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Micromorphology of the weathering products of some soil-forming igneous rocks of the Sudetes

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INTRODUCTION

The weathering process is the fundamental soil-forming one, as it leads in the final effect to a more or less visible differentiation of the soil mass in its natural state. From among many factors responsible for the weathering process and the soil formation the most important one is the parent material, as its structure, mineral composition, chemical and physical properties condition the rate of change occurring in the soils. Therefore, soils developed from various parent formation usually show different bio-physico-chemical and typological properties [1, 2, 6, 7, 9, 10, 11].

From this starting point the main aim of the investigation was to trace the changes occurring in the weathering process of igneous rocks, taking as example the representatives of two different groups: (1) granite, as an acid rock (Fig. 7), and (2) olivine gabbro, as an alkaline rock (Figs. 3, 10). These rocks come from the Sudetes and are parent materials of brown soils occurring there.

INVESTIGATION METHODS

The examined soils are utilized as permanent green culture being situated at 440-490 m above sea level, under similar climatic conditions. The mean annual temperature is from 6.0 to 6.6°C and the sum of annual precipitation amounts from 700 to 1,000 mm.

In the investigated soil profiles a special attention was paid to micromorphological features determined by Kubiëna's and Brewer's methods [8, 3]. Also have been investigated the micromorphological changes in the parent rocks and soils developed therefrom and have been designated the mineral components of different soil horizons. The examination were completed by determinig the granulometric composition after Gorbunow's sievy-sedimentation method [5], and by X-ray after the Debye-Scherer-Hull's method.

Table 1. Some micromorphological properties of investigated soil profiles

Soil profile	Horizon	Depth cm	Plasma	Distribution of skeleton and plasma	Voids		
					arrangement	morphology	size in μ
Brown soil developed from weathered granite	A_1	0-22	silasepic, locally skelsepic	agglomero-plasmic	intrapedal	vughs, channels	30-600
	(B)	22-35	sila-skelsepic, locally vomasepic	agglomero-plasmic	intrapedal	vughs	30-600
	C	> 35	sila-skelsepic, locally mavosepic	agglomero-plasmic	intrapedal	vughs, channels	30-400
Brown soil developed from weathered olivine gabbro	A_1	0-20	silasepic, locally skelsepic	agglomero-plasmic	intrapedal interpedal	vughs, channels	30-650
	(B)	20-45	silasepic, locally skelsepic	agglomero-plasmic	interpedal intermineral	vughs, channels	30-500
	C	> 45	skelsepic, locally insepic	agglomero-plasmic granular	intermineral	vughs	30-700

INVESTIGATION RESULTS

Some more important micromorphologic properties of the investigated soils are shown on Table 1, and the Figs. 1-12, whereas their mineral composition and the organic matter contents are given on Table 2.

THE PROFILE DEVELOPED FROM WEATHERED GRANITE

The granulometric composition of the brown soil developed from granite in its upper horizons A_1 and (B) was that of loamy sand, while the parent rock underlying beneath 35 cm had the granulometric composition of loamy gravel.

As shown on Table 1 the characteristic plasma form is a silaskelsepic and, somewhere, a vo-masepic one. The latter appears in a bit greater amounts in the middle and lower horizons of the investigated soil profile (Figs. 1, 2, 8, 9).

Granite, as the parent rock of the examined soil has granular structure and disorderly compact arrangement. Its mineral composition comprises, first of all, quartz, potassium feldspars, plagioclases, and biotite.

Table 2. Mineral composition and organic matter of investigated soil profiles

Soil profile	Horizon	Depth cm	Organic matter %	*Quartz* %	Feldspar %	Plagioclase %	Pyroxene %	Mica %	Chlorite %	Olivine %	Clay plasma %	Iron-clay plasma %	Main clayey mineral-groups		
													kaolinite	illite	montmorillonite
Brown soil developed from weathered granite	A_1	0-22	5.2	24.8	17.6	4.0	—	2.8	—	—	33.2	12.4	+++	++	—
	(B)	22-35	0.2	43.0	23.2	5.7	—	2.4	—	—	19.8	5.7	+++	++	—
	C	> 35	0.1	41.9	25.1	10.0	—	2.4	—	—	16.6	3.9	+++	+	—
Brown soil developed from weathered olivine gabbro	A_1	0-20	7.2	—	—	28.8	12.3	—	2.3	0.4	45.7	3.3	—	+	+++
	(B)	20-45	2.0	—	—	25.0	13.4	—	4.6	—	37.1	17.9	—	+	+++
	C	> 45	—	—	—	50.1	42.9	—	0.1	0.6	1.3	5.0	—	+	+++

Explanations: +++ > ++ > +; — not identified.

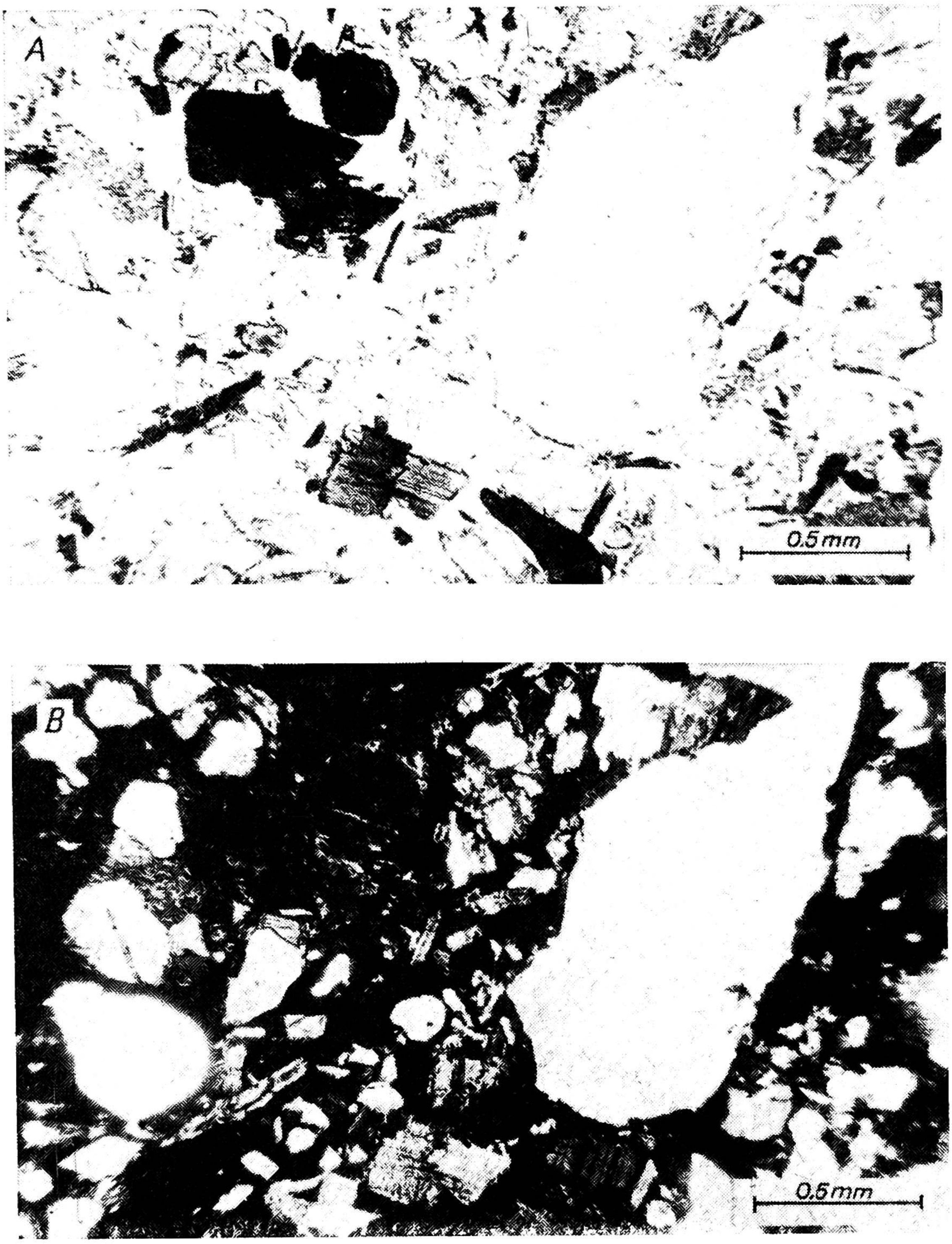

Fig. 1. Micromorphology of brown soil developed from granite. Horizon C, depth 70-120 cm. Weathered granite. Feldspars and biotite show some marks of weathering. Visible granular desintegration. *A* — in plain light, *B* — under crossed polarizers.

Quartz forms xenomorphic grains. In the weathering process it undergoes mainly physical disintegration; its amount, generally, increases in the lower soil horizons.

Potassium feldspars occur as pertites with well visible plagioclase laminae. They show twinnings of Carlsbad type, and rarely occur in fresh form and are usually woven with lamellae of gray low-birefringent kaolinite.

Plagioclases mostly exhibit an advanced weathering process starting in twinning seams and mineral cracks. There mainly is observed a process of sericitization, but rarelier of kaolinization.

Biotite occurs in small amounts. It forms elongated laminae of olive and/or brown colour at different weathering degrees. During the weathering the traces of cleavage planes get obliterated, and the colour of the mineral becomes unequally intensive. Along with intensification of the weathering process the mineral grains get woven with black precipitations of iron oxide compounds. As weathering process advances, only very weak pleochroism reveals the mineral form to be a product of biotite metamorphosis [7]. This is in keeping with Meyer's and Kalk's observations [9].

Mineralogical quantitative analysis at the soil profile developed from

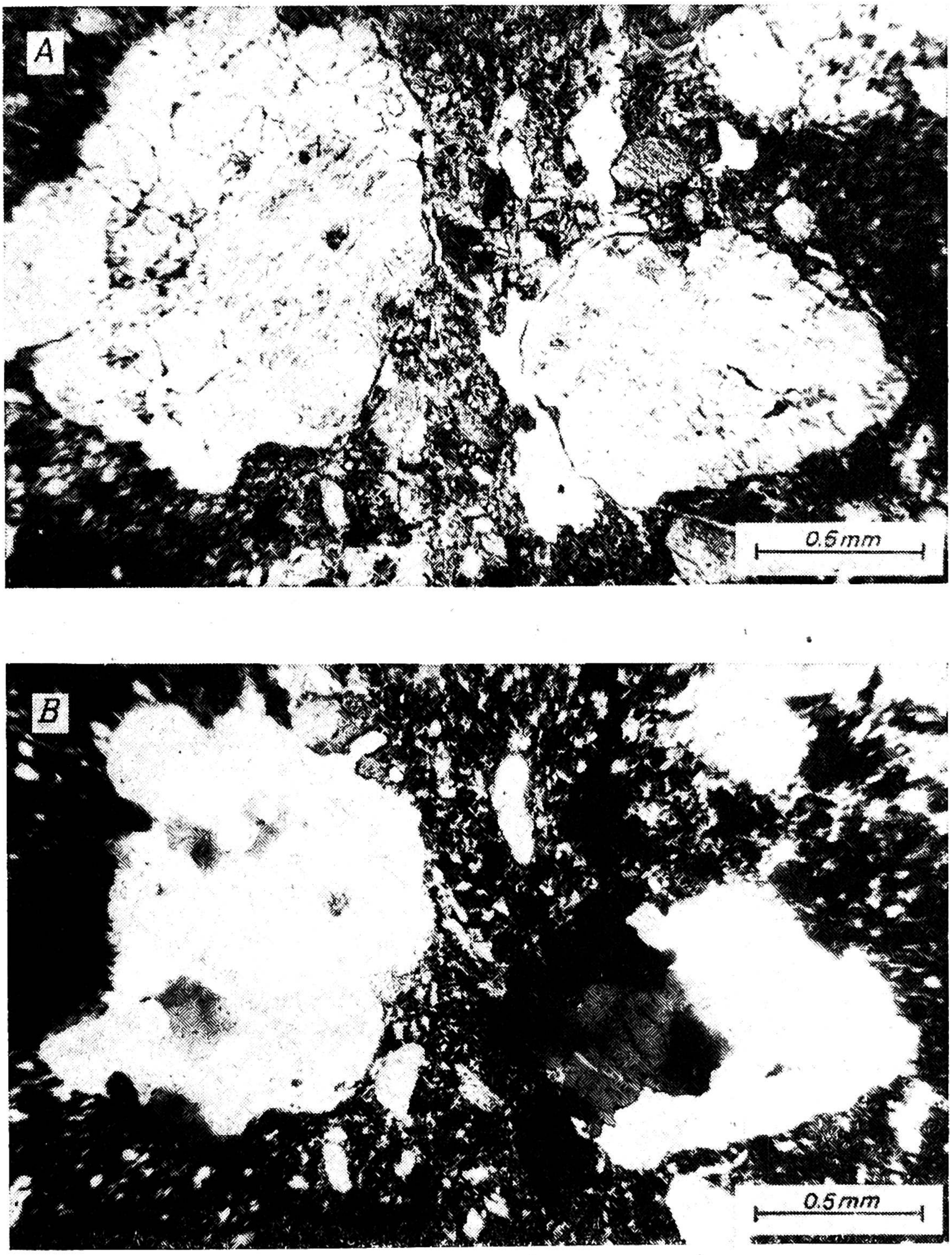

Fig. 2. Micromorphology of brown soil developed from granite. Horizon (B), depth 22-35 cm. Silasepic. Bigger mineral grains weakly weathered. *A* — in plain light, *B* — under crossed polarizers.

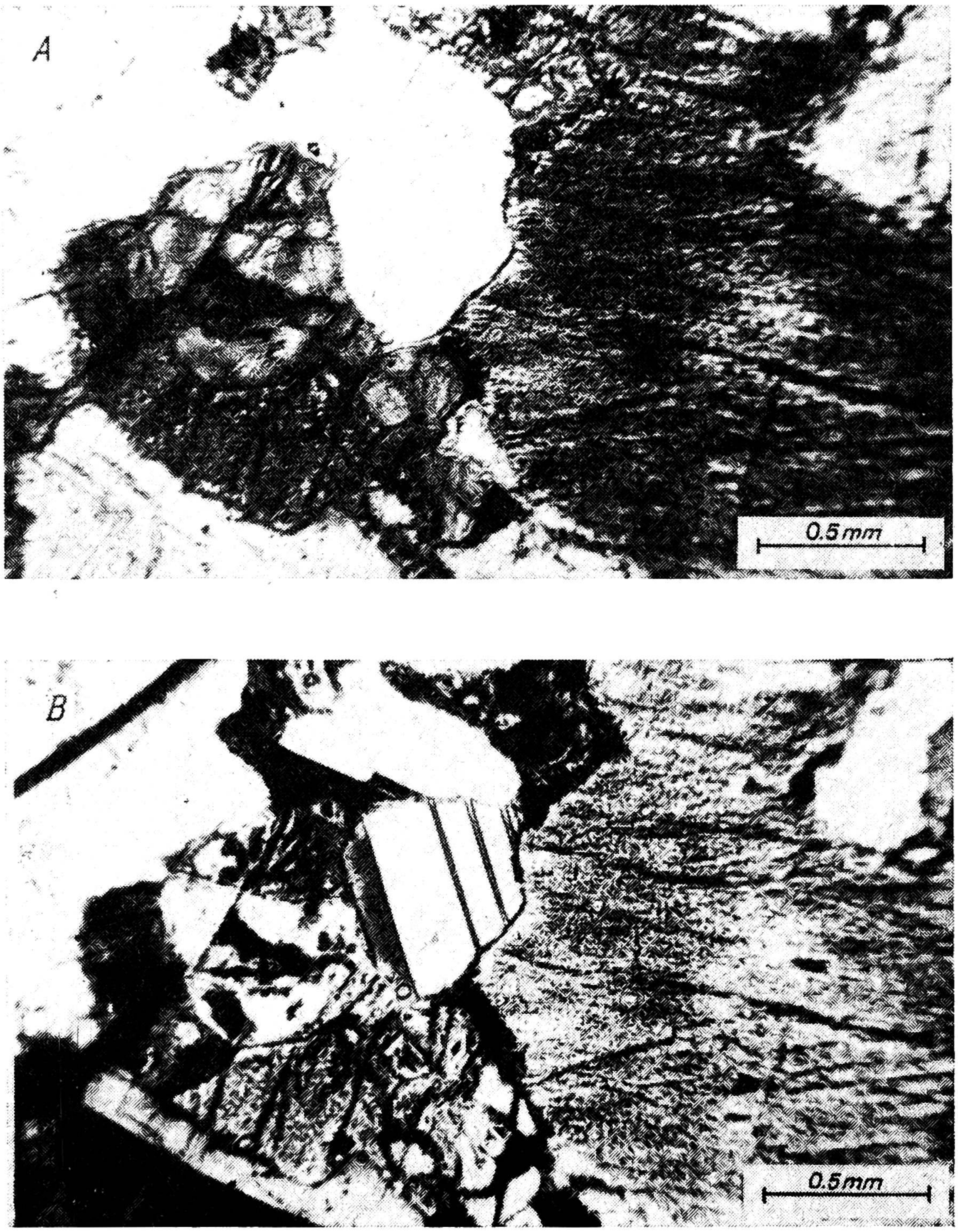

Fig. 3. Micromorphology of brown soil developed from olivine gabbro. Horizon C, depth 115-150 cm. Olivine gabbro as the parent rock. Main minerals show slight weathering. *A* — in plain light, *B* — under crossed polarizers.

granite points to a relatively easy weathering of feldspars. Therefore, in the microscopic picture only few unweathered feldspar grains can be found. Thus one can explain the dependence between the contents of feldspars and clay plasma in horizons A_1 and (B). In the upper soil horizons the amount of clay plasma is twice as great as in horizon C. When going deeper into the soil profile the amount of unweathered feldspars increases. On X-ray lines of the fractions finer than 1 μ the clay minerals developed from weathered granite have been found consisting mainly of kaolinite and illite (Table 2).

THE PROFILE DEVELOPED FROM WEATHERED OLIVINE GABBRO

The brown soil developed from olivine gabbro shows a granulometric composition of horizon A_1 and (B) as skeletic silty-loam, and of horizon (C) as a loamy gravel. Micromorphologically, the characteristic plasma is silasepic (Table 1, and Figs. 5, 6, 12). Locally skelsepic appears, too, hampering the weathering of some mineral grains (Fig. 11). Comparing to the soil profile developed out of granite, this soil derived from gabbro did not show any typical vosepic plasma.

Gabbro, as the parent rock of the studied soil has a coarse grain structure and a disorderly compact fabric. Its mineral composition comprises

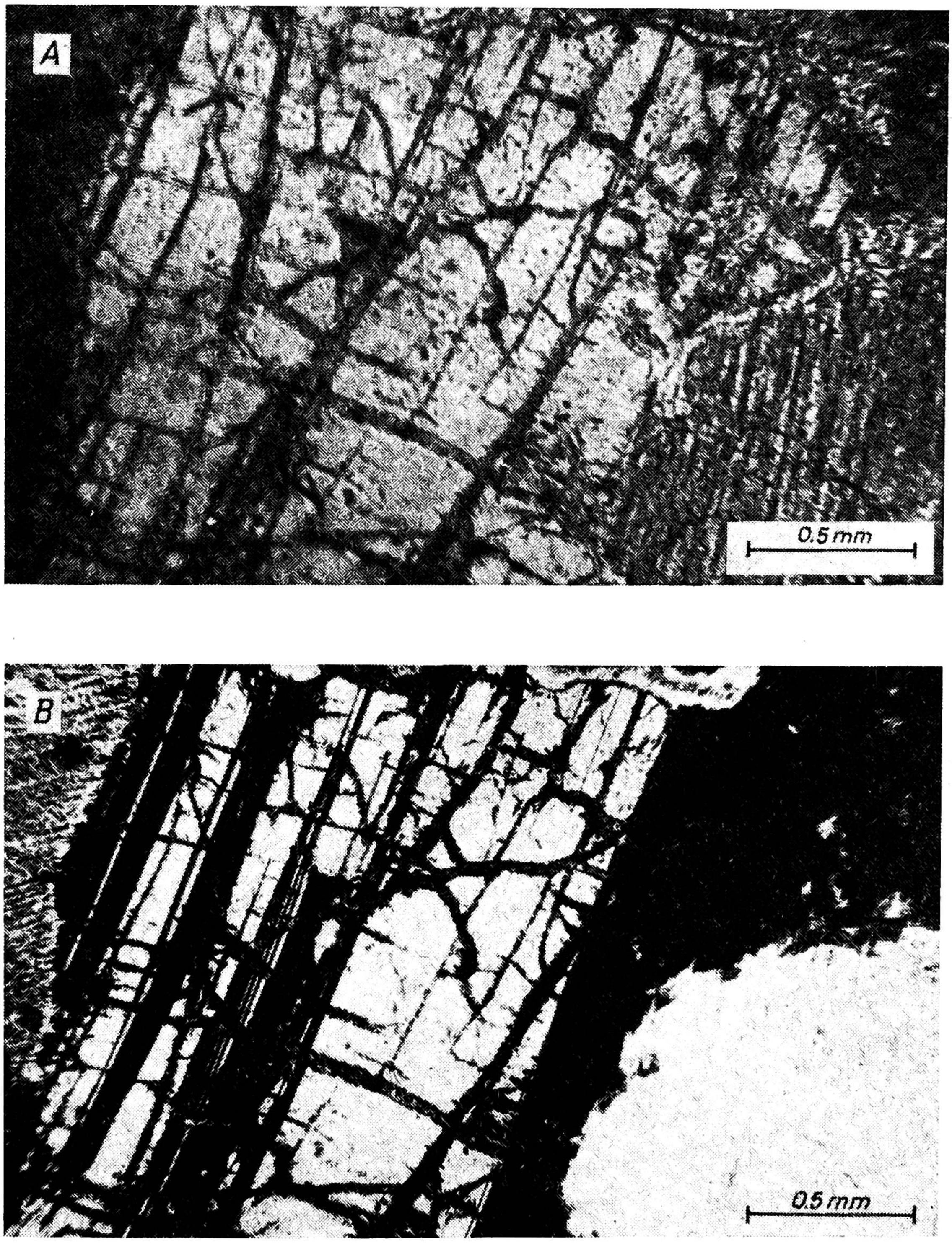

Fig. 4. Micromorphology of brown soil developed from olivine gabbro. Horizon C, depth 65-100 cm. Slightly weathered gabbro. A jointy grain of labradorite; secondary products of weathering in form of low-birefringent gray lamellae accumulated in the cracks. *A* — in plain light, *B* — under crossed polarizers.

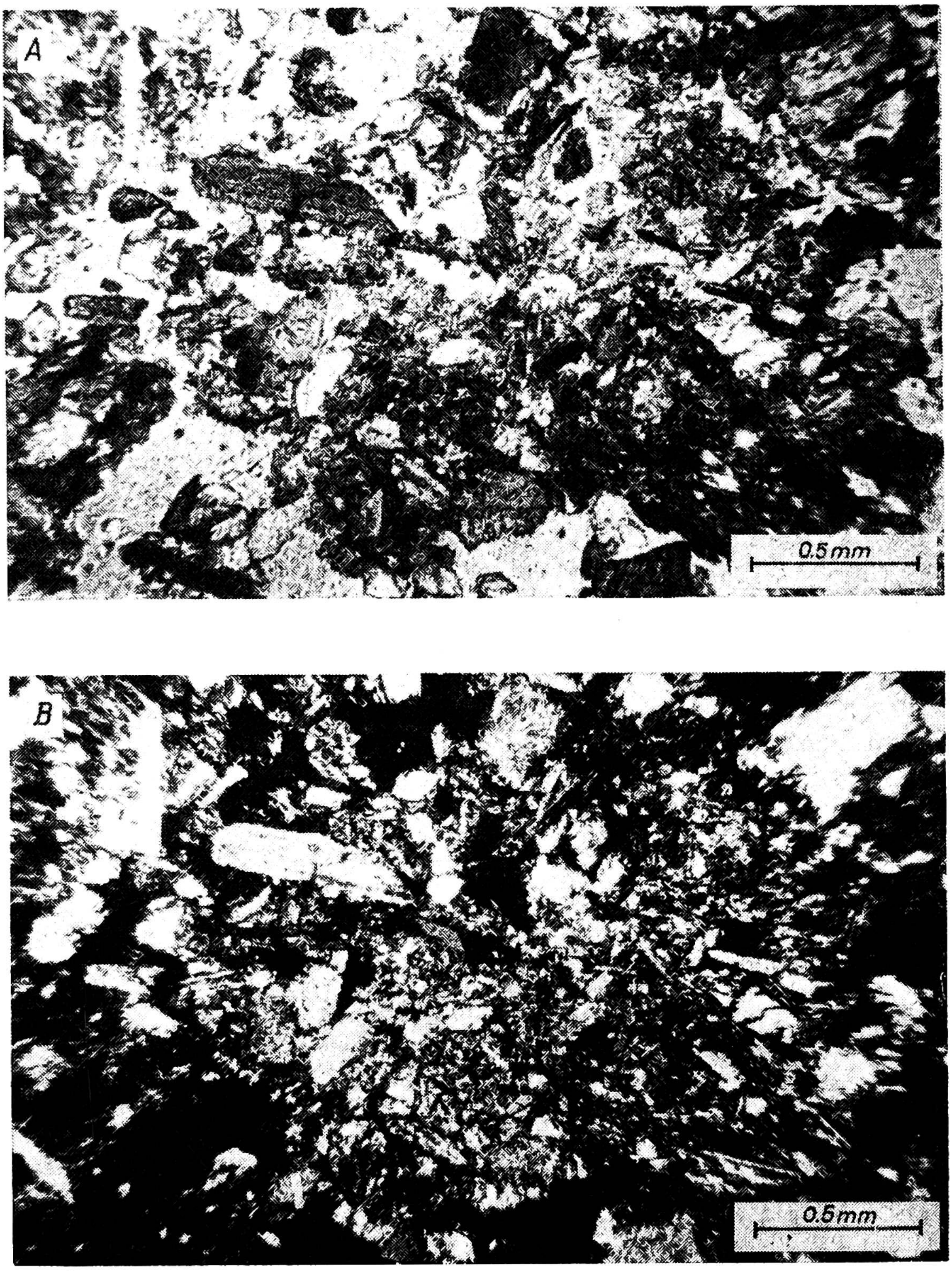

Fig. 5. Micromorphology of brown soil developed from olivine gabbro. Horizon (B), depth 20-45 cm. Silasepic. Plagioclases and pyroxenes show higher disintegration. *A* — in plain light, *B* — under crossed polarizers.

plagioclases (labradorite), pyroxene (diallage) and olivine. To the minerals arising at the cost of primary minerals belong: uralite hornblende, chlorite, iron hydroxide compounds and serpentine minerals.

Among plagioclases, first of all *labradorite* exhibits albite and albite-pericline twinnings. Along with decreasing depth the number of fresh grains decreases. The weathering starts in twinnings seams and cracks of the minerals (Fig. 4).

Among pyroxene, *diallage* forms grains of gray colour changing in polarized light according to section. It undergoes disintegration faster than plagioclase.

Olivine forms grains of gently rounded up shapes. These are, as a rule, antigorite pseudomorphoses of light-green colour with separated black pigment of magnetite. This mineral gets fastest weathered, that being in keeping with Goldich's observations [4].

In the profile of brown soil developed from olivine gabbro, there is observed a similar phenomenon of increasing contents of clay plasma in horizons A_1 and (B). A characteristic feature of horizon (B) is the accumulation of a greater amount of iron compounds.

In the mineral composition of clay fractions coming from weathered olivine gabbro, there mainly appear montmorillonite accompanied by illite.

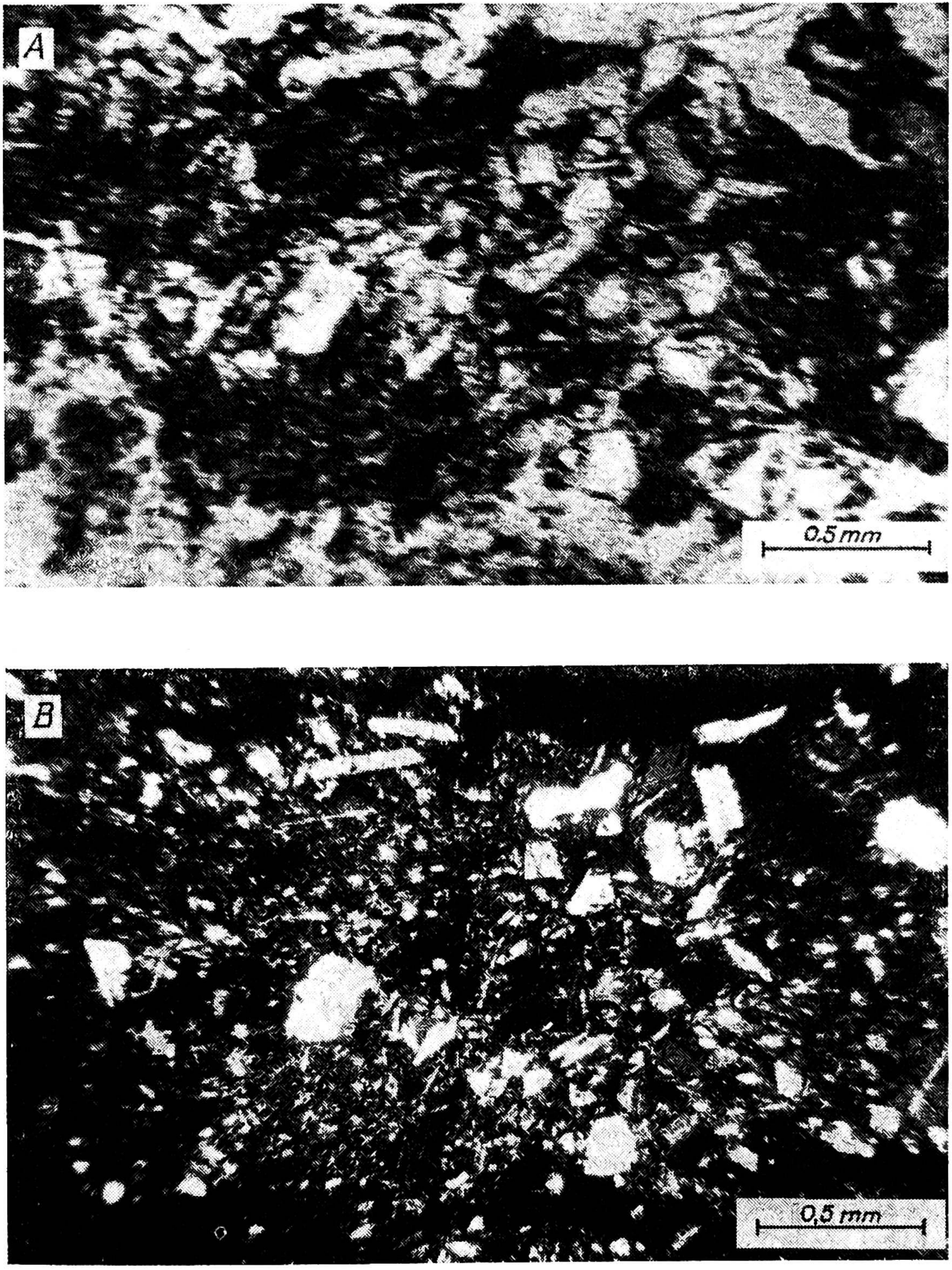

Fig. 6. Micromorphology of brown soil developed from olivine gabbro. Horizon A_1, depth 0-20 cm. Silasepic, locally skelsepic. Mineral grains show higher desintegration. *A* — in plain light, *B* — under crossed polarizers.

CONCLUSIONS

The micromorphologic investigation has allowed to draw the following conclusions:

1. The minerals contained in the examined soil parent rock may be ranked according to their rising resistance to the action of weathering factors. This range is (1) in case of soil developed from granite: biotite—plagioclase—potassium feldspar—quartz, and (2) in case of soil developed from olivine gabbro: olivine—pyroxene—plagioclase.

2. In the mentioned soils, during the weathering of granite, there forms mainly kaolinite and illite, and during the weathering of olivine gabbro—montmorillonite and insignificant amounts of illite.

3. The soil developed from granite has the character of oligotrophic brown soil with the tendency to a more distinct dislocation of colloidal clay deep into the profile and transition into the lessivé soil stage.

4. The soil developed from olivine gabbro belongs to the eutrophic and/or mesotrophic brown soils, where any more distinct features in the profile differentiation of the flow plasma are not observed.

5. The soil developed from granite, as compared to those developed from olivine gabbro, shows greater profile differentiation of the plasma, particularly that of vosepic type.

SUMMARY

The aim of the investigation was to trace the changes occurring during the weathering process of igneous rocks representative of two different groups: (1) granite, as an acid rock, and (2) olivine gabbro, as an alkaline rock, appearing in the region of the Sudetes and being the parent rocks of those brown soils.

The soil formed out of granite has the character of oligotrophic brown soil with the tendency to a more distinct displacement of colloidal clay down the profile and passing into the stage of lessivé soil. The soil formed out of olivine gabbro belongs to the eutrophic or mesotrophic brown soils in which no more distinct features in the profile differentiations of plasma are observed.

X-ray examinations of fractions smaller than 0.001 mm have shown that in the above mentioned mineral soils in the weathering process of granite are formed mainly kaolinite and illite, and in the weathering process of olivine gabbro are formed montmorillonite and some slight amounts of illite.

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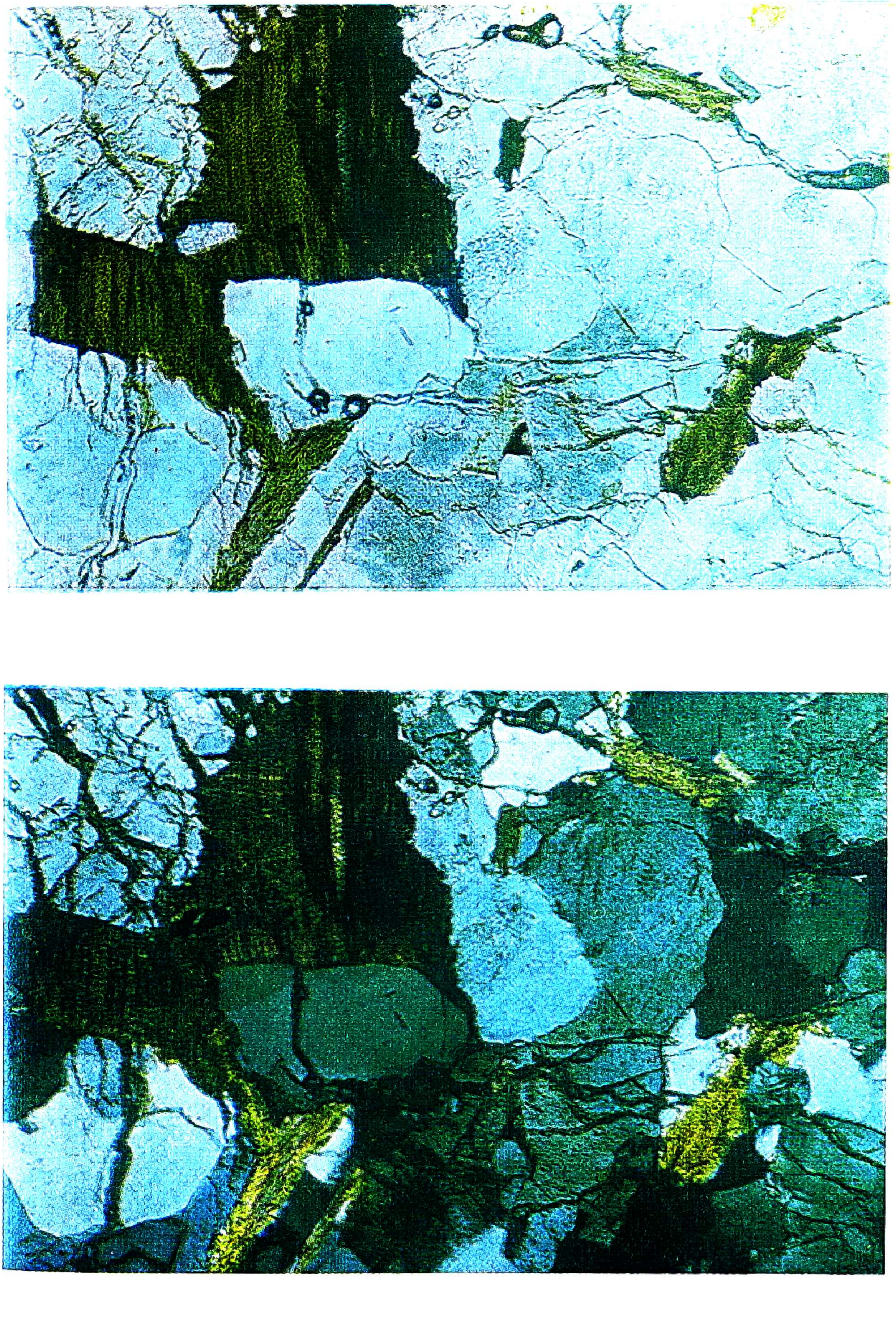

Fig. 7. Micromorphology of brown soil developed from granite. Horizon C, depth 120-180 cm. Granite as the parent rock. Granular structure, and disorderly compact arrangement. *A* — in plain light, *B* — under crossed polarizers. Magnif. ×36.

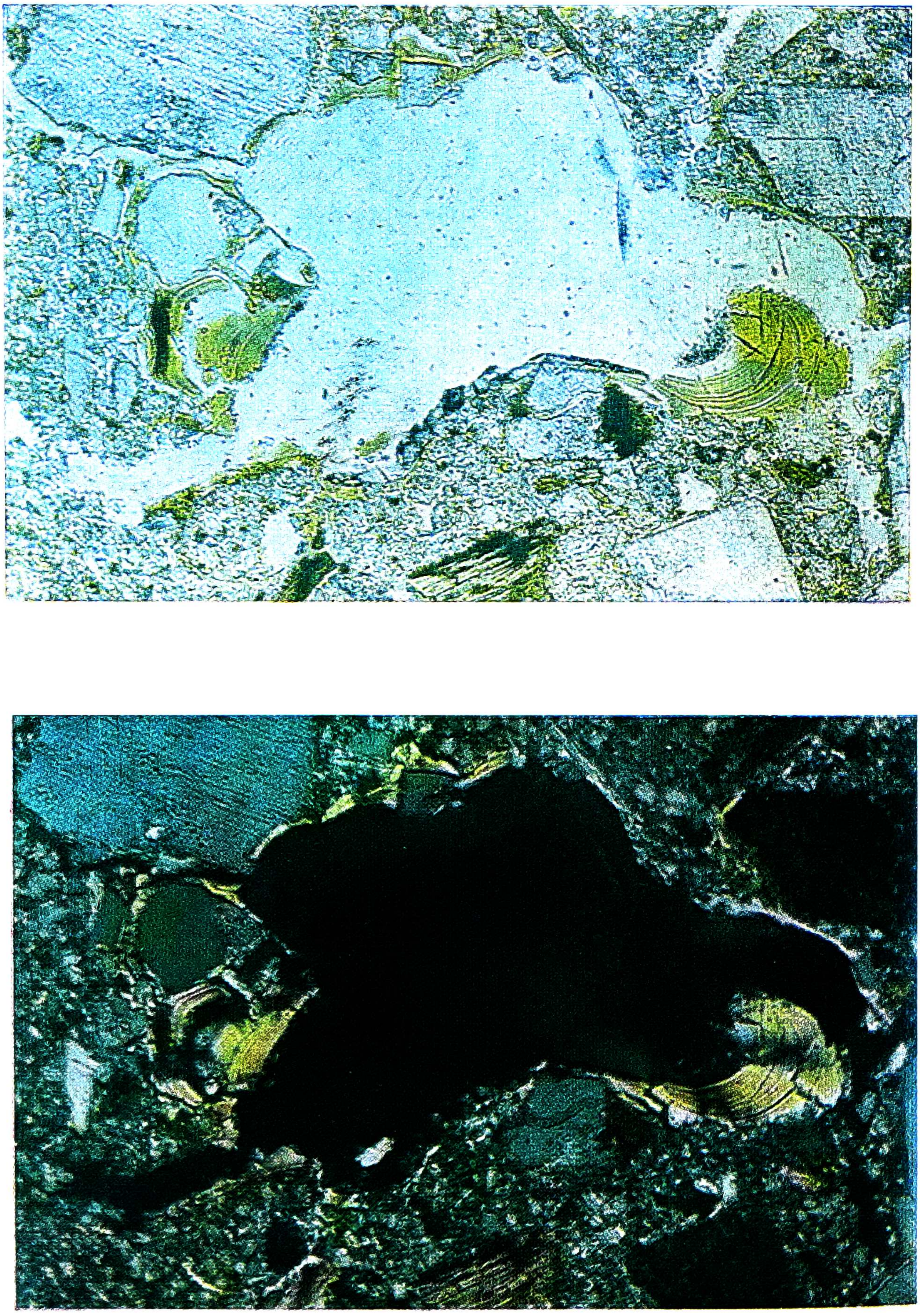

Fig. 8. Micromorphology of brown soil developed from granite. Horizon (B), depth 22-35 cm. Vosepic. On the walls of voids clay-ferruginous coatings. Flown from of plasma. *A* — in plain light, *B* — under crossed polarizers. Magnif. × 36.

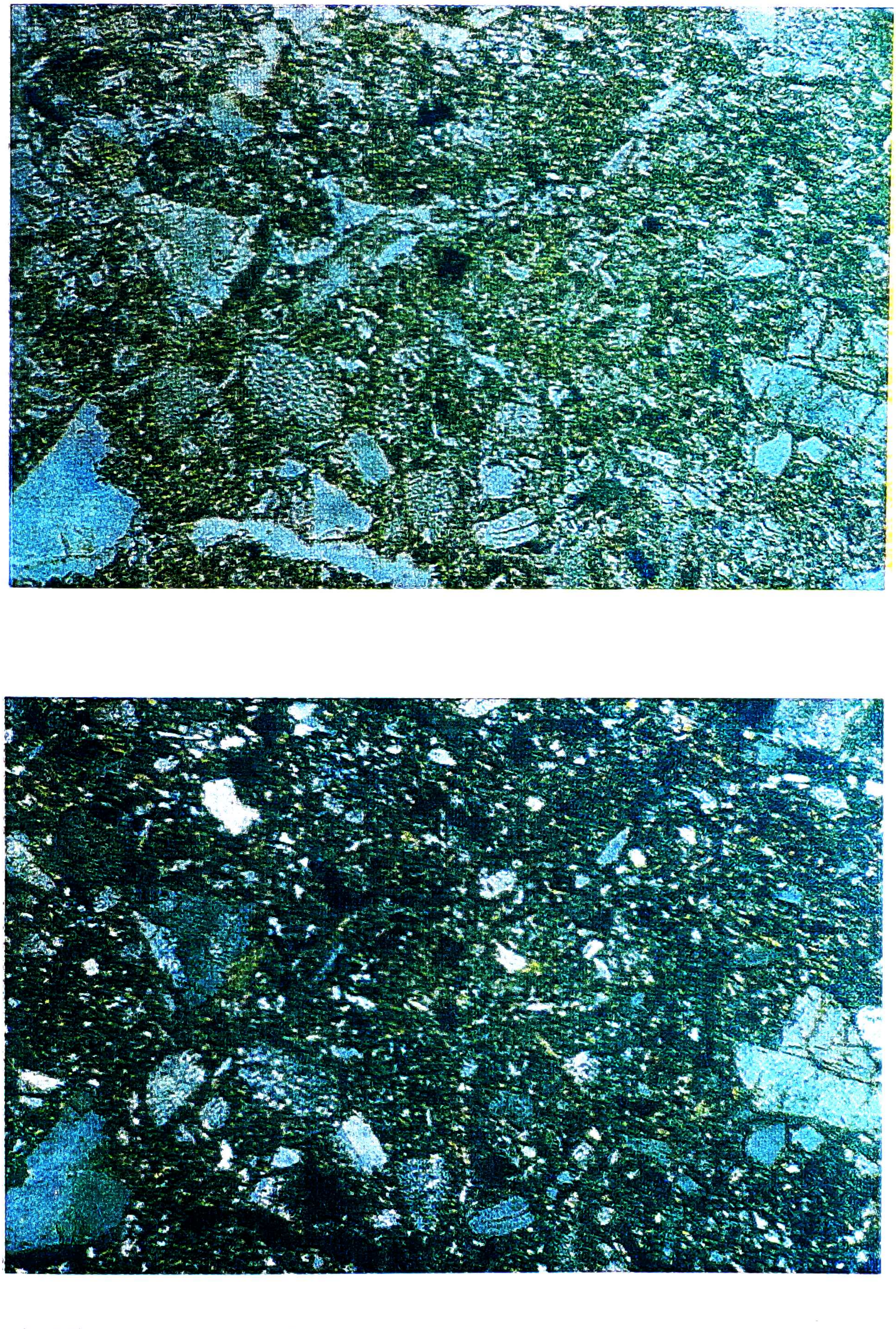

Fig. 9. Micromorphology of brown soil developed from granite. Horizon A_1, depth 0-22 cm. Silasepic. Main minerals show higher disintegration. *A* — in plain light, *B* — under crossed polarizers. Magnif. × 36.

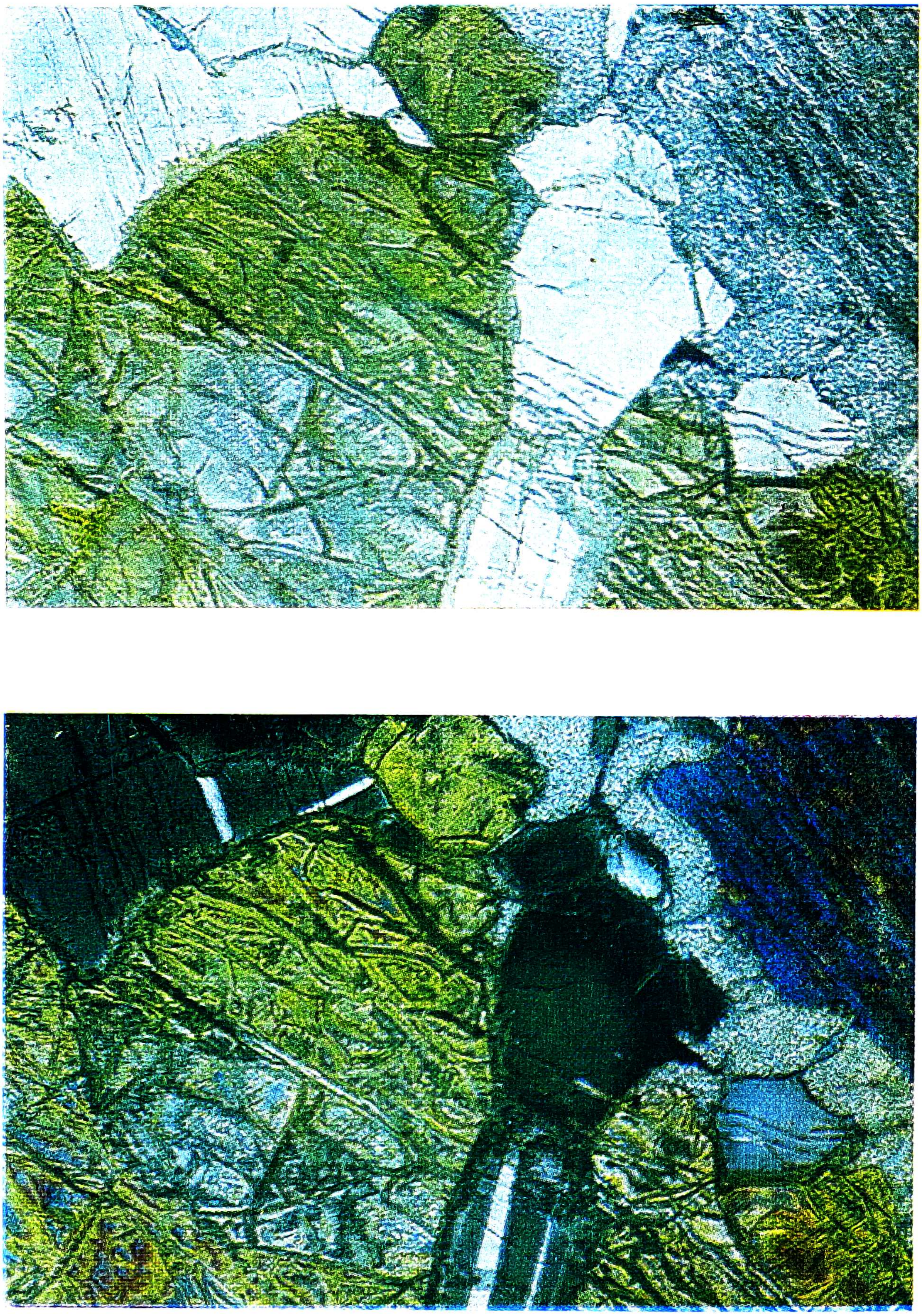

Fig. 10. Micromorphology of brown soil developed from olivine gabbro. Horizon C, depth 100-115 cm. Olivine gabbro as the parent rock. Granular structure, and disorderly compact arrangement. *A* — in plain light, *B* — under crossed polarizers. Magnif. × 36.

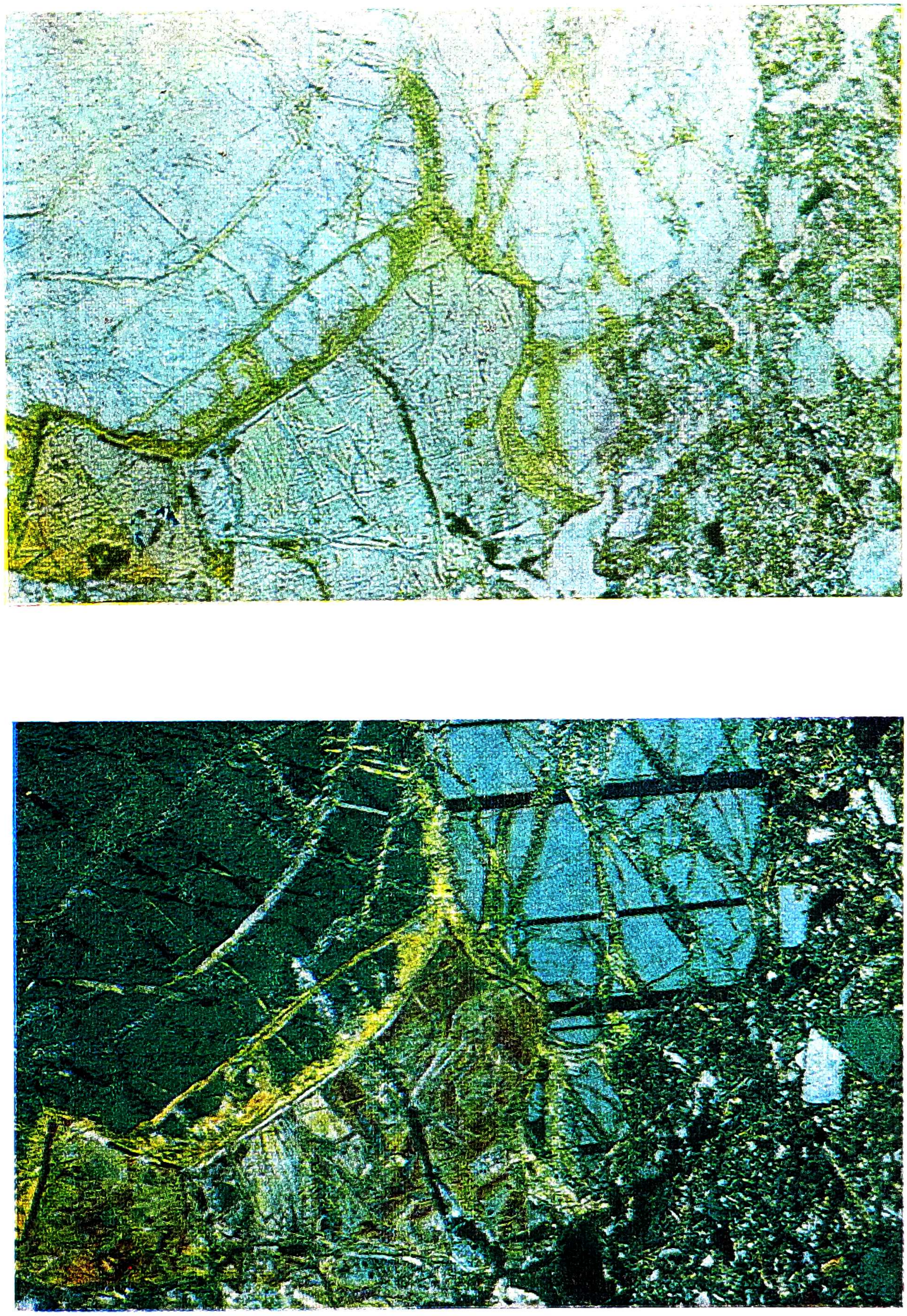

Fig. 11. Micromorphology of brown soil developed from olivine gabbro. Horizon (B), depth 20-45 cm. Some mineral grains coated with plasma hampering the weathering process. *A* — in plain light, *B* — under crossed polarizers. Magnif. ×36.

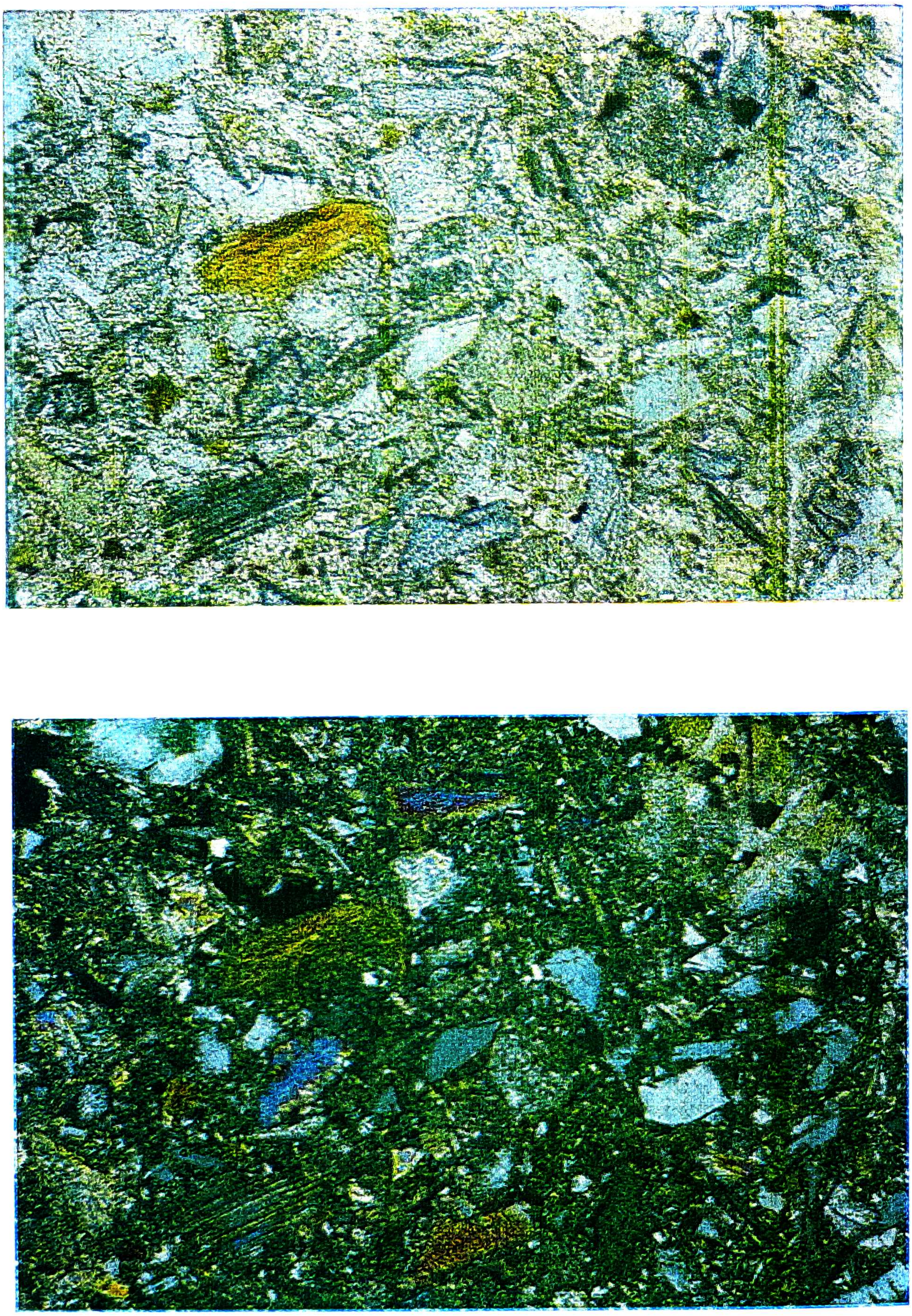

Fig. 12. Micromorphology of brown soil developed from olivine gabbro. Horizon A_1, depth 0-22 cm. Silasepic, locally skelsepic. Some minerals show higher disintegration. *A* — in plain light, *B* — under crossed polarizers. Magnif. ×36.

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