Slovak Geol. Mag., 7, 3 (2001),303 – 308

Plagioclase-clinopyroxene hornfels: raw material of 4 lengyel culture axes (Svodín, Slovakia)

DUŠAN HOVORKA[1], ĽUDMILA ILLÁŠOVÁ[2] and JÁN SPIŠIAK[3]

[1]Faculty of Natural Sciences, Comenius University, Mlynská dolina, 842 15 Bratislava, Slovak Republic
[2]Archaeological Institute of Slovak Academy of Sciences, Akademická 2, 949 21 Nitra, Slovak Republic
[3]Geological Institute of the Slovak Academy of Sciences, Severná 5, 974 01 Banská Bystrica, Slovakia

Abstract. Among numerous polished stone artefacts, which have been collected during systematic excavation of site Svodín in the past, we have studied 4 small non bored axes of very similar shape and identical raw material. It is represented by very fine-grained plagioclase-diopside hornfels of granoblastic fabric. We suppose central Slovakia Late Tertiary volcanic area to be provenience of raw material of the given type. Identity of raw material of all 4 axes allow us to consider their in situ production (from one block of the rock).

Key words: 4 axes, plagioclase-diopside hornfels, lengyel culture, Svodín, Slovakia

Introduction

Site Svodín (Fig. 1) systematicaly excavated in the past (1971-1983: Němejcová-Pavúková) belongs to the most extended polycultural sites of the lengyel culture in the whole central Europe. Unfortunatelly sudden death of formerly expert (Němcová-Pavúková) of this site unabled her to finish planed systematic studies of implements of the given site in the past. Mentioned author published (1995) problematic of roundels and determined four stratigraphic as well as cultural-typological horizons. In more than 150 skeletal graves rich inventory of polished implements have been gathered. Implements of chipped type have been studied and published by Kaczanowska and Kozlowski with contribution by Němejcová-Pavúková (1991). First results of laboratory studies of polished implements have been outlined by Pavúk et al. (2000). From the set of stone implements 4 small (4-6 x 3-4 x 0.8-1.3 cm) non bored flat axes constructed from hornfels have been documented (Fig. 2). One of them is insignificantly demaged on its sharp end, and the other one is represented by axe fragment. Studied axes are deposited under denomination: 1364, 1379, 1624 and 1876 in deposit of the Archaeological Institute of the Slovak Academy of Sciences in Vozokany. On one of them (1364) on surface rough brownish "skin" formed by products of weathering processes (mostly carbonates) is present (Fig. 3).

In the frame of systematical thin section studies we have identified 4 axes made of identical raw material. Consequently we have studied mentioned raw material in detail using electron microprobe for determination of composition of rock-forming minerals of the given rock. Obtained results allow authors to follow "geological history" of the given raw material type and consequently to consider provenience of its occurrences in nature.

Fig. 1. Location of site Svodín

In the set of several hundreds thin section studied till now no contact thermic hornfelses have been described yet (for review see paper by Hovorka and Illášová 2000) in Slovakia.

Raw material of axes

Discussed raw material type is aphanitic, with very slightly developed flaky polished surfaces of artefacts. Flakes are represented by irregular portions of various (but generaly light) tints of ash-gray colour. Raw material on cutted surfaces bears no signs of weathered outer zones - tint of the raw material on polished surfaces and in cutted planes is identical.

Thin sections image of the rock under consideration is simple. Discussed rock is composed of two main mineral phases: plagioclases and clinopyroxenes. Both of them are very fine-grained (less than 0.1 mm). Their distribution in detail is uneven (Figs. 4, 5). In small areas of thin section one of them dominates. Limits of such irregular areas are non sharp. Fabric of the given rock is granoblastic, mostly massive, in places weakly

Slovak Geol. Mag., 7, 3 (2001), 303 – 308

Fig. 2. Morphology of implements made of plagioclase-clinopyroxene hornfels, Svodín

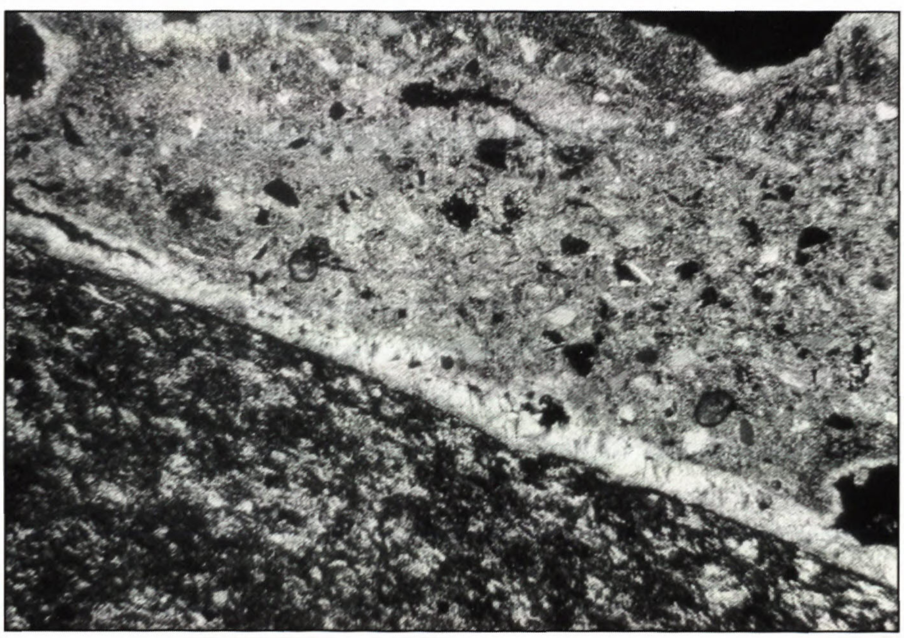

Fig. 3. Product of weathering processes (mostly carbonates: lighter portion of thin section) on axe surface (No 1346). Enlarg. 27x, // polars

expressed foliation is observable (Fig. 6). In artefact No. 1624 one vein-like (of 0.6 mm thickness: Fig. 7) arrangement of shortcolumnar clinopyroxenes is observable. Size (0.2-0.3 mm) of individual clinopyroxene crystals in this case is pronouncedly greater than matrix Cpx size. Clinopyroxene crystals within "vein" have locally radial orientation, and individual pyroxene crystals are of shortcolumnar habit. Submicroscopical isometric nonzonal and non twinned plagioclases represent disseminated crystals within clinopyroxene mass, or they are concentrated in "spots" of irregular shape and non sharp limits. Quantitative ratio of clinopyroxene vs. plagioclase in given rock is approx. 60 vs. 40 vol. per cents.

Clinopyroxenes of the rock are represented by uniform type and following IMA clinopyroxene classification (Morimoto et al. 1988) they are projected into field of diopside. In general clinopyroxene studied are of non- or very weakly zonal composition. Exception represents axe No. 1379, in which clinopyroxenes two zones are present. The lighter zone in comparison to the darker one is enriched in Fe - this is the case of shifting their projection point in direction to the hedenbergite field (Fig. 8). For all analysed clinopyroxene crystals very low or even non detected content of Ti and Na is characteristic (Tab. 1).

Plagioclases have high An content and are represented by labradore to bytownite. The highest detected An content (An 85) has plagioclase from sample 1624, which has simultaneously the highest content of Mg in clinopyroxenes.

Plagioclases analysed are fresh and have homogeneous (nonzonal) composition (Tab. 2).

In the given rock type in accessory amount tiny crystals of **apatite, pyrite** and **titanite** were detected. In the case of last mentioned mineral it appears as submicro/

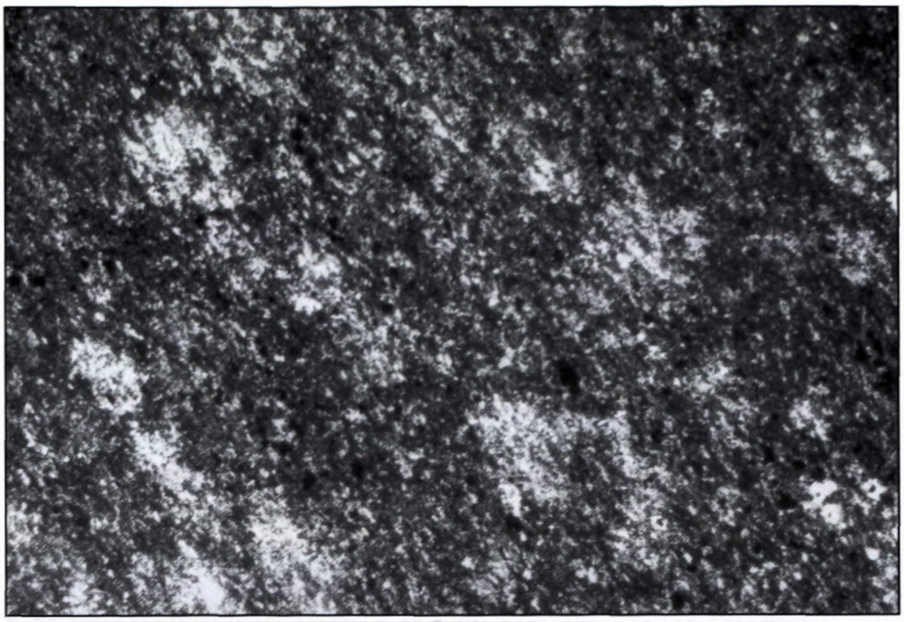

Fig. 4. Spotty pattern of the plagioclase-clinopyroxene hornfels

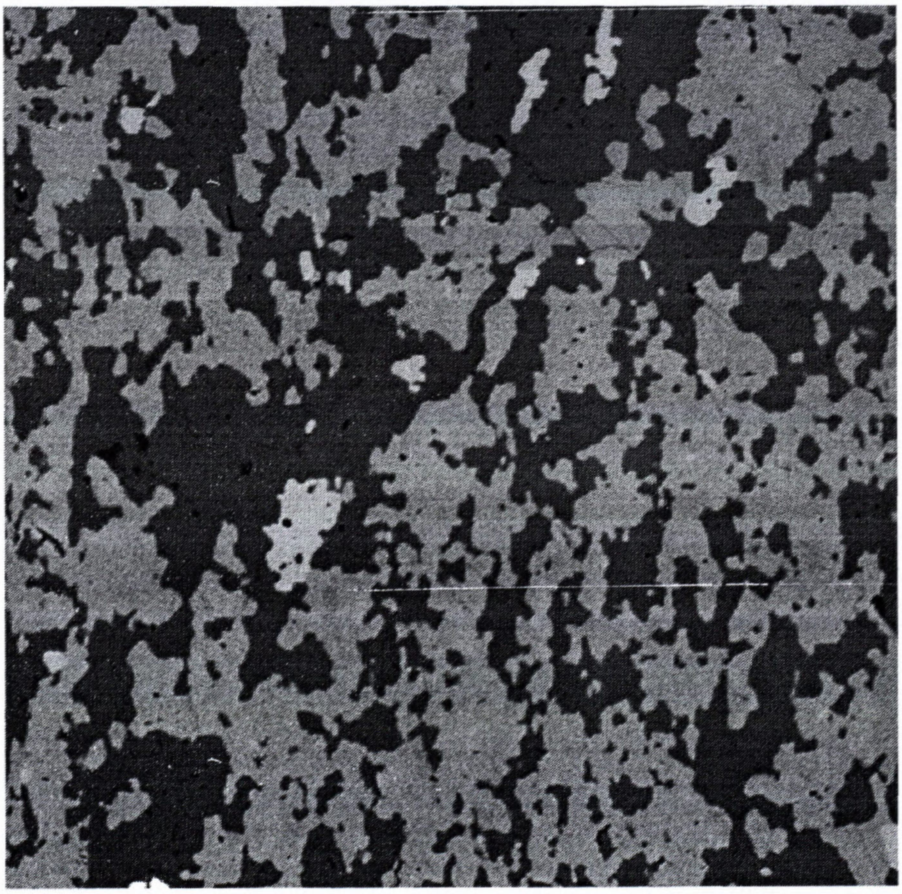

Fig. 5. Back scattered electron image of the studied rock. Axe No. 1364. Light portions = clinopyroxenes, dark portions = plagioclases.Enlarg.180 x.

scopical crystals allways in clinopyroxenes. Its origin in breakdown process of original clinopyroxene is probable.

Discusion and conclusion

Identical mineral composition of all 4 axes found within one archaeological site and one culture allows to suppose:

a) one rock block to be raw material source,

b) this rock block have been elaborated just on the axes finding site,

c) transport of mentioned block in "distance of one or several days walk" is the most probable,

d) non significant textural (pattern) differences should reflect spatial location of given partial piece in the frame of bigger block used for discrete implement construction.

Based on mineral composition of the given rock and namely on its texture (pattern) contact-thermic recrystal-

Slovak Geol. Mag., 7, 3 (2001), 303 – 308

Tab. 1 Composition of clinopyroxene

Sample	1379	1379	1379	1634	1634	1634	1876	1876	1876	1364	1364	1364
N. anal.	3	4	6	8	10	11	15	16	17	21	22	23
SiO_2	51.28	50.44	52.07	51.34	51.84	52.45	52.07	52.26	52.23	51.93	51.89	51.71
TiO_2	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Al_2O_3	0.84	0.42	0.48	1.71	0.32	0.67	0.46	0.49	0.51	0.49	0.71	1.25
FeO^+	14.03	17.44	13.16	12.67	11.27	12.61	12.80	11.90	12.04	13.51	14.71	13.90
MnO	0.44	0.35	0.00	0.00	0.00	0.28	0.36	0.33	0.26	0.00	0.41	0.32
MgO	9.14	7.21	9.68	9.83	11.62	10.47	9.94	11.06	10.50	9.73	8.87	9.32
CaO	24.22	23.55	24.74	24.09	24.01	24.40	24.07	24.40	24.22	24.07	24.08	24.14
Na_2O	0.00	0.00	0.00	0.12	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00
K_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	99.95	99.41	100.13	100.01	99.06	100.98	99.70	100.44	99.76	99.73	100.67	100.64
Formula based on 6 O												
Si^{IV}	1.98	1.98	1.99	1.96	1.98	1.98	2.00	1.98	1.99	1.99	1.99	1.97
Al^{IV}	0.02	0.02	0.01	0.04	0.01	0.02	0.00	0.02	0.01	0.01	0.01	0.03
Al^{VI}	0.02	0.00	0.01	0.04	0.00	0.01	0.02	0.00	0.01	0.01	0.02	0.03
Ti	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe^{2+}	0.45	0.57	0.42	0.40	0.36	0.40	0.41	0.38	0.38	0.43	0.47	0.44
Mn	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.01	0.01
Mg	0.53	0.42	0.55	0.56	0.66	0.59	0.57	0.63	0.60	0.56	0.51	0.53
Ca	1.00	0.99	1.01	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Na	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
K	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FeO^+ = total Fe as FeO

Tab. 2 Composition of plagioclases

Sample	1379	1379	1624	1624	1876	1876	1876	1364	1364	1364
N. anal.	1	5	7	9	12	13	14	18	19	20
SiO_2	49.81	49.03	46.80	46.38	50.68	51.51	49.85	49.40	48.72	48.06
Al_2O_3	31.90	32.18	34.56	34.29	31.34	30.85	32.00	32.45	32.13	33.43
FeO	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24
CaO	15.18	15.06	17.57	17.63	13.51	12.94	14.46	15.00	15.12	15.58
Na_2O	3.17	2.75	1.75	1.56	3.90	3.93	3.35	3.01	3.06	2.47
K_2O	0.11	0.00	0.08	0.10	0.00	0.00	0.12	0.13	0.08	0.00
TOTAL	100.54	99.02	100.76	99.96	99.43	99.23	99.78	99.99	99.11	99.78
Formula based on 8 O										
Si^{IV}	2.27	2.26	2.14	2.13	2.32	2.35	2.28	2.26	2.25	2.20
Al^{IV}	1.71	1.74	1.86	1.86	1.68	1.65	1.72	1.74	1.75	1.80
Al^{VI}	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.01	0.00	0.01
Fe^{2+}	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Ca	0.74	0.74	0.86	0.87	0.66	0.63	0.71	0.73	0.75	0.77
Na	0.28	0.25	0.15	0.14	0.35	0.35	0.30	0.27	0.27	0.22
K	0.01	0.00	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.00
Or	0.60	0.00	0.50	0.60	0.00	0.00	0.70	0.80	0.50	0.00
Ab	27.30	24.80	15.20	13.70	34.30	35.50	29.30	26.50	26.70	22.30
An	72.10	75.20	84.30	85.70	65.70	64.50	70.00	72.80	72.90	77.70

FeO^+ = total Fe as FeO

lization of its protolith has been the leading process of the origin of this raw material type.

As the site Svodín is located on southwestern rim of the central Slovakia Late Tertiary volcanic province, thermic effect of volcanic/subvolcanic bodies on adjacent rock complexes is considered. In individual cases also blocks of surrounding rocks should have been incorporated into thermally not yet consolided lava flows or subvolcanic bodies and underwent thermic recrystallization under pyroxene hornfels facies pT conditions.

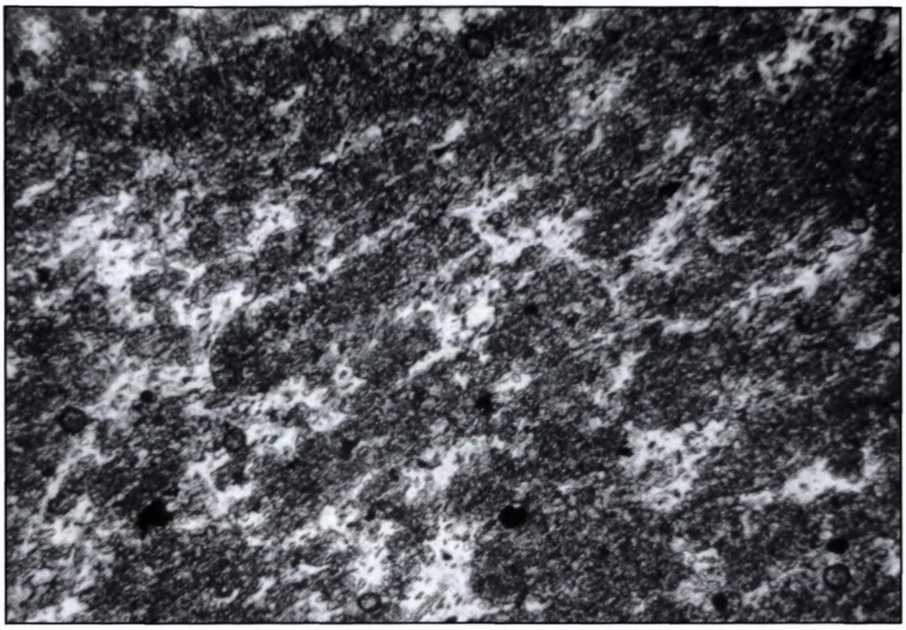

Fig. 6. Expresionless foliation of plagioclase-diopside hornfels. Enlarg. 90x, // polars

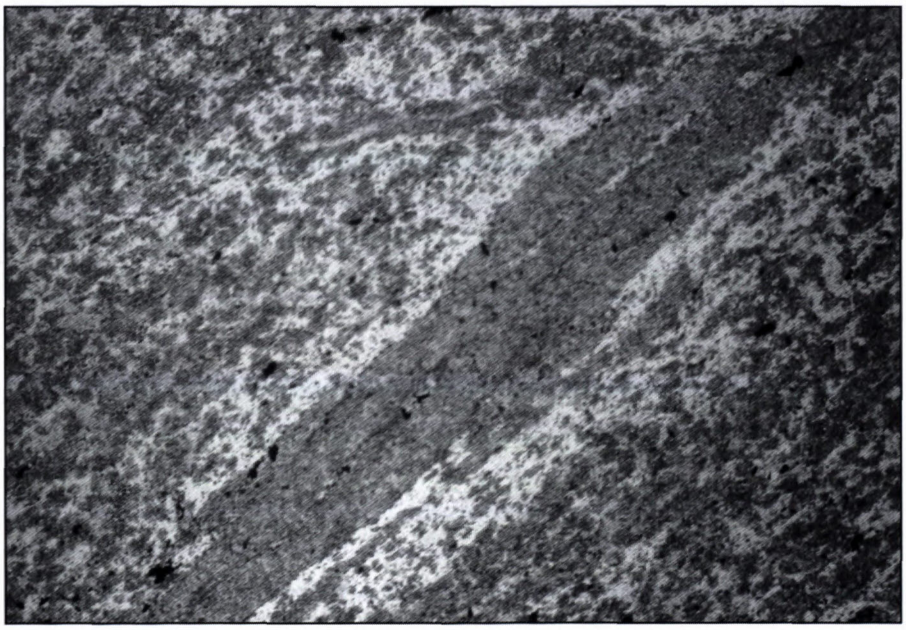

Fig. 7. Monomineralic clinopyroxene "vein" in hornfels (No. 1264) on the rim of which higher concentration of plagioclases is visible. Enlarg. 27x, // polars

Rapid diminishing of heat flow and the absence of water vapor in both media resulted in the absence of retrogressive stage mineral association in the given rock. More-or-less homogeneous grain size and homogeneous distribution of mineral phases in the rock allows to suppose fine grained premetamorphic protolith of the discussed hornfels. Based on the determined content of main oxids, namely those of SiO_2, Al_2O_3, CaO and FeO, in leading mineral phases (clinopyroxenes and plagioclases), fine grained volcaniclastics of andesito-basaltic composition should be considered as original premetamorphic rock. Due to the fact that mineral composition of the axes under study is simple (basically, only two mineral phases are represented) and they are rather evenly grained to tried to calculate their chemical composition. We did this on the basis of modal composition detected with electron microrpobe (Fig. 5) and from analyzed mineral composition. Density values for individual minerals were taken from Deeer et al. (1983) and we considered the minerals closest in composition to our minerals being compared. The most suitable samples for calculation were Nos. 1364 and 1876. The initial value and the resulting chemical composition are given in the Table 3 the supplementary information on the original rocks which the axes were made from. The calculated data result in the following conclusions:

i) the contents of all main oxids except for CaO point to the basic character of the original rocks

i) compared to common basalt types the axes under study show increased CaO contents.

The increased CaO content and consequently modal composition as well may be a reflection of two possible primary sources:

1. the original (premetamorphic) rocks of axes were basic volcaniclastic rocks with an admixture of carbonate material (increased CaO content)

Table 3. Composition of main phases of hornfels being basis for rock chemistry calculations

Minerals	Cpx	Plg	Cpx	Plg
Sample	1876	1876	1364	1364
N. anal.	17	12	10	19
SiO_2	52,23	50,68	51,84	48,72
TiO_2	0,00		0,00	
Al_2O_3	0,51	31,34	0,32	32,13
FeO^+	12,04	0,00	11,27	0,00
MnO	0,26		0,00	
MgO	10,50		11,62	
CaO	24,22	13,51	24,01	15,12
Na_2O	0,00	3,90	0,00	3,06
K_2O	0,00	0,00	0,00	0,08
TOTAL	99,76	99,43	99,06	99,11

Density	3,43	2,71	3,43	2,71
Vol.%	49,80	48,90	47,00	50,00
Weight part	170,81	132,32	161,21	135,70
Weight %	56,35	43,65	54,30	45,70

Table 4. Calculated composition of rocks

Sample	1364	1876
	Weight %	Weight %
SiO_2	50,88	51,75
TiO_2	0,00	0,00
Al_2O_3	15,00	14,02
FeO^+	6,18	6,81
MnO	0,00	0,15
MgO	6,37	5,94
CaO	20,13	19,62
Na_2O	1,41	1,71
K_2O	0,04	0,00
TOTAL	100,01	100,00

2. The original rocks of axes were basic rocks with high clinopyroxenes and basic plagioclases contents originated by fractionation and/or differentiation.

Taking into account all available information we prefer possibillty presented ad 1).

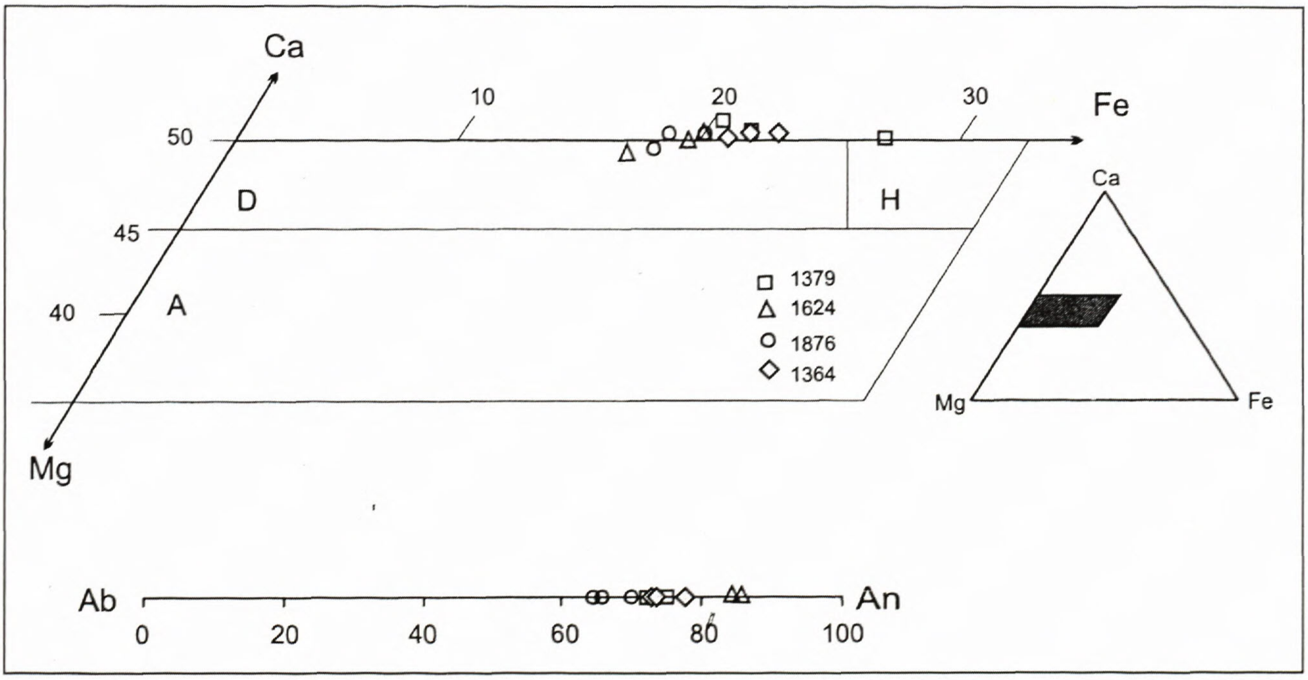

Fig. 8. Plot of analysed clinopyroxenes and plagioclases in diagram

References

Hovorka, D. and Illášová, Ľ. 2000: What do we know about abiotic raw materials used by the Neolithic/Aeneolithic populations on the territory of nowadays Slovakia? Krystalinikum, 26, 83-110, Brno.

Kaczanowska, M. und Kozlowski, J. K. 1991: Spaltindustrie der Lengyel-Kultur aus Svodin, Slowakei. Uniw. Jagielonski - Panstw. wydaw. Naukowe, 116 S., Warszawa - Kraków.

Morimoto, N., Fabries, J., Ferguson, A. K., Ginzburg, I. V., Ross, M., Seifert, F. A., Zussman, J., Aoki, K. and Gottardi, G. 1988: Nomenclature of pyroxenes. Amer. Mineralogist, 73, 1123-1133.

Němejcová-Pavúková, V. 1995: Svodín. Zwei Krerisigrabenanlagen der Lengyel-Kultur. Studia archaeologica Mediaevalia, Tomus II, 1-249, Bratislava.

Pavúk, J., Hovorka, D. and Illášová, Ľ. 2000: Svodín - raw material used by population of type locality of the lengyel culture (Aeneolithic): western Slovakia. 3rd workshop of the IGCP/ UNESCO Project No. 442, 19-20, Eggenburg, Austria