,28	0,07	0,31	0,22	0,10	−0,38
FeO	1,37	0,61	0,16	1,40	0,64	0,29	−0,09
MnO	0,06	0,03	0,01	0,07	0,04	0,02	−0,19
MgO	0,41	0,40	0,10	0,42	0,23	0,10	−0,47
CaO	0,73	0,45	0,12	1,18	0,33	0,15	−2,01
Na_2O	2,85	0,51	0,13	3,34	0,54	0,24	+2,12
K_2O	5,10	1,13	0,29	4,75	0,36	0,16	−0,67
$+H_2O$	1,10	0,24	0,06	0,87	0,56	0,25	−1,35
$-H_2O$	0,05	0,04	0,01	0,24	0,14	0,06	+4,72
P_2O_5	0,13	0,09	0,02	0,05	0,02	0,01	+2,47
CO_2	0,08	0,10	0,03	0,13	0,20	0,09	−0,67
Σ	100,13			100,21			

Table 12

The chemical composition of the albitites discovered in the Ferencszállás—Deszk—Algyő area

	albitite		
	$\overline{X}_{n=3}$	S_x	$S_{\bar{x}}$
SiO_2	73,32	1,12	0,65
TiO_2	0,01	0,02	0,01
Al_2O_3	16,24	0,30	0,17
Fe_2O_3	0,56	0,24	0,14
FeO	0,86	0,23	0,13
MnO	0,09	0,05	0,03
MgO	0,16	0,14	0,08
CaO	0,76	0,31	0,18
Na_2O	4,84	1,50	0,87
K_2O	2,45	0,20	0,12
$+H_2O$	1,06	0,41	0,24
$-H_2O$	0,06	0,03	0,02
P_2O_5	0,23	0,04	0,02
CO_2	0,02	0,02	0,01
Σ	100,66		

metamorphites still contain identifiable relicts of the source rock. According to the author's observations made until recently the proportion of the albite generation is higher than that of the new feldspar generation, which is reflected in the chemical composition of the rocks as well (Table 13).

TABLE 13

The chemical composition of the albitic gneisses

1. Szank, Tázlár
2. Endrőd

	1			2			1—2
	$\overline{X}_{n=8}$	S_x	$S_{\overline{x}}$	$\overline{X}_{n=2}$	S_x	$S_{\overline{x}}$	$t_{0,95=2,30}$
SiO_2	67,40	5,62	1,99	71,92	1,88	1,34	−1,05
TiO_2	0,40	0,32	0,11	0,26	0,33	0,23	−0,54
Al_2O_3	14,40	0,98	0,35	14,27	0,78	0,55	−0,16
Fe_2O_3	0,82	0,76	0,27	0,31	0,11	0,08	−0,91
FeO	3,28	1,17	0,41	1,92	1,92	1,36	−1,33
MnO	0,12	0,03	0,01	0,03	0,01	0,01	+3,32
MgO	1,80	0,83	0,29	1,62	1,19	0,05	−0,26
CaO	2,15	0,79	0,28	1,45	0,47	0,33	−1,16
Na_2O	3,51	1,18	0,42	3,69	0,93	0,66	−0,19
K_2O	2,49	0,59	0,21	1,92	0,25	0,18	−1,28
$+H_2O$	1,50	0,42	0,15	1,81	0,39	0,28	−0,95
$-H_2O$	0,08	0,05	0,02	0,16	0,12	0,09	−1,63
P_2O_5	0,15	0,06	0,02	0,13	0,07	0,05	−0,27
CO_2	1,17	2,26	0,80	0,68	0,80	0,57	−0,29
Σ	99,27			100,17			

THE GENESIS OF THE METAMORPHIC AND GRANITOGENIC ROCKS

The overwhelming majority of the crystalline formations in the Great Hungarian Plain are *polymetamorphic* rocks. As a result of different metamorphic effects, which could be attached to different geotectonic cycles, the primary mineral association of the source rock has transformed and new associations have developed replacing the primary one. By distinguishing these the determination of the relative age and the metamorphic processes becomes possible in addition to drawing petrogenetic conclusions. The postulated process of the metamorphic evolution is outlined in *Fig. 2.* The qualitative changes of the metamorphic processes, the superimposing character of these concomitant transformation processes as well as the directions of the metamorphic transformation show a geological evolution.

The rocks infilling the one-time — probable Proterozoic — sedimantary basin were mostly sedimentary rocks, although a subordinate amount of magmatic rock was also present. *The effect of the first tectonometamorphic cycle was a regional one which caused a regional metamorphism of the rocks involved.* The sedimentary series being rich in pelitic components transformed into mica-schists the coarse-grained series greywackes did into biotite plagioclase gneisses. The scattered amphibolite bodies are probably the products of metamorphism of basic magmatism of initial character.

It is a hard job to evaluate the role of the Proterozoic plutonites. K. SZEPESHÁZY [1966] considers the crystalline basement of the Danube-Tisza Interfluve and that of the overwhelming majority of the Great Hungarian Plain as an ancient granitoid massif which has been hit by a regional metamorphism. The possibility could not be excluded that among the source rocks had been even granitogenic rocks, but the author is not in the position to show up any proof asserting this assumption.

The chemical composition and the uniform chemical character of the large central gneiss-range occupying a central position does not correspond to the granitic

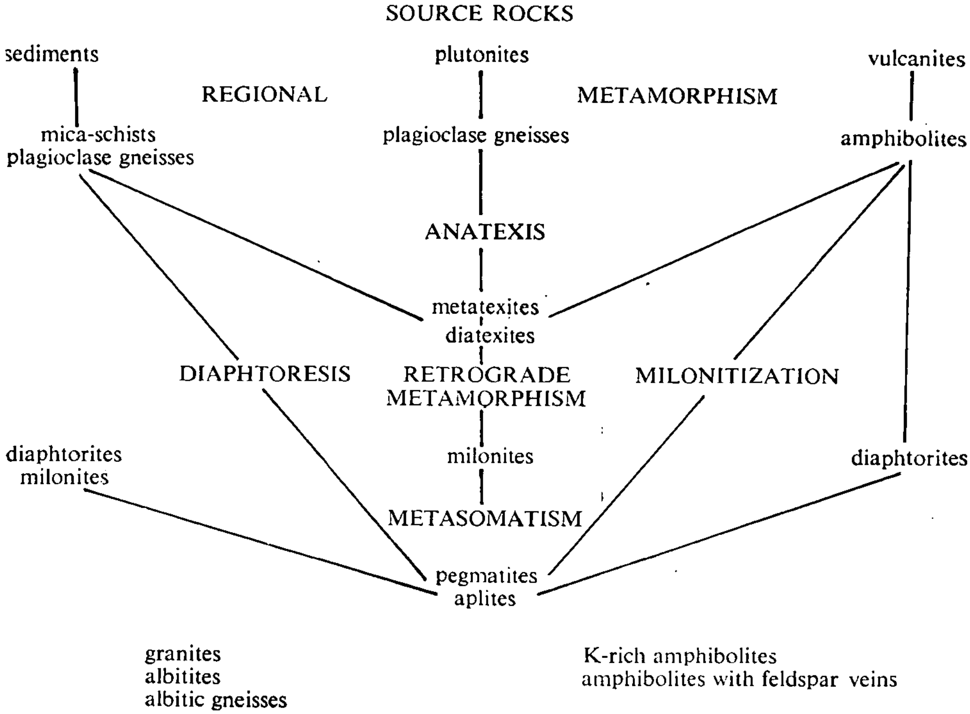

Fig. 2. Postulated process of the metamorphic evolution

or the granodioritic composition either. The 20–28% An-content of the primary plagioclases in the mica-schists and gneisses hints to the same i.e. sedimentary origin of the rocks. The lack of the primary feldspars do also assert the assumption that these rocks are mostly of sedimentary origin.

As a result of a regional metamorphism, they have formed in conditions equal to the Barrow-type staurolite-almandine or almandine-kyanite-muscovite subfacies of the amphibolite facies, and a primary quartz-plagioclase-biotite mineral association corresponding to the sedimentary composition has developed.

The polymetamorphic character of the rocks makes difficulties while studying the genetic relationship of the mica-schists and gneisses. The regional regularities could be elucidated by subsequent and more detailed mineralogical studies to be done, and by the spatial position of the index minerals.

The ultrametamorphic nature of the regional metamorphism locally and the onset as well as intensification of the anatectic process can be traced in the southeastern part of the Great Hungarian Plain and in the Danube–Tisza Interfluve. The neosome mobilizatum of the anatectites is a *venitic* product of a closed system differentiation produced by the partial melting of the source rock (paragneiss).

The geochemical analyses of the metatexites found in the Great Hungarian Plain have led to conclusions similar to those of K. R. Mehnert [1968] concerning the genesis of the migmatites in the Black Forest (W-Germany) (Table 14). It can be stated from the distribution of the elements that closed system differentiation of the

TABLE 14

Comparison of the chemical composition of some migmatites, and their source rock from the southern part of the Great Hungarian Plain

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	$+H_2O$	$-H_2O$
leucosome differentiate	69,14	0,27	16,75	0,23	1,49	0,04	0,62	2,11	4,54	2,41	1,26	0,12
melanosome differentiate	50,08	0,96	15,85	1,13	7,59	0,19	4,26	4,73	1,90	3,89	3,15	0,85
average of 3 leucosome and 1 melanosome differentiates	64,32	0,44	16,51	0,46	3,01	0,08	1,58	2,76	3,89	2,77	1,74	0,30
source rock	63,65	0,60	17,21	0,63	3,31	0,09	1,66	2,30	3,25	2,59	2,72	0,18
difference +	0,67							0,46	0,64	0,18		0,12
difference −		0,16	0,70	0,17	0,30	0,01	0,08				0,08	

paleosome has taken place (*i. e.* without accumulation of any material of significant amount from outside).

The most advanced stage of the anatexis is represented by the diatexites of granodioritic origin. In accordance with plagioclase crystals in the leucosome of the migmatite, its plagioclase crystals are oligoclases of 15–20% An-content. The primary K-feldspar making an appearance in the diatexites, however, suggests a more advanced stage of the melting as compared to the formation of the neosome in the migmatite. The partial melting of the K-feldspar-proof biotite-plagioclase gneisses resulted in metatexites, their full melting did in diatexites. The degree of melting of the source rock explains the absence of the K-felspars in the metatexites and/or their presence in the diatexites.

H. G. F. WINKLER [1967] has prooved by experiments, that at corresponding temperature a granodioritic melt may develop from K-felspar-proof, plagioclase-quartz-biotite bearing gneisses. The melt may contain different amount of K-felspar depending on the conditions of the melting. W. KNABE [1966] studied the anatexis of a material composed of biotite-quartz-plagioclase at a hydrostatic pressure of 2 Kbar. It has been stated that the biotite do not disappear totally at the beginning of the anatexis. A part of the biotite remains as resistite during the anatexis, while the other part yields K-feldspar components by the incongruent melting of the biotite.

At the starting phase of the anatexis a fragmentary part of the biotite transforms only, and that time a small amount of K-felspar develops as compared to the plagioclase, quartz. Concentrating the K-content the biotite separates itself in a form of resistites in the melanosome surrounding the leucosome. The latter developes in a lower temperature and concentrates the Si and Na content. Simultaneously to the increase of the temperature, however, the biotite also melts, the minerals cease to exist separately, a homogeneous melt developes which has a sufficient K-content for the crystallization of the primary feldspars.

The processes outlined here, i.e. the segregation, the melting and the subsequent K metasomatism which resulted in the development of the microcline-phenoblasts and pegmatites of the granodiorites, have been illustrated in triangle diagrams on the basis of chemical analyses *(Fig. 3)*.

The first metamorphic evolution cycle has finished with the palingenesis. The first tectonometamorphic evolution cycle resulted in the regional metamorphism of rock masses consisting of mostly pelitic sediments and greywackes in amphibolite facies. As a result of the regional metamorphism wide zones of mica schists gneisses, amphibolites have developed. Because of the steeper temperature gradient and the considerable amount of volatile components the rocks have partially or totally melted in the more heavly tectonized zones of the metamorphism, forming granodioritic rocks of palingenic origin.

In the contrary to the first one, the second metamorphic cycle has been a regressive one. The regressive metamorphism, milonitization of the rocks formed earlier have taken place. As a result of the regressive effects, mineral assemblages of the greenschist facies have developed in the metamorphites originally belonging to the amphibolite facies. The simultaneous nature of the regressive effect could be definitely stated by analysing the fabric, thus this process is considered as the result of a single geotectonic cycle. The regressive metamorphism may be allocated in time in between the regional metamorphism in the amphibolite facies and the younger regional metamorphism in the greenschist facies.

In the third significant tectonomorphic cycle the effect of the metasomatism is a decisive one. Locally and/or in one area even metamorphism in greenschist and/or amphibolite facies has taken place as a result of which chlorite schists, epidote-gneisses, mica-quarzite and/or staurolitic mica-schist have developed.

The regional metamorphism is characterized by low-temperature mineral associations of similar age. The young mineral association occurs in rock-forming amount in the aplites, medium-grained granites, albitites, albitic gneisses, while in the whole metamorphic complex manifests itself in form of blastic transformation marks.

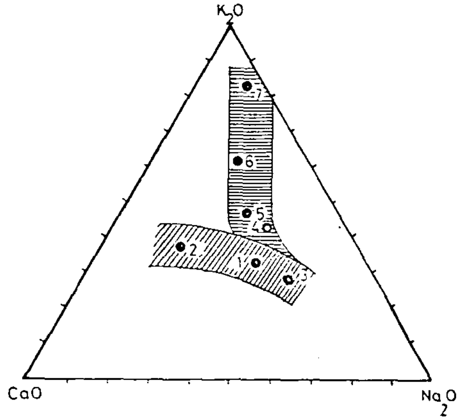

Fig. 3. Anatectic and metasomatic processes of the crystalline rocks in the Great Hungarian Plain.
1. Biotite-plagioclase gneiss of SE part of the Great Hungarian Plain
2. melanosome (SE part of the GHP)
3. leucosome (SE part of the GHP)
4. granodiorite (SE part of the GHP)
5. granodiorite (Danube—Tisza Interfluve)
6. pegmatite (SE part of the GHP)
7. pegmatite (Danube—Tisza Interfluve)

During the metasomatic process of regional extent the Si, K and Na were remobilized *(Fig. 4)*. A part of the mobilizates causing the metasomatic transformation originated from the source rock itself. Their migration has taken place within a short distance and local realignement of the materials has happened. All the alkalis, however, could not be stemmed from the rocks involved. It may be postulated that the water released in supracritical condition could remobilize during its migration the alkali content even of the deeplying rocks. Becoming spatially differentiated during their migration, the Na and K have formed granites rich in microclines and young albitites rich in plagioclase in the upper zones and along the tectonic lines.

The granitoids of other origin are the results of the evolutional phases of the process of the orogenesis. *Synkinematic* and *latekinematic* granitoides could equally be found in the areas discussed here. (Classifying the granitoids the MARMO's classification principles based on ESKOLA's magmatectonic system have been applied.)

Synkinematic rocks of the migmatite-granodiorite ranges surrounding the central gneiss-mica schist range. The characteristics of the synkinematic granitoids are as follow: source rock of dominantly sedimentary origin, anatectic formation and a presence of a wide migmatite zone. Their chemical composition is granodioritic; the K_2O/CaO ratio exceeds 1. (This ratio 3.76/1.76 and 3.92/1.97 in the cases of the granodiorites of the Great Hungarian Plain and that of the Danube-Tisza Interfluve, respectively.) The granitizing effect has hit the synkinematic granodiorites later. The only K-felspar component is the microcline which is mostly younger

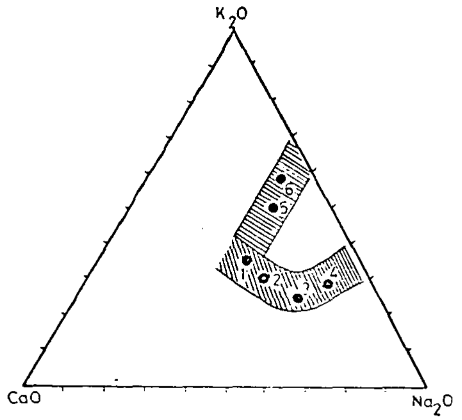

Fig. 4. Post-crystallizational Na and K metasomatism of the crystalline rocks in the Great Hungarian Plain.

1. Biotite-plagioclase gneiss (average of the GHP)
2. Albitic-gneiss (Szank, Tázlár)
3. Albitic gneiss (Endrőd)
4. Albitite (Ferencszállás, Deszk)
5. Granite (Ferencszállás, Deszk, Kiskundorozsma)
6. Granite (Szank, Pálmonostora, Jászszentlászló)

than the primary mineral association and it is considered as a result of a younger K-mobilizing geotectonic cycle.

The late-kinematic granites are represented by younger medium-grained granites, found in forms of narrow zones within the ancient crystalline rocks. Their chemical composition is granitic, the K_2O/CaO ratio systematically exceeds 2 (in aplites 5.06/1.02 and/or 5.37/0.58, in the medium-grained granites 5.20/0.33 and/or 4.75/1.18).

The narrow, belt-like form and the lack of migmatization in the country rock refer to *the tectonically defined character of the late-kinematic granite formation.* On the basis of their mineral associations of the same age (*i.e.* microcline with high triclinity and plagioclase of albitic composition) *the late-kinematic granites are as metasomatic formations.*

Postkinematic granites have not uncovered until recently in the area involved. The author is of the opinion that the ortoclase bearing granites of the granitoid zone south of the Lake Balaton represent this group.

REFERENCES

ÁRKAI, P., NAGY, G., PANTÓ, GY. [1975]: A ciklus folyamatok szuperpozíciója (polimetamorfózis) és azok ásványtani kimutatása. Geonómia és Bányászat *8*, 3—4, pp. 383—389.

BUDA, GY. [1970]: Vizsgálati jelentés a Duna—Tisza-közi, békési és algyői granitoid és metamorf kőzetek földpátelegyrészeinek optikai és röntgenvizsgálatairól. Manuscript (OKGT Adattár).

KNABE, W. [1966]: Anatektische Schmelzbildung in Quarz — Plagioklas — Biotit Gesteinen. Dissertation, Göttingen.

MARMO, V. [1971]: Granite petrology and the granite problem. London.
MEHNERT, K. R. [1968]: Migmatites and the origin of granitic rocks. London.
SZALAY, Á. [1975]: A Battonya—mezőhegyesi granitogén képződmények genetikai viszonyai. Manuscript (Dissertation).
SZÁDECZKY-KARDOSS, E., BUBICS, I., JUHÁSZ, Á., ORAVECZ, J., PANTÓ, G., SZEPESHÁZY, K. [1967]: Metamorphose in Ungarn. Acta Geol. Ac. Sci. Hung., *11*, 1—3, pp. 49—58.
SZÁDECZKY-KARDOSS, E., JUHÁSZ, Á., BALÁZS, E. [1969]: Erläuterung zur Karte der Metamorphite von Ungarn. Acta Geol. Ac. Sci. Hung., *13*, pp. 27—34.
SZEPESHÁZI, K. [1968]: A kristályos aljzat fontosabb kőzettípusai a Duna—Tisza-köze középső és déli részén. MÁFI Évi jelentése az 1966. évről, pp. 257—289.
SZEPESHÁZY, K. [1973]: A Kárpátok és az Alföld metamorf képződményeinek kapcsolatai. Ált. Földt. Szemle, *3*, (Manuscript).
WINKLER, H. G. F. [1967]: Die Genese der metamorphen Gesteine. — Berlin.

Manuscript received, May 10, 1977

DR. ÁRPÁD SZALAY
Research Laboratory
for Oil and Gas Industry
H-5000 Szolnok, Munkásőr u. 43.
Hungary