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A PRACTICAL GUIDE FOR THE IGNEOUS ROCKS OF THE CARPATHIAN-PANNONIAN REGION

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Chapter I. Introduction

Igneous rocks form due to one of the most important natural processes, i.e. melt generation in the upper mantle or in the lower crust followed by magma uprise, stalling, crystallization, mixing of other magmas, contamination by wall rocks and finally either solidification at the depth or eruption onto the surface. This natural processes has been taking place since the formation of our planet. Magmatism is close related to plate tectonic processes and a general consensus has been developed that certain rock types prevail at particular tectonic setting. Data are growing significantly from igneous rocks from all over the world and this huge information could help scientists to interpret the petrological and geochemical features of igneous formations. Nevertheless, there are still a lot of open questions waiting to be resolved, but this is the what helps geoscientists to go on, go into the details and attempt to refine our knowledge how magma forms, what happens between melt generation and the formation of the igneous rocks and how we can use this knowledge in our society. Volcanic activity provides advantage and disadvantage for society, volcanoes could be potentially dangerous and therefore scientists are working hard to obtain information from volcanic rocks to know more about the mechanism of volcanic eruption, to know more about the pre-eruption processes in the plumbing system beneath volcanoes. All these information is hidden in the volcanic rocks as well as in the intrusive rocks. The volcano petrology provides a challenging perspective even in eruption forecasting activity. Furthermore, igneous rocks play an important role in having more information about the geodynamic evolution of a given area as well as ore resources prospecting.

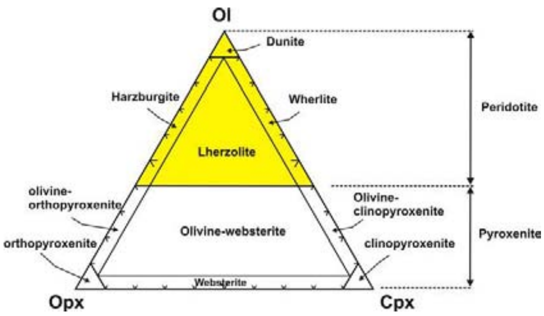
The Carpathian-Pannonian region located in eastern-central Europe provides an excellent opportunity to investigate a wide spectrum of igneous rocks from peridotites to granites and from nephelinites and leucitites to phonolites and rhyolites. It is indeed a natural laboratory for studying igneous rocks! In this e-book, our aim is to show the main characteristics of igneous rocks using examples from this region. Characteristic microscopic pictures of certain igneous rocks from different localities could give a general impression about the occurrences of such rocks. We know that this summary is far from being complete and we plan to extend this to other areas and other localities. Nevertheless it is the first comprehensive summary on the igneous rocks of this region that could help students to get a general picture about igneous rocks and their localities in the Carpathian-Pannonian region.

Chapter II. Igneous rocks in the Carpathian-Pannonian Region

The Carpathian-Pannonian region is a kind natural laboratory for the igneous rocks. Plate tectonic events in the western Tethys region during the Mesozoic led to the formation of various volcanic rocks and these formations play an important role in the reconstruction of these complex processes. The Pannonian Basin was formed during the Neogene and this was accompanied with the formation of wide range of volcanic rocks for the last 20 Ma. In this region, almost every type of igneous rocks are found from the mantle derived peridotites to the granites, from the silica-undersaturated nephelinites and leucitites to the phonolites and rhyolites. In the next sections, description of the major igneous rocks is given along many examples from the Carpathian-Pannonian region. The great selection of microscopic photos could help to recognize the often subtle differences of given rock types in different localities.

II.1. Ultrabasic rocks

PERIDOTITE GROUP



<u>Appearance</u>: When fresh it is green coloured, and coarse grained. Macroscopically we can recognise in the rock olive-green coloured olivines, black orthopyroxenes and grass-green clinopyroxenes. Using microscope the brown spinels can also be observed and the clinopyroxenes have light green colour. Using petrographic microscope olivines and orthopyroxenes are colorless with one nicol, their pictures with crossed nicols can help to discriminate them as orthopyroxenes have usually grey while olivines have second-third order colours (blue-red).

<u>Mineral content:</u>

Essential minerals: olivine>40%, ortho- and clinopyroxenes

Accessory minerals: spinel or garnet, rarely amphibole, phlogopite, apatite

Secondary minerals: serpentine group minerals, limonite

<u>Rock types:</u>

- dunite: olivine>90%
- harzburgite: olivine>40%, orthopyroxene, clinopyroxene < 5%
- lherzolite: olivine>40%, clinopyroxene, orthopyroxene
- wehrlite: olivine>40%, clinopyroxene, orthopyroxene < 5%

Figure II.1. – Peridotite xenolith with the essential minerals (Bondoró)

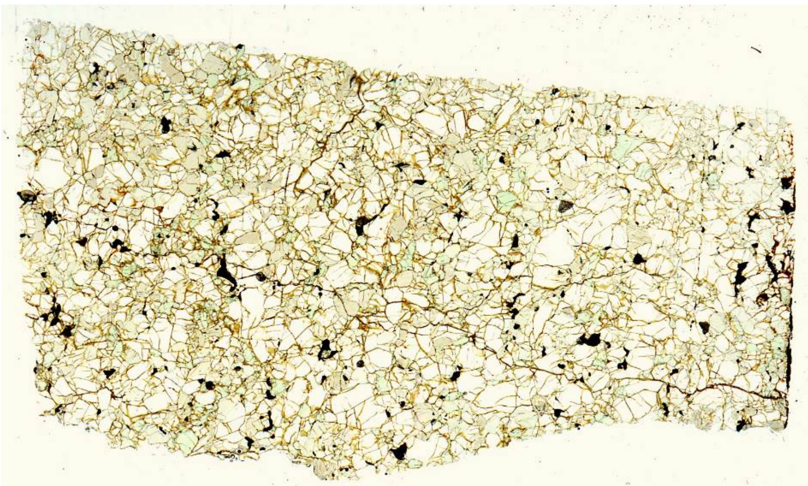


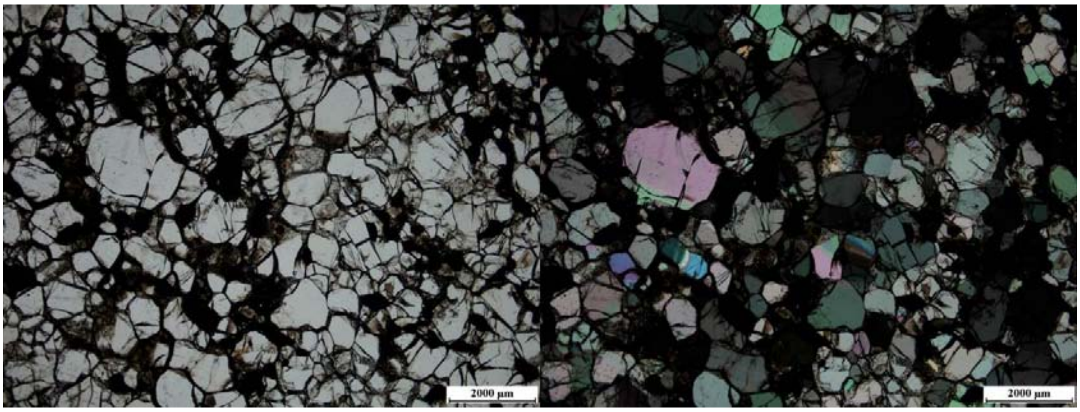
Figure II.2. – Thin section of a lherzolite xenolith. We can recognise the green clinopyroxenes the light brownish orthopyroxenes, the colourless olivines and the black spinels (Al Haruj, Libya)

Occurrences in the Carpathian-Pannonian Region: As xenoliths in basalts from Kapfenstein, Tobaj, Gérce, Bondoró, Füzes, Szentbékkálla, Szigliget; Maskófalva-Maskova, Fülek-Filakovo-Kercsiktető, Medves-Eresztvény and Magyarbánya, Nagy-Salgó, Bagókő, Bárna-Nagykő and Kiskő; Hidegkút (Gruiu), Nádas-völgy/Trestia and Berek (Barc; Persány Mts.), and in late Cretaceous lamprophyres (e.g. Alcsútdoboz borehole, Villányi Mts.). The so called „ore-peridotite" near Szarvaskő has cumulate origin.

Figure II.3. – Peridotites from the Carpathian-Pannonian Region: (left) peridotite xenoliths in the pyroclastite from Szentbékkálla (right), rounded peridotite bomb from the scoria cone of Bondoró (photos: Szabolcs Harangi).

Figure II.4. – Peridotites from the Carpathian-Pannonian Region: (left) peridotite xenolith in a spindle bomb (Füzes-tó), (right) blocky peridotite xenolith in basaltic lava rock (Mátéfalva, Mateias; Persány Mts.) (photos: Szabolcs Harangi).

Figure II.5. – The cumulate originated „ore-peridotite” from Szarvaskő (southwest Bükk)



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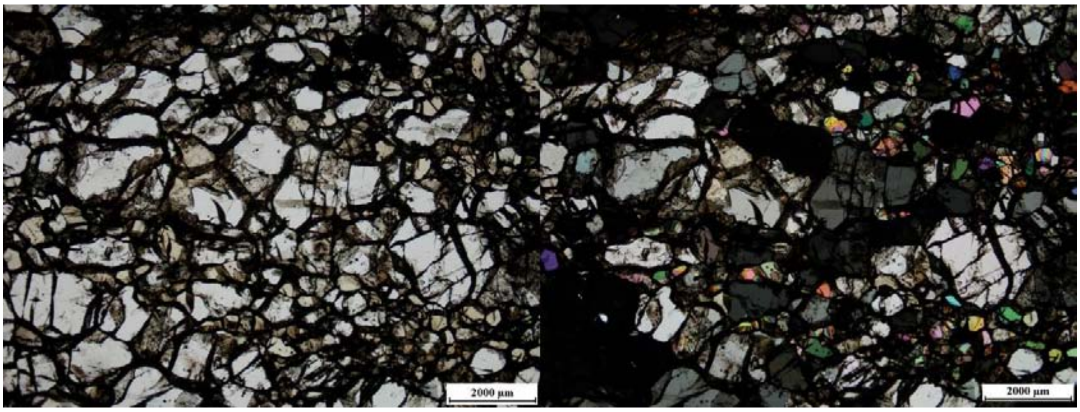

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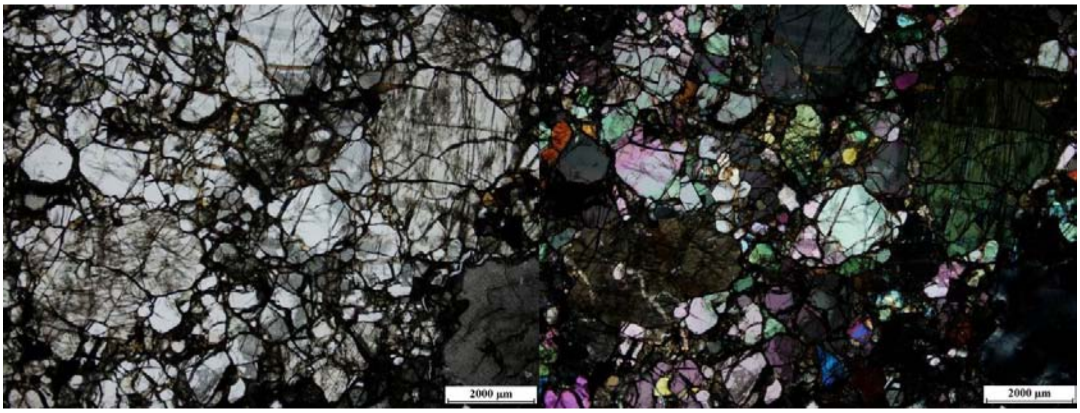

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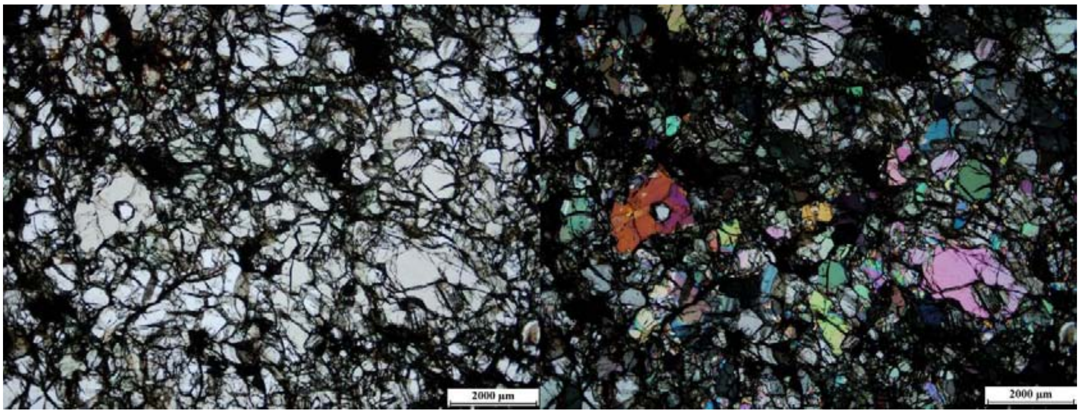

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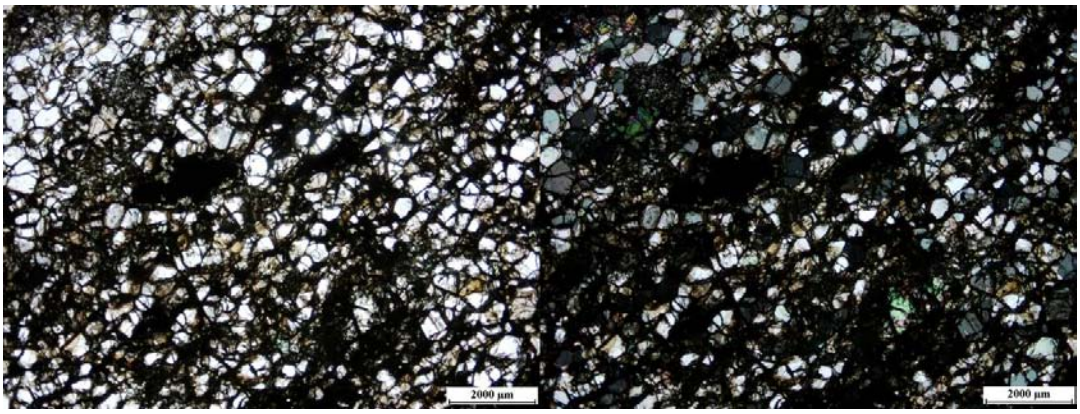

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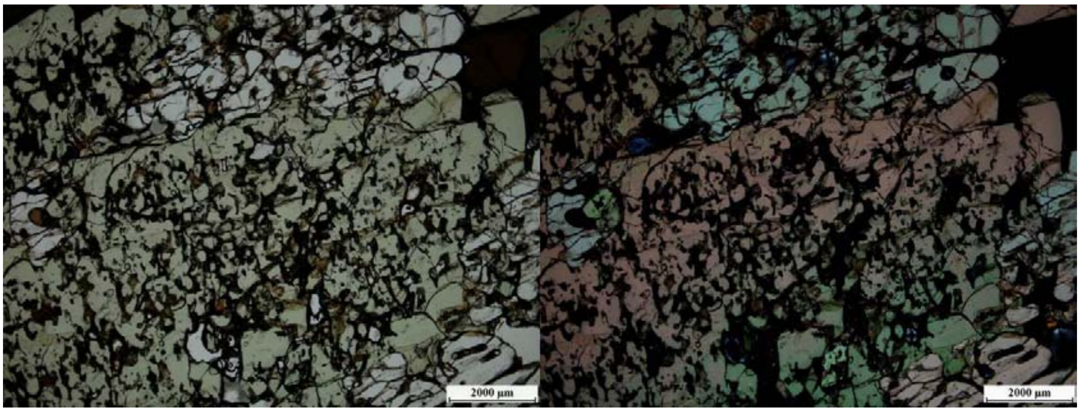

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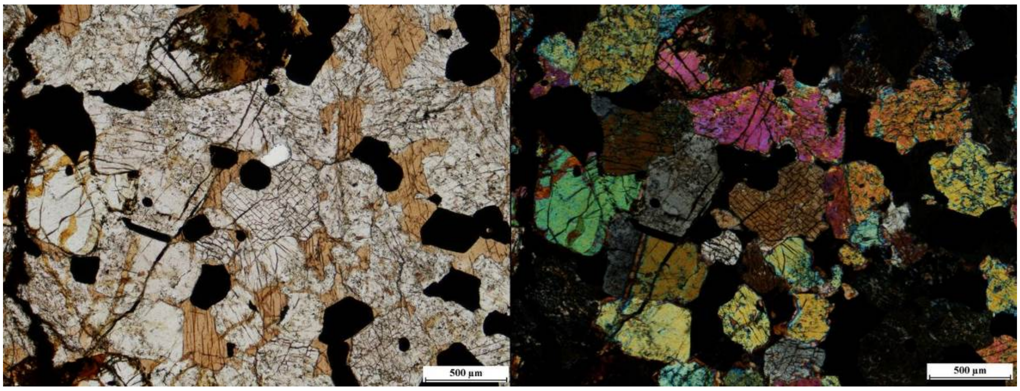

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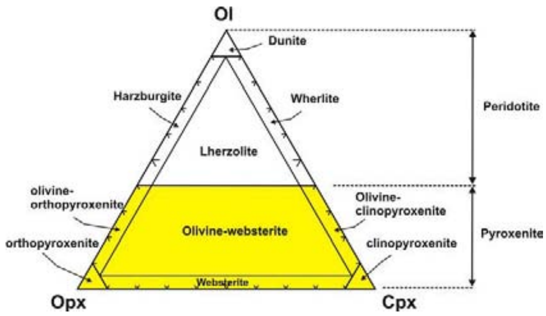
PYROXENITE GROUP



Appearance: The rock is usually black or dark green coloured and medium or coarse grained. Apart from the pyroxenes it can contain spinel or garnet which can only be recognised using petrographic microscope.

Mineral content:

Essential minerals: mainly ortho- and clinopyroxenes and less than 40% olivine

Accessory minerals: spinel, garnet, Fe-Ti-oxides, plagioclase

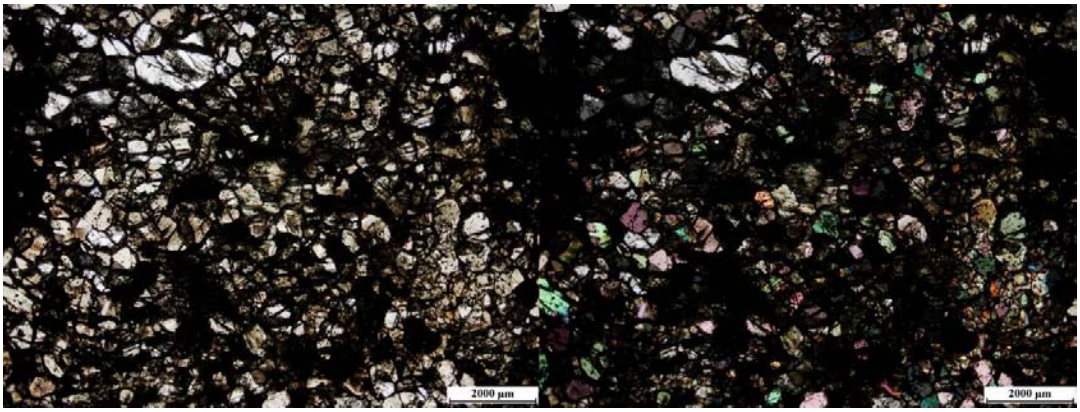
Secondary minerals: serpentine group minerals, chlorite

Rock types:

- clinopyroxenite: more than 90% clinopyroxene
- orthopyroxenite: more than 90% orthopyroxene
- websterite: more than 60% clinopyroxene and orthopyroxene, less than 10% olivine
- olivine websterite: more than 60% clinopyroxene and orthopyroxene, 10-40% olivine

Figure II.13. – Pyroxenite intrusion in Fuerteventura (left, Canary Islands) and macroscopic photo of the rock. (photos: Szabolcs Harangi)

Occurrences in the Carpathian-Pannonian Region: Usually beside peridotite xenoliths e.g. Tobaj, Bondoró, Szentbékkálla, Maskófalva-Maskova, Fülek-Filakovo-Kercsiktető, Medves-Eresztvény and Magyarbánya, Nagy-Salgó, Bagókő, Bárna-Nagykő and Kiskő; Nádas-völgy/Trestia (Persány Mts.), and in late Cretaceous lamprophyres (e.g. Alcsútdoboz borehole, Villányi Mts.).



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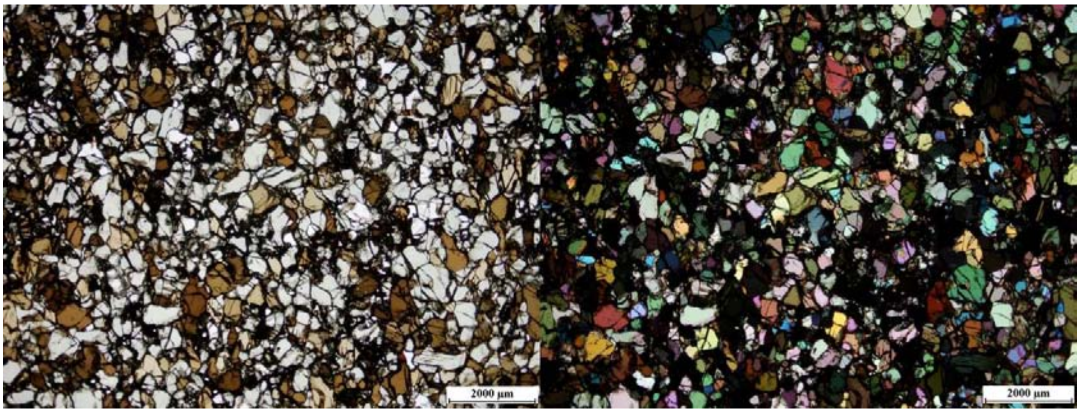

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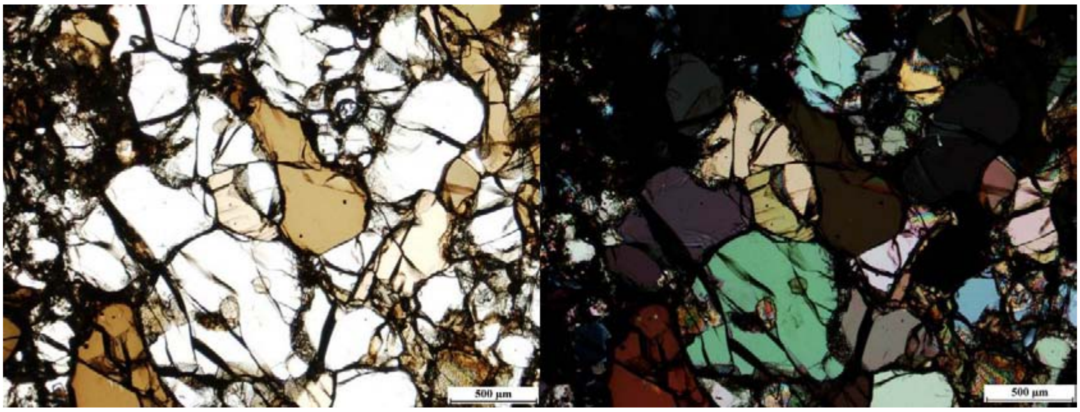


Figure II.16. – Typical microscopic photos of hypidiomorhic granular hornblende clinopyroxenite (Nádas/Trestia, Transylvania, Romania). Left ones with one nicol, right ones with crossed nicols.

HORNBLENDITE GROUP

Appearance: The rock usually black coloured, medium or coarse grained. It contains more thn 90% amphibole (hornblende). Hornblendite is a rare igneous rock in contrast with the more aboundant amphibolite which is a metamorphic rock containing mainly amphibole (hornblende) and plagioclase.

Mineral content:

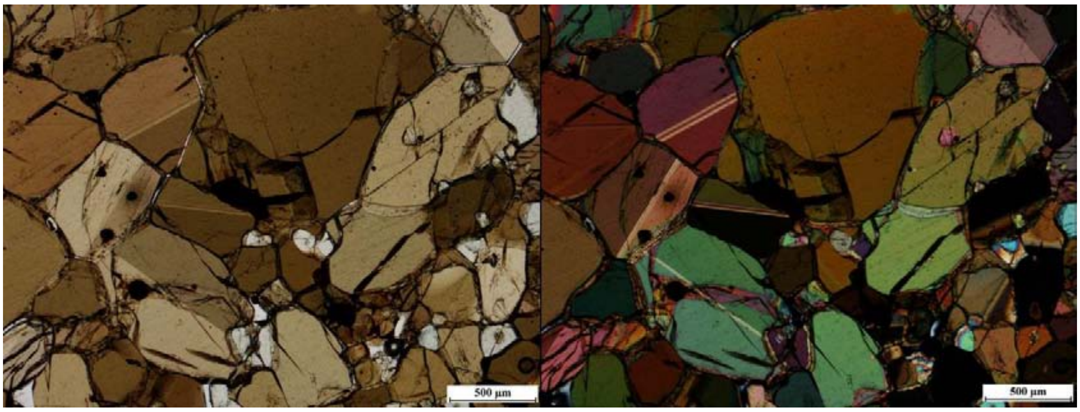
Essential minerals: dominantly (>90%) amphibole (primarily hornblende), with less amount of pyroxene and olivine

Accessory minerals: Fe-Ti-oxides

Secondary minerals: chlorite

Occurrences in the Carpathian-Pannonian Region: Szarvaskő (southwest Bükk), Nádas-völgy/Trestia (Persány Mts.)

Figure II.17. – Hornblendite (Szarvaskő, southwest Bükk)



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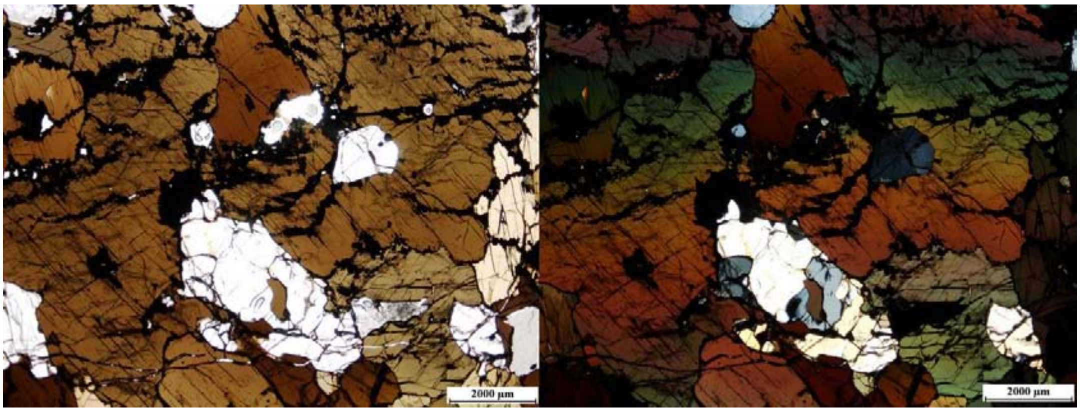


Figure II.19. – Microscopic photos of apatite bearing hornblendite (Nádas/Trestia, Transylvania, Romania). Left ones with one nicol, right ones with crossed nicols.

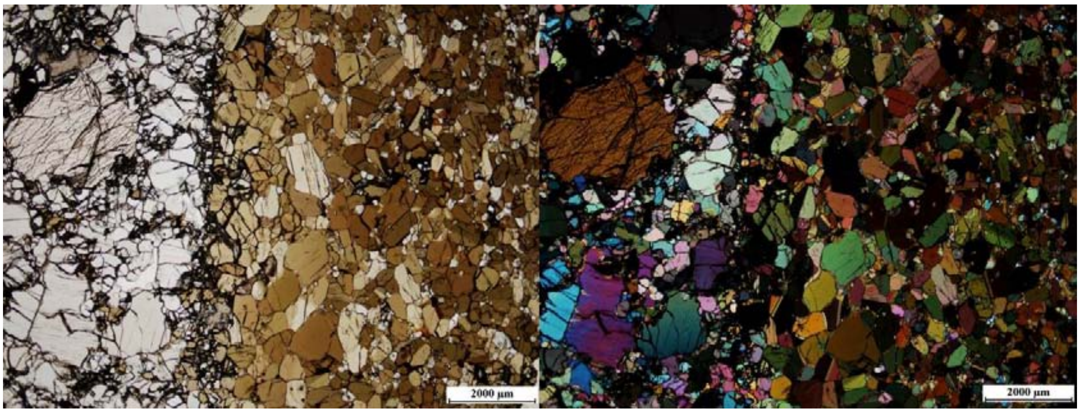
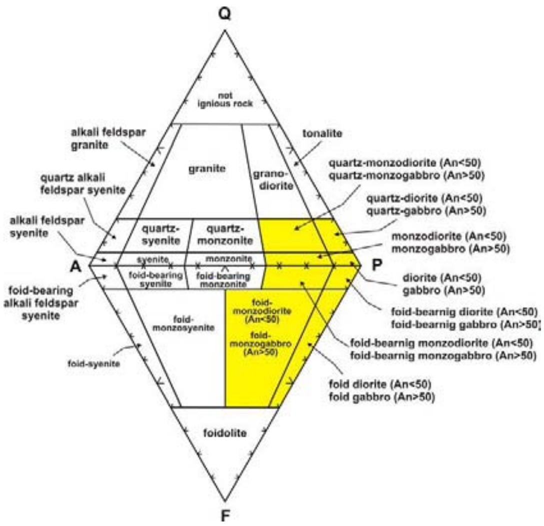


Figure II.20. – Microscopic photos of a lherzolite/hornblendite composite xenolith (Nádas/Trestia, Transylvania, Romania). Left ones with one nicol, right ones with crossed nicols.

II.2. Basic/Mafic igneous rocks

GABBRO



Appearance: Dark green or greenish black coloured, medium or coarse grained intrusive igneous rock. Compositionally similar to diorite but the anorthite content of plagioclases is more than 50mol%.

Mineral content:

Essential minerals: Ca-rich plagioclase, clino- and/or orthopyroxene, olivine, amphibole

Accessory minerals: apatite, magnetite, ilmenite; and may contain less amount of quartz, alkali feldspar or olivine and feldspathoids

Secondary minerals: chlorite, titanite, serpentine group minerals, epidote

Rock types (variations):

- norite: orthopyroxene and plagioclase bearing gabbro
- troctolite: olivine and plagioclase bearing, pyroxene poor gabbro
- anorthosite: gabbro containing more than 90% Ca-rich plagioclase

Considering the presence of quartz or feldspathoid, and the relative proportion of alkali feldspar and plagioclase we can differentiate varieties of gabbros such as monzogabbro, quartz-gabbro and quartz-monzogabbro as well as foid-gabbro, foid-bearing gabbro, foid-bearing monzogabbro and foid-monzogabbro.

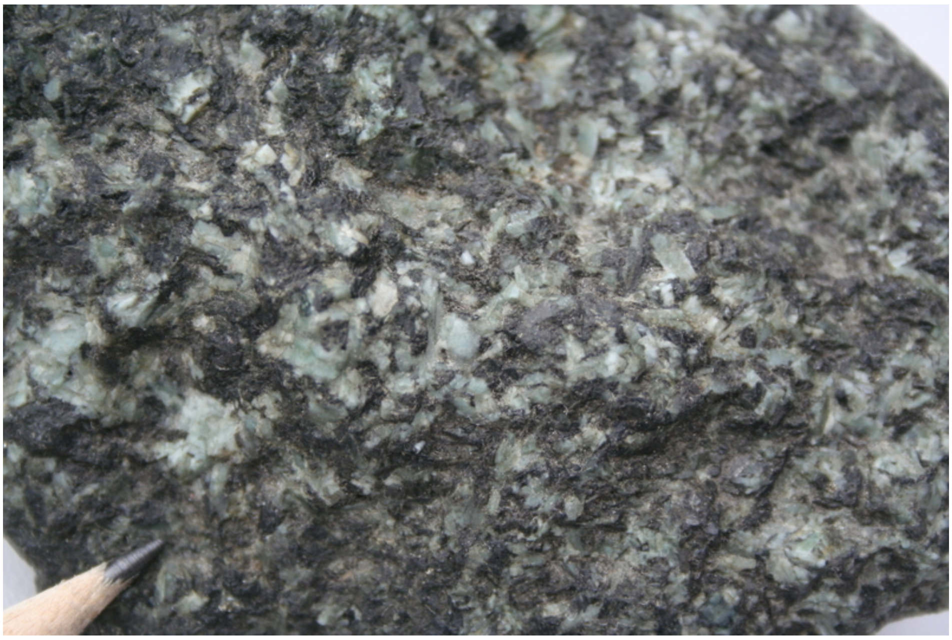


Figure II.21. – Gabbro (Tardos quarry, Szarvaskő, SW Bükk)

Figure II.22. – Typical gabbro

Figure II.23. – Typical anorthosite

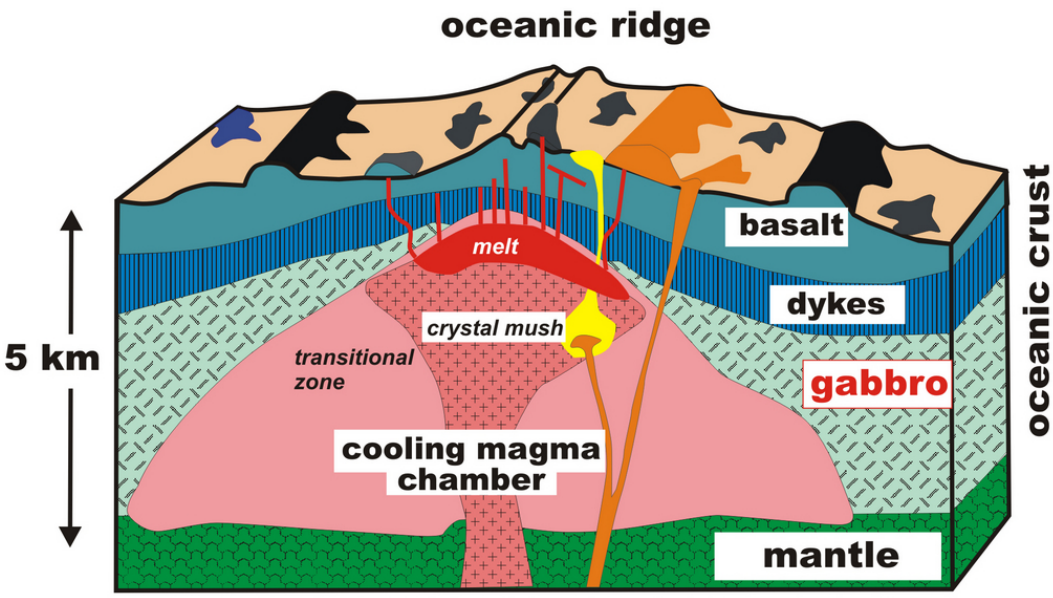


Figure II.24. – Cross section of an oceanic ridge, a typical tectonic setting of the formation of gabbros. After Perfit et al. (1994 Geology, 22, 375-379)

Locations in the Carpathian-Pannonian region: Tardos and Tóbérc quarries (SW-Bükk, close to Szarvaskő; Early Jurassic), boreholes around Darnó-hill (Triassic), ophiolites at the Maros valley (Apuseni Mts., Jurassic).

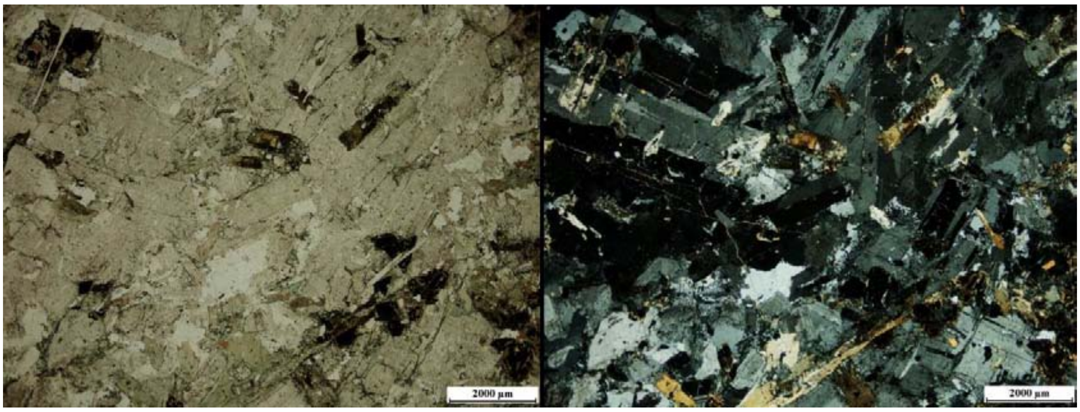


Figure II.25. – Typical microscopic photos of a gabbró from the Tardos quarry (SW Bükk). Left with one nicol, right with crossed nicols.

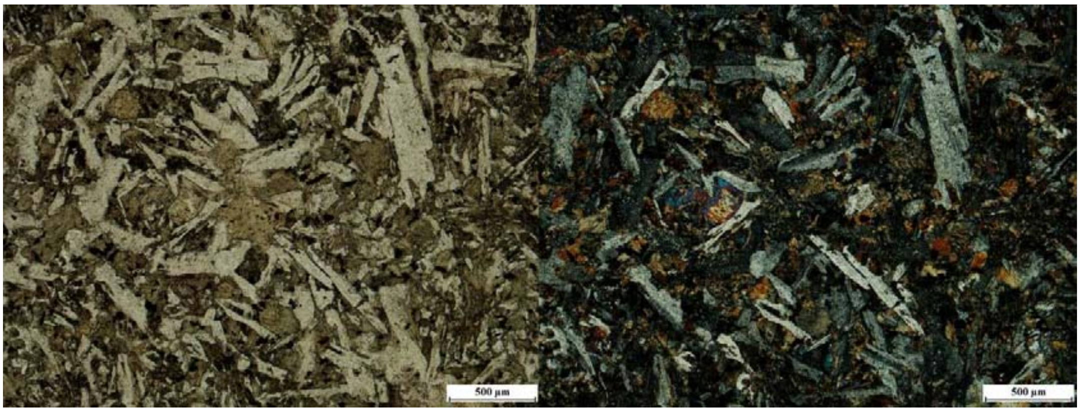


Figure II.26. – Typical microscopic photos of a subophitic microgabbro from the Tardos quarry (SW Bükk). Left with one nicol, right with crossed nicols.

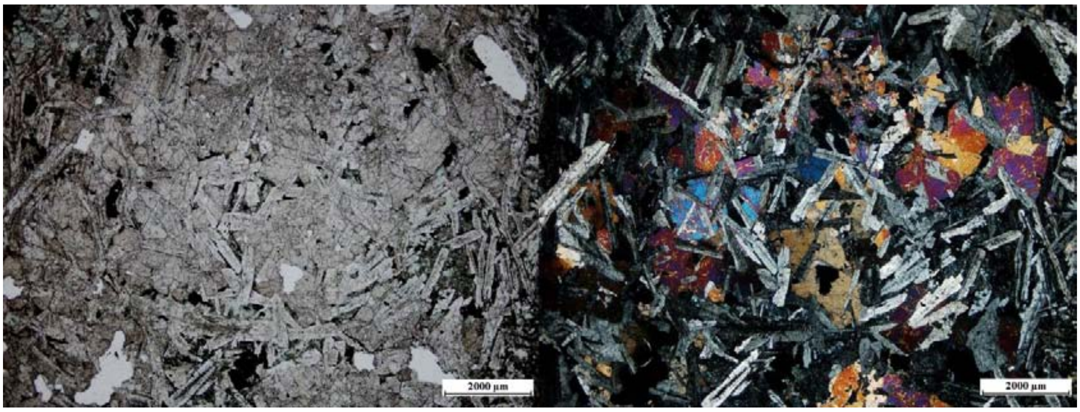
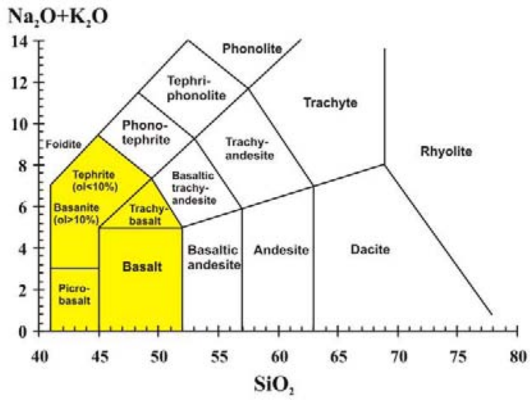


Figure II.27. – Typical microscopic photos of a subophitic microgabbro from the Darnó hill (SW Bükk). Left with one nicol, right with crossed nicols.

BASALT s.l.



Appearance: Dark, mostly aphyric rock with minor amount of phenocrysts (mostly olivine, rarely clinopyroxene and/or plagioclase). The effusive equivalent of gabbro. It occurs almost every plate-tectonic setting.

Mineral content:

Essential minerals: olivine, Ca-rich plagioclase, clinopyroxene

Accessory minerals: spinel (usually as inclusions in olivine and clinopyroxene), apatite, magnetite, ilmenite, nepheline and leucite (in alkaline basalts), K-feldspars (in Si-saturated basalts), rarely amphibole

Secondary minerals: serpentine group minerals, chlorite, carbonate materials

Rock types:

- alkali basalt: Si-undersaturated basalt with feldspathoids (nepheline or leucite). Olivine often occurs as phenocrysts occasionally with clinopyroxenes
- tholeiitic basalt: Si-saturated or oversaturated basalts. Ol-tholeiites contain olivine phenocrysts along with clinopyroxene and plagioclase, whereas quartz-tholeiite does not contain olivine but instead orthopyroxene appears. Quartz may be present in the groundmass.
- calc-alkaline basalt: the most frequent phenocrysts are clinopyroxene, occasionally with orthopyroxene and/or amphibole with fairly abundant plagioclase. Olivine could be also present.
- basanite: Si-undersaturated alkaline mafic rocks with typically less SiO_2 content then the basalts. The normative olivine content is higher than 10 wt%. Feldspathoids are usually present in the groundmass.
- tephrite: Si-undersaturated alkaline mafic rocks with normative olivine content less than 10 wt%. Feldspathoids are usually present in the groundmass.
- trachybasalt: plagioclase-phyric basalts with higher alkaline content than the normal basalts. The sodic trachybasalt is called hawaiite (plagioclase, anorthoclase, olivine, clinpyroxene, biotite). It is often difficult to recognize them petrographically, therefore bulk rock major element compositional data are necessary.
- Pcrite: olivine-rich basaltic rocks. Although their major element composition, particularly the relatively low SiO_2 content, indicates ultrabasic character, it is not the effusive equivalent of the peridotites, but rather a rare primitive variety of basaltic rocks. The high MgO and the low SiO_2 contents can be explained by the abundance of olivines, both phenocrysts and xenocrysts. Picritic magmas are usually formed at high pressure and high temperature with high degree of melting of the upper mantle rocks.
- Ankaramite: clinopyroxene and olivine-phyric (clinopyroxene>>olivine) varity of basalt

Figure II.28. – Basalt from Somoskő (Nógrád-Gömör)

Figure II.29. – Olivine phenocryst in basalt

Formation of basaltic rocks:

Figure II.30. – Active pahoehoe basaltic lava flow (left; Kilauea, Hawaii) and already solidified pahoehoe basaltic lava rock (right, Reykjanes, Iceland; photos: Szabolcs Harangi)

Figure II.31. – Pahoehoe and aa basaltic lava flows (Kilauea, Hawaii) és aktív aa-lávafolyás (Etna, 1992; photos: Lukács Réka és Szabolcs Harangi)

Figure II.32. – Thin compound pahoehoe basaltic lava flow rocks (Tenerife) and cross section of a basaltic aa lava (Etna; photos: Szabolcs Harangi)

Figure II.33. – Basaltic lava lake in the Erta Ale (Ethiopia) (photo: Ildikó Ipach)

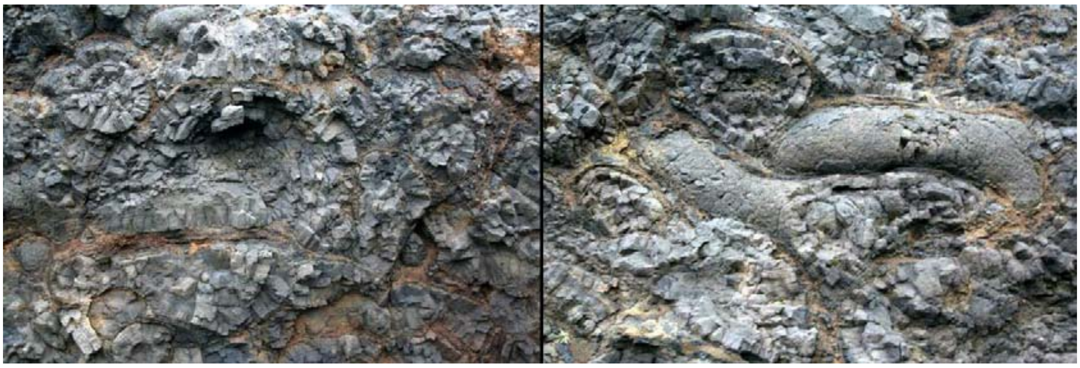


Figure II.34. – Characteristic submarine pillow lava rock: Reykjanes, Iceland (photo: Szabolcs Harangi)

Figure II.35. – Slowly cooled basalt lava with three-tired columnar structure (left, Racos, Persány Mts.) and fan-shaped columnar structured vent-filled basalt (right, Ság hill)

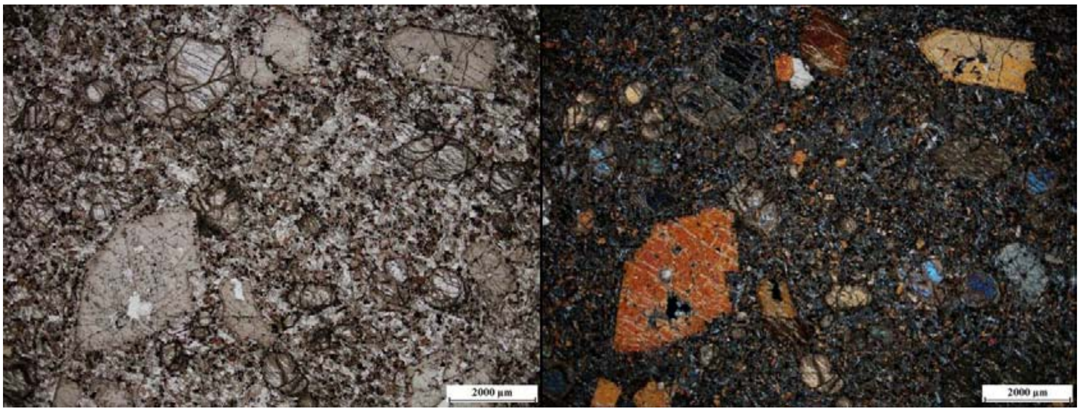


Figure II.36. – Typical microscopic photos of a basalt with olivine phenocrysts (Vasas, Mecsek). Left with one nicol, right with crossed nicols.

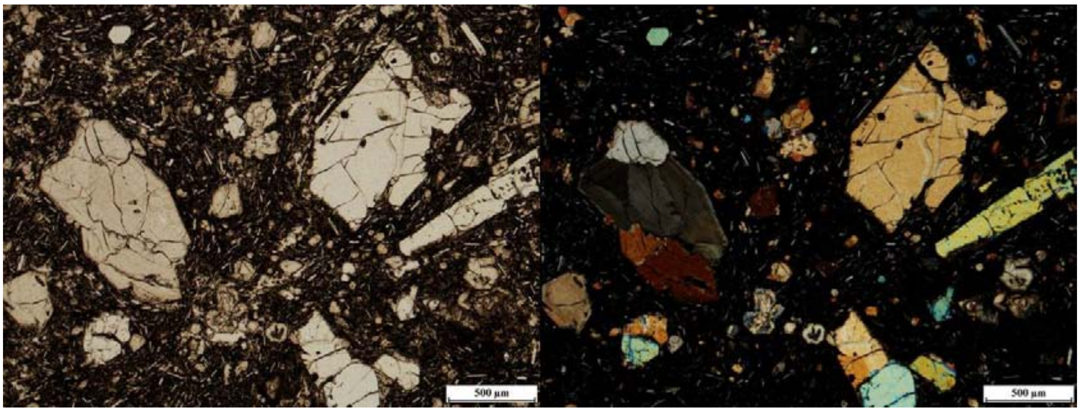


Figure II.37. – Typical microscopic photos of a basalt with olivine phenocrysts (Sőreg/Surice, Cseres Mts., Nógrád-Gömör). Left with one nicol, right with crossed nicols.

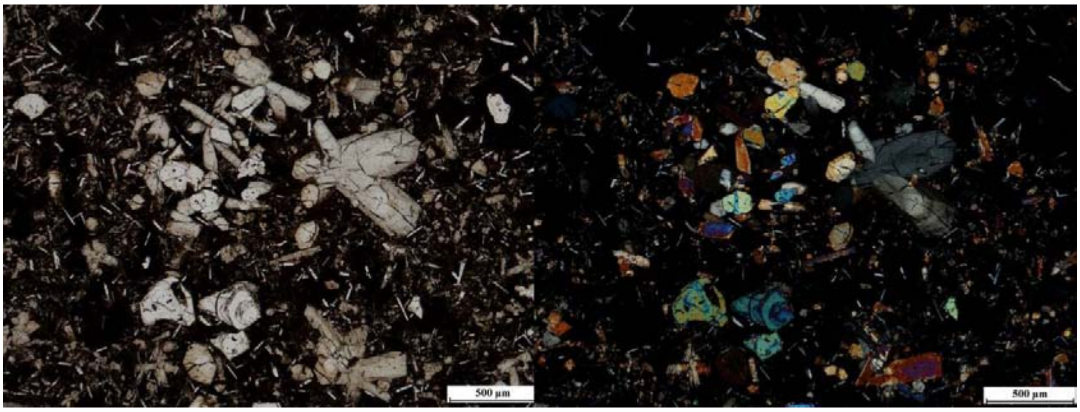


Figure II.38. – Typical microscopic photos of a basalt with clinopyroxene glomerocrysts (Steinberg, Styrian basin). Left with one nicol, right with crossed nicols.

Locations in the Carpathian-Pannonian region: Boreholes at Darnó hill and Bódva valley (Triassic to Jurassic); Szarvaskő (Early Jurassic); Maros valley (Apuseni; Jurassic); Eastern Mecsek and basement of the Great Hungarian Plain (Early Cretaceous); Miocene-Quaternary alkali basalt volcanic fields: Styrian basin (4.9-1.9 Ma), Burgenland (11.5-11.0 Ma), Kemenesalja (5.5-4.5 Ma), Bakony-Balaton Upland (7.9-2.6 Ma), Nógrád-Gömör (7-0.4 Ma), Selmec (7 és 100 ezer év), Persány (1.2-0.6 Ma). Calc-alkaline basalts: Vlchi vrch, Ziar nad Hronom (Central Slovakian volcanic field; 9-10 Ma), Sárospatak borehole (9 Ma)

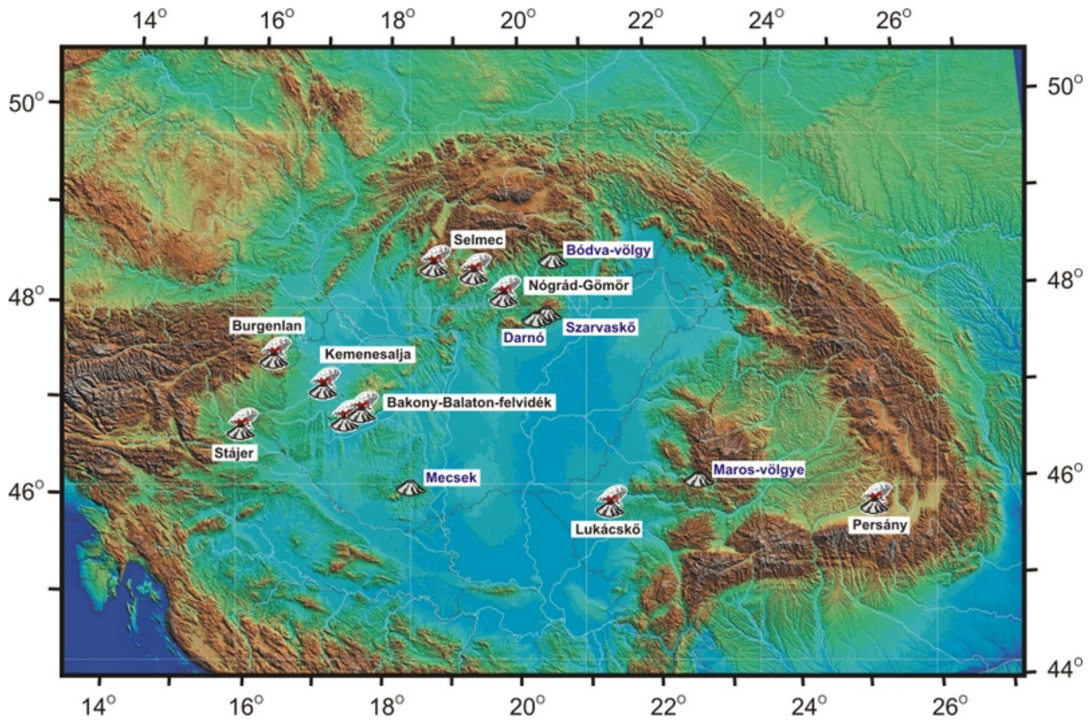


Figure II.38. – Locations of the Mesozoic (symbol of volcano without eruption) and Miocene to Quaternary (symbol of volcano with eruption) basalts in the Carpathian-Pannonian region.

Mesozoic basalts:

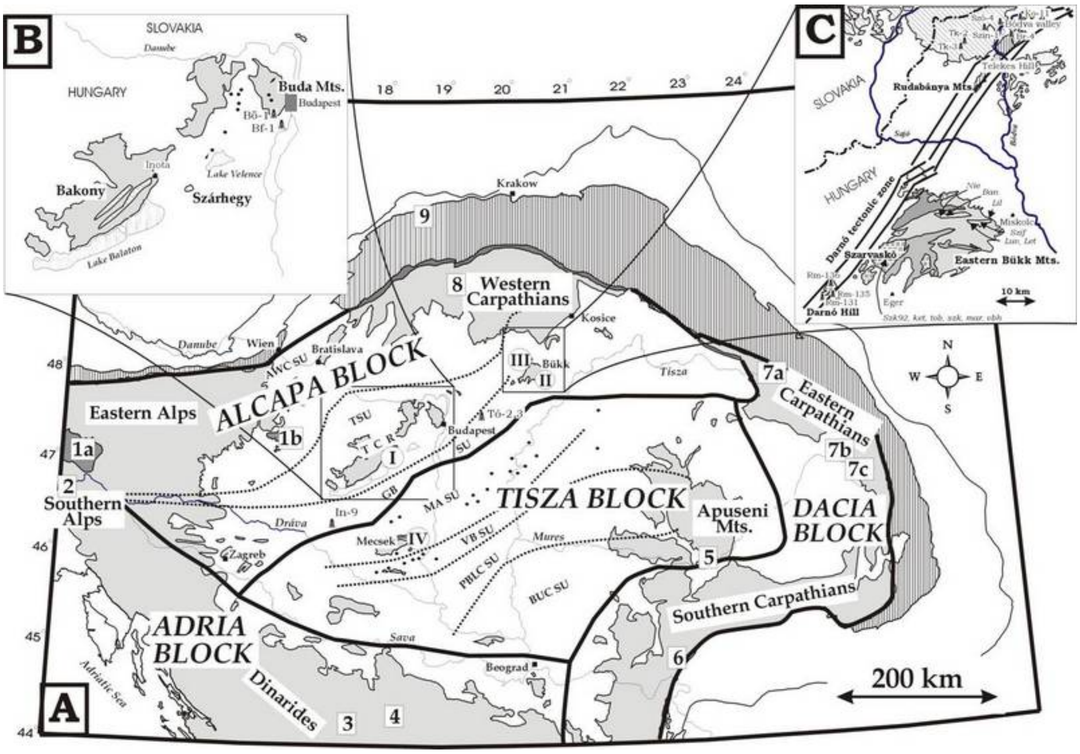


Figure II.38. – Locations of the Mesozoic basalts in the Carpathian-Pannonian region based on the work of Harangi et al. (1996, Int. Geol. Rev.). In the Fig. C occurrences of basaltic rocks in the area of Darnó (boreholes) and Bódva-valley can be seen.

Figure II.39. – Early Jurassic basaltic (tholeiite) pillow lava at Szarvaskő.

Figure II.40. – A closer view of Early Jurassic basaltic (tholeiite) pillow lava at Szarvaskő.

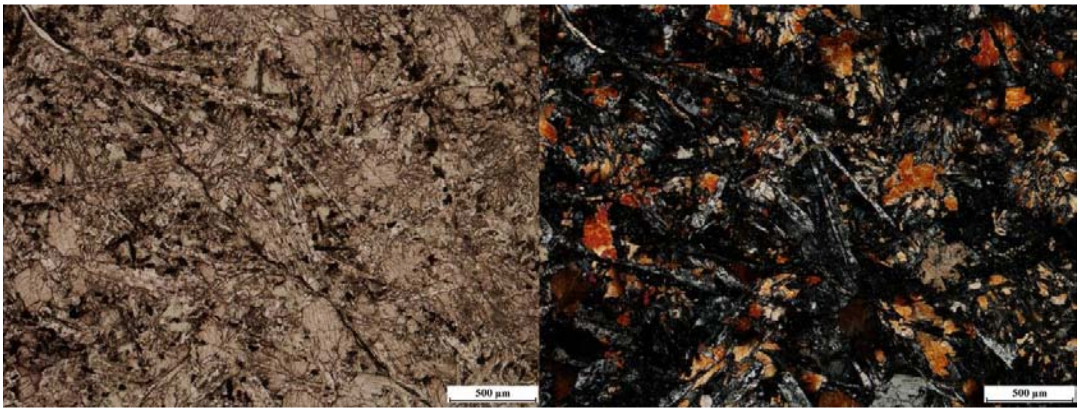


Figure II.41. – Typical microscopic photos of the pillow lava basalt at Szarvaskő. In the aphyric rock plagioclase and clinopyroxene needles (variolitic texture) can be seen. Left with one nicol, right with crossed nicols.

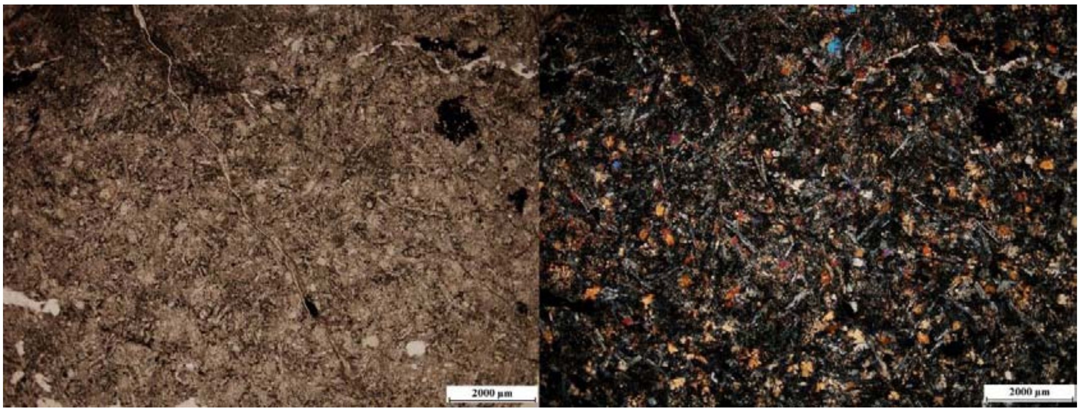


Figure II.42. – Typical microscopic photos of the pillow lava basalt at Szarvaskő. In the aphyric rock plagioclase and clinopyroxene needles (variolitic texture) can be seen. Left with one nicol, right with crossed nicols.

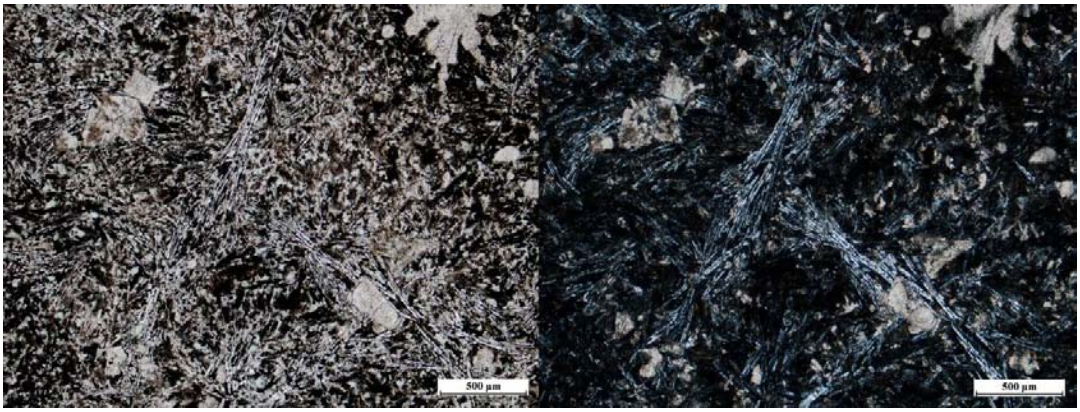


Figure II.43. – Typical microscopic photos of variolitic pillow lava basalt from a borehole near Darnó hill. Left with one nicol, right with crossed nicols.

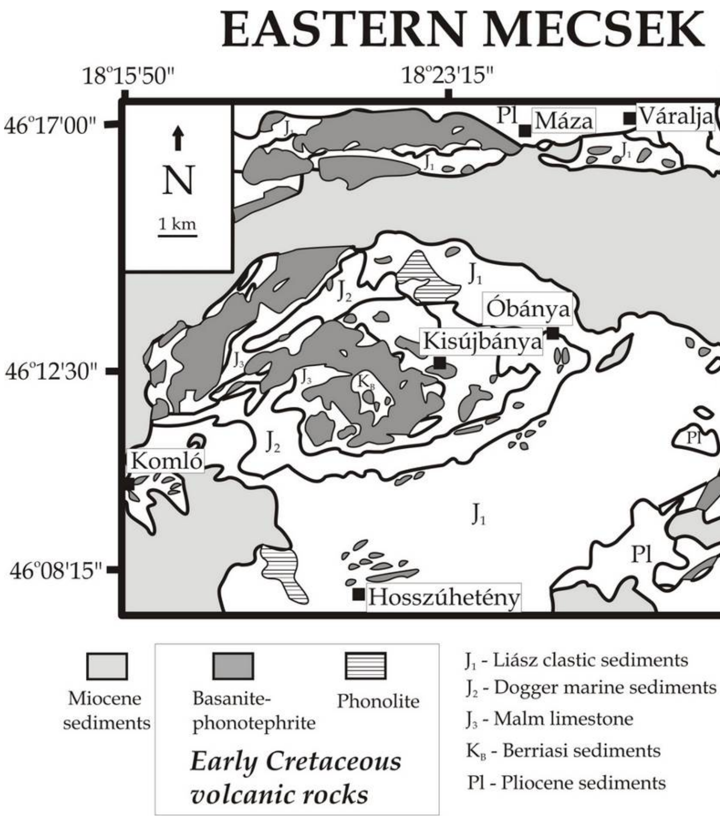


Figure II.44. – Early Cretaceous volcanic rocks in the Eastern Mecsek based on the work of Harangi, 1994 in Lithos

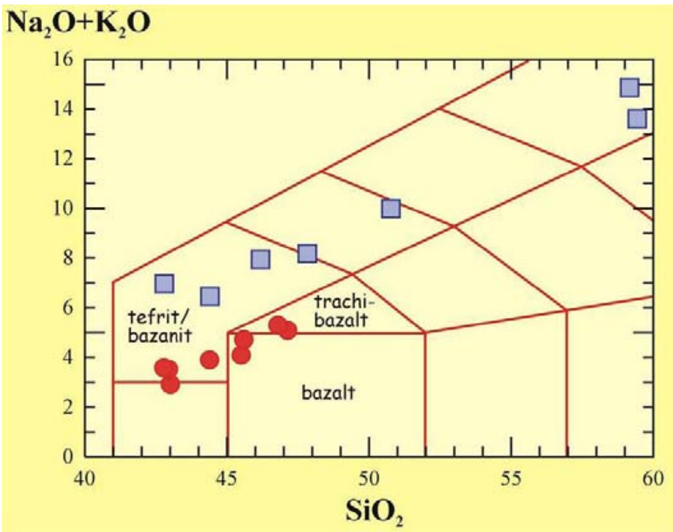


Figure II.45. – Classification of the Early Cretaceous volcanic rocks in the TAS diagram based on the work of Harangi, 1994 in Lithos

Figure II.46. – Basaltic pillow lava in the Síngödör and lava breccia in the Márévári valley

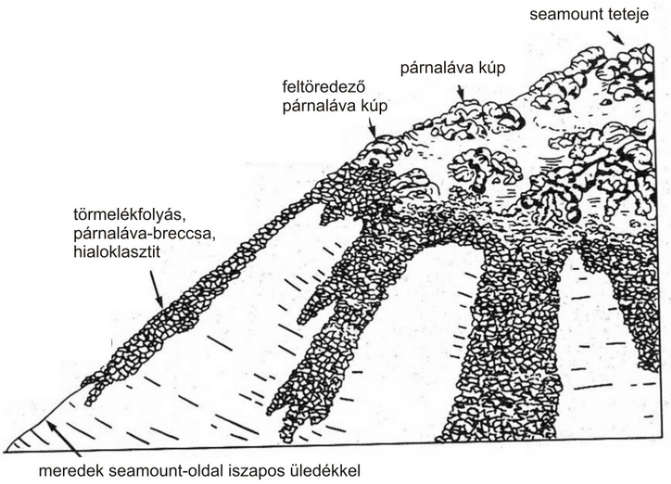


Figure II.47. – Reconstruction of the paleoenvironment during the submarine volcanic activity in the Mecsek area

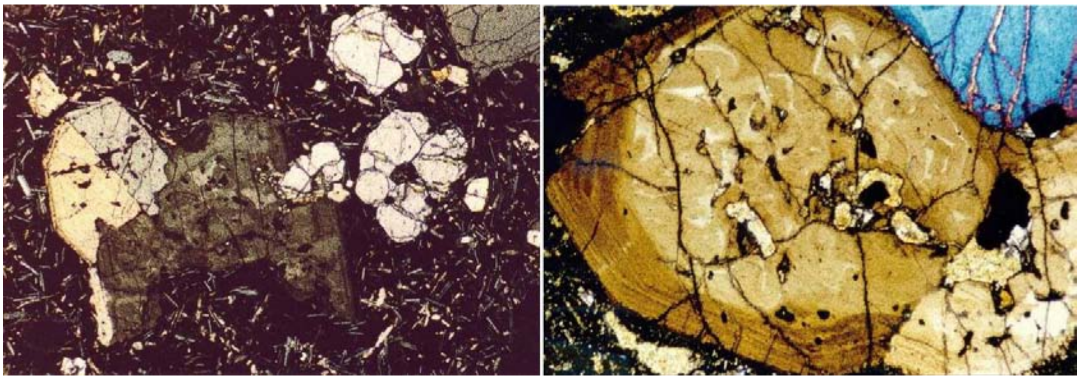


Figure II.48. – Characteristic microscopic feature of the Early Cretaceous ankaramites from the Eastern Mecsek. They contain large, complex zoned clinopyroxene phenocrysts in addition to smaller olivines. Crossed nicols, the length of the lower side of the picture is 2.99 mm.

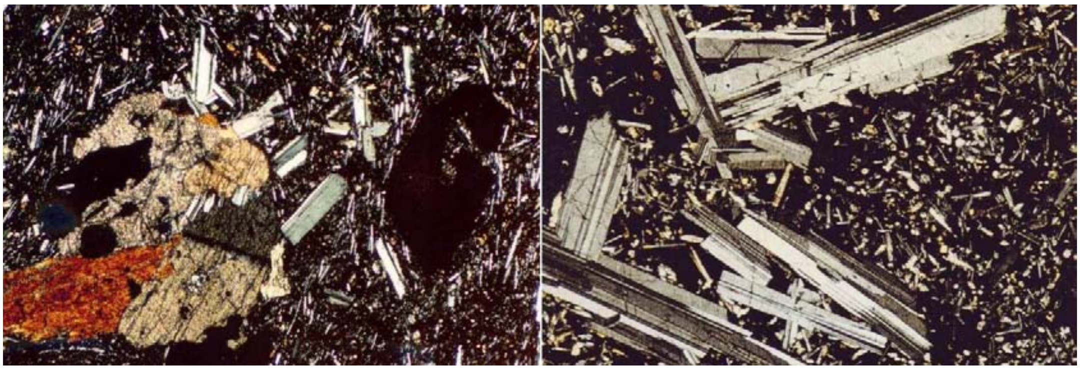


Figure II.49. – Characteristic microscopic feature of the Early Cretaceous alkali basalts from the Eastern Mecsek. They contain clinopyroxene, plagioclase and ilmenite phenocrysts. Crossed nicols, the length of the lower side of the picture is 2.99 mm.

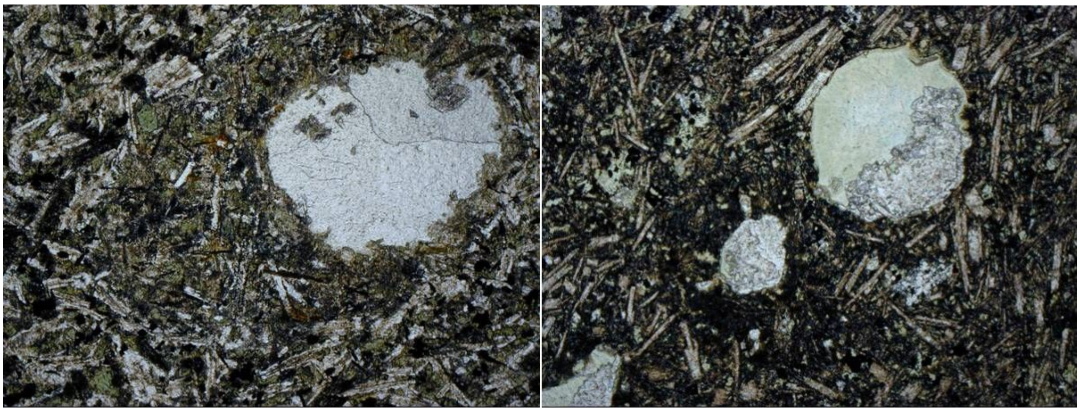


Figure II.50. – Characteristic carbonate filled vesicles with ilmenite-rich reaction corona around it in the Early Cretaceous alkali basalts from the Eastern Mecsek. Photo with one nicol, the length of the lower side of the picture is 2.99 mm.

Miocene-Quaternary basalts – Styrian basin

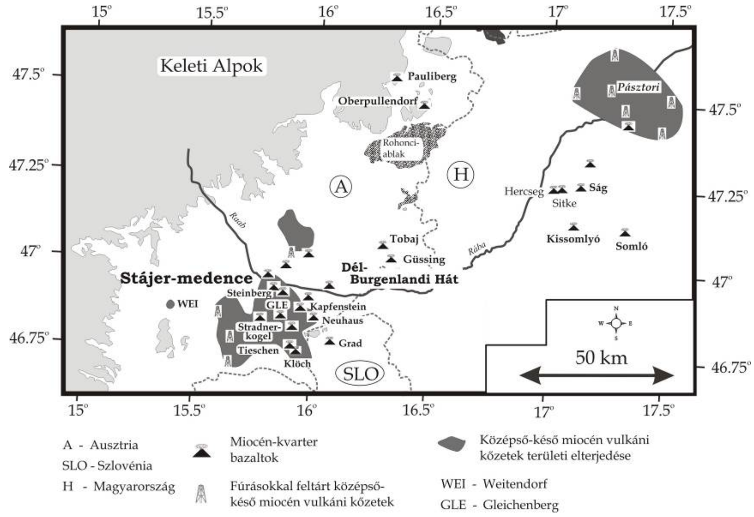


Figure II.51. – Miocene-Quaternary basalts and Miocene K-rich trachyandesites in the western part of the Pannonian region. The buried trachyte volcano at Pásztori is also indicated based on borehole data. (after Harangi, 2001, Acta Vulcanologica)

Figure II.52. – Klöch: basalt quarries

Figure II.53. – Erosional remnants of maar volcanoes: Kapfenstein at left and Riegersburg at right (Photos: Szabolcs Harangi)

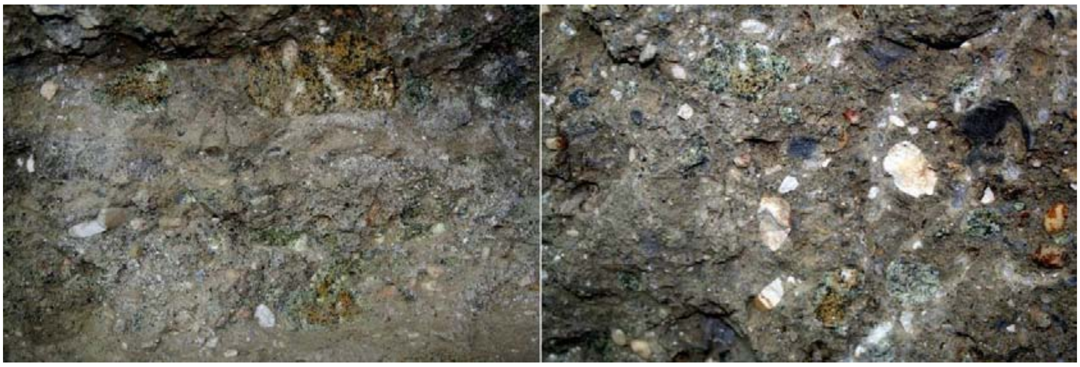


Figure II.54. – Lithoclast-rich maar deposit at Kapfenstein (Photos: Szabolcs Harangi)

Figure II.55. – Lithoclast-rich maar deposit at Riegersburg (Photos: Szabolcs Harangi)

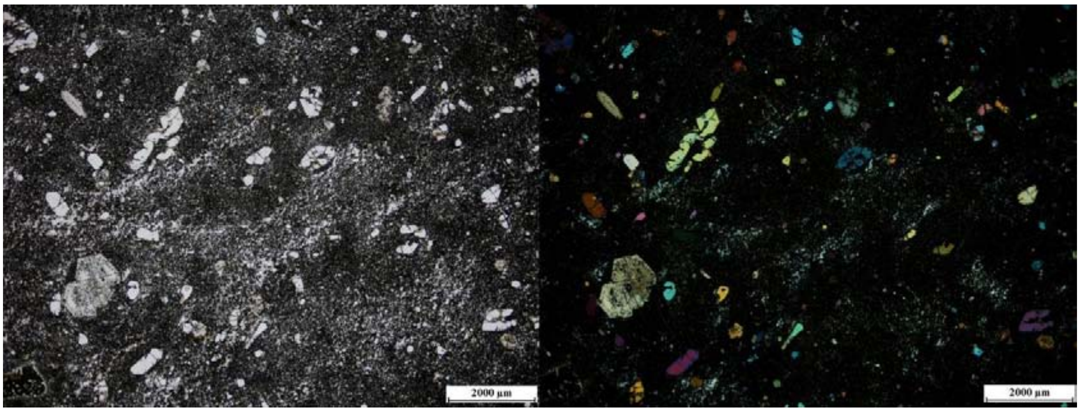


Figure II.56. – Typical microscopic photos of the basalts from Klöch. Left with one nicol, right with crossed nicols.

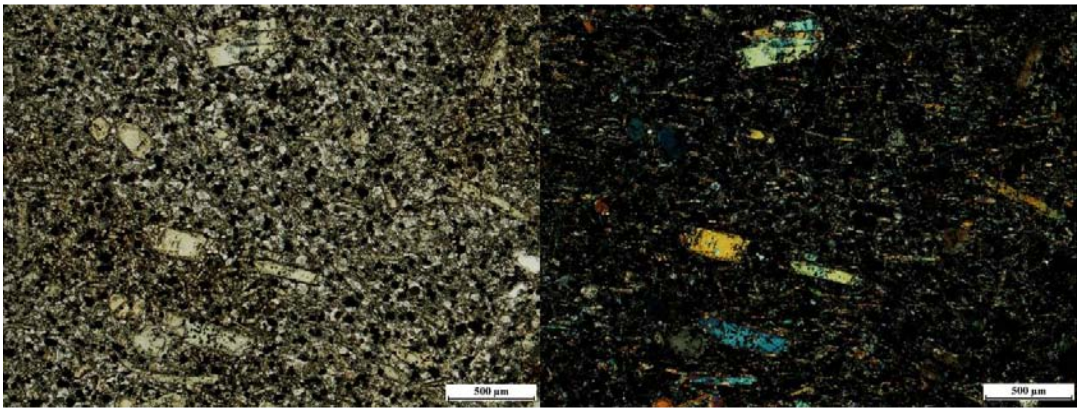


Figure II.57. – Typical microscopic photos of the nephelinite from Stradner Kogel. Left with one nicol, right with crossed nicols.

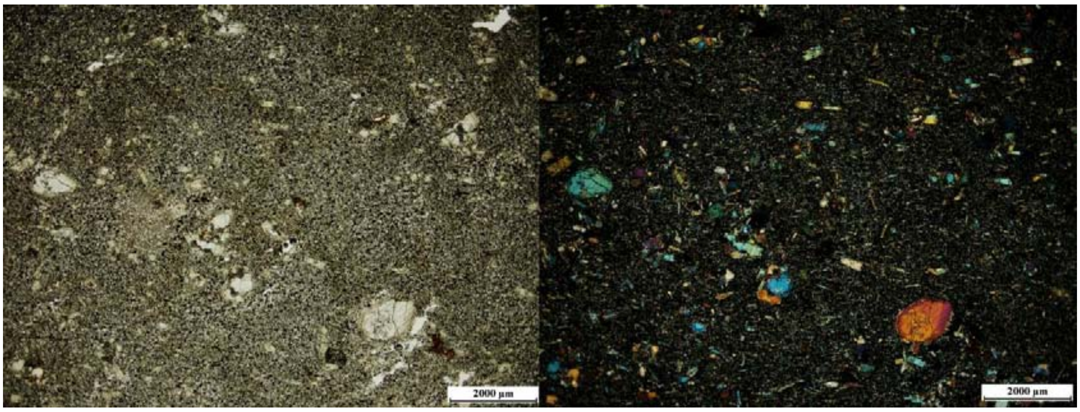


Figure II.58. – Typical microscopic photos of the nephelinite from Stradner Kogel. Left with one nicol, right with crossed nicols.

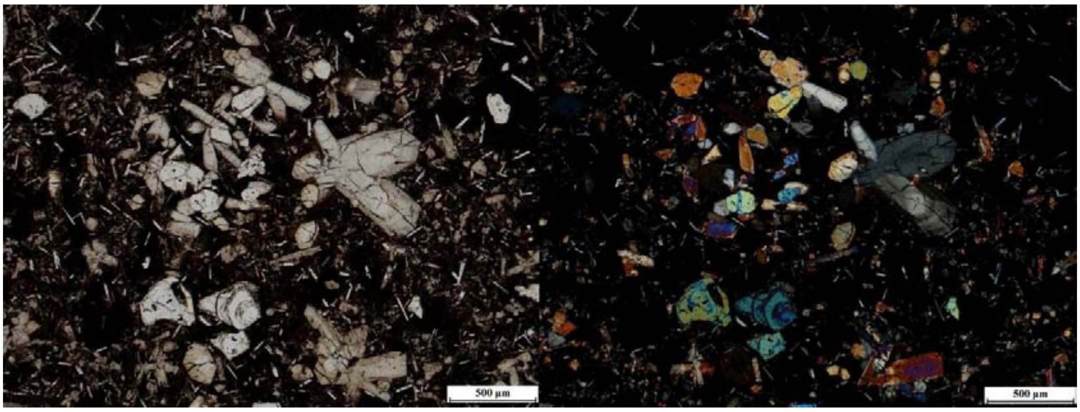


Figure II.59. – Typical microscopic photos of the basanite from Steinberg. Note the abundance of clinopyroxenes occurring often in glomerophyric groups. Left with one nicol, right with crossed nicols.

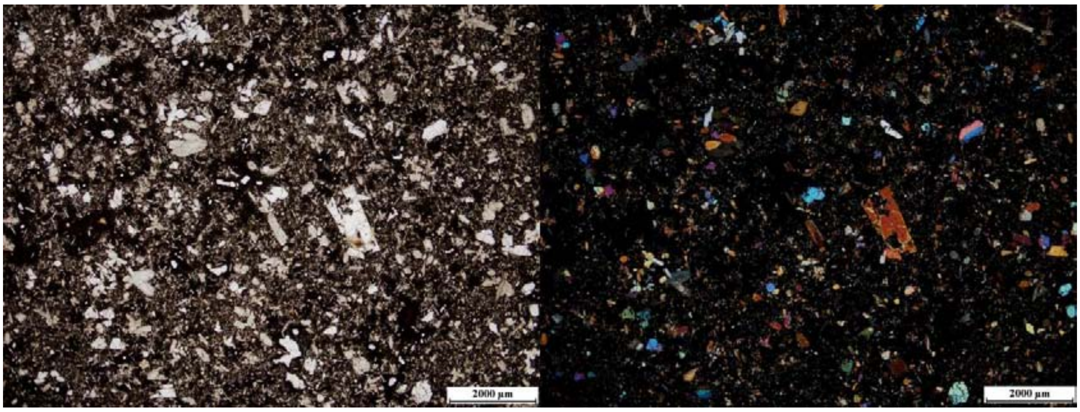


Figure II.60. – Typical microscopic photos of the basanite from Steinberg. Note the abundance of clinopyroxenes occurring often in glomerophyric groups. Left with one nicol, right with crossed nicols.

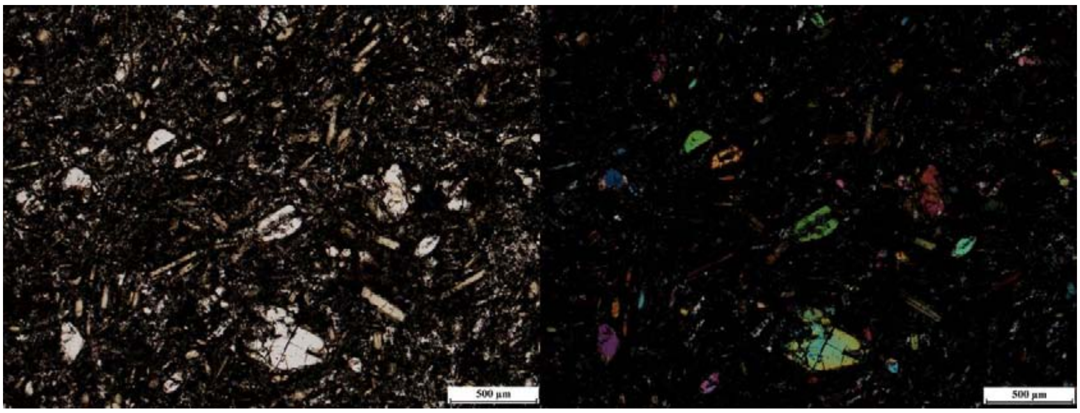


Figure II.61. – Typical microscopic photos of the olivine-basanite from Pauliberg. Note the abundance of clinopyroxenes occurring often in glomerophyric groups. Left with one nicol, right with crossed nicols.

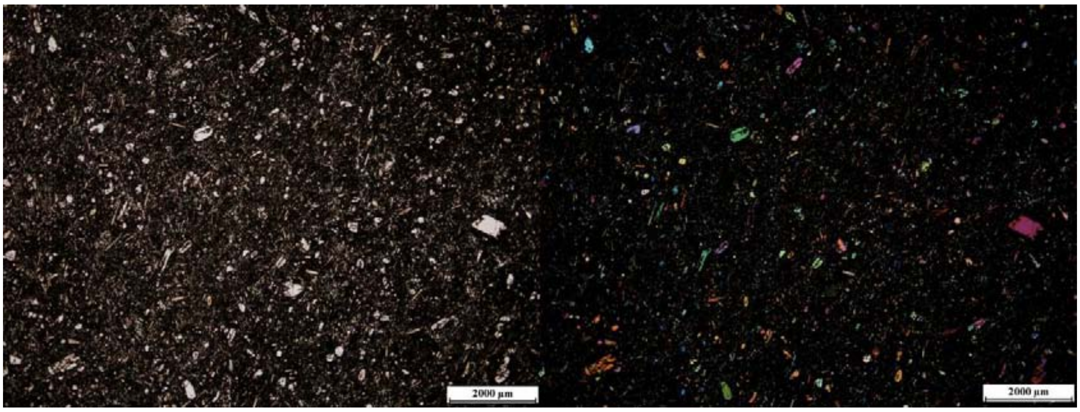


Figure II.62. – Typical microscopic photos of the olivine-basanite from Pauliberg. Note the abundance of clinopyroxenes occurring often in glomerophyric groups. Left with one nicol, right with crossed nicols.

Miocene-Quaternary basalts – Kemenesalja and the Bakony-Balaton Upland:

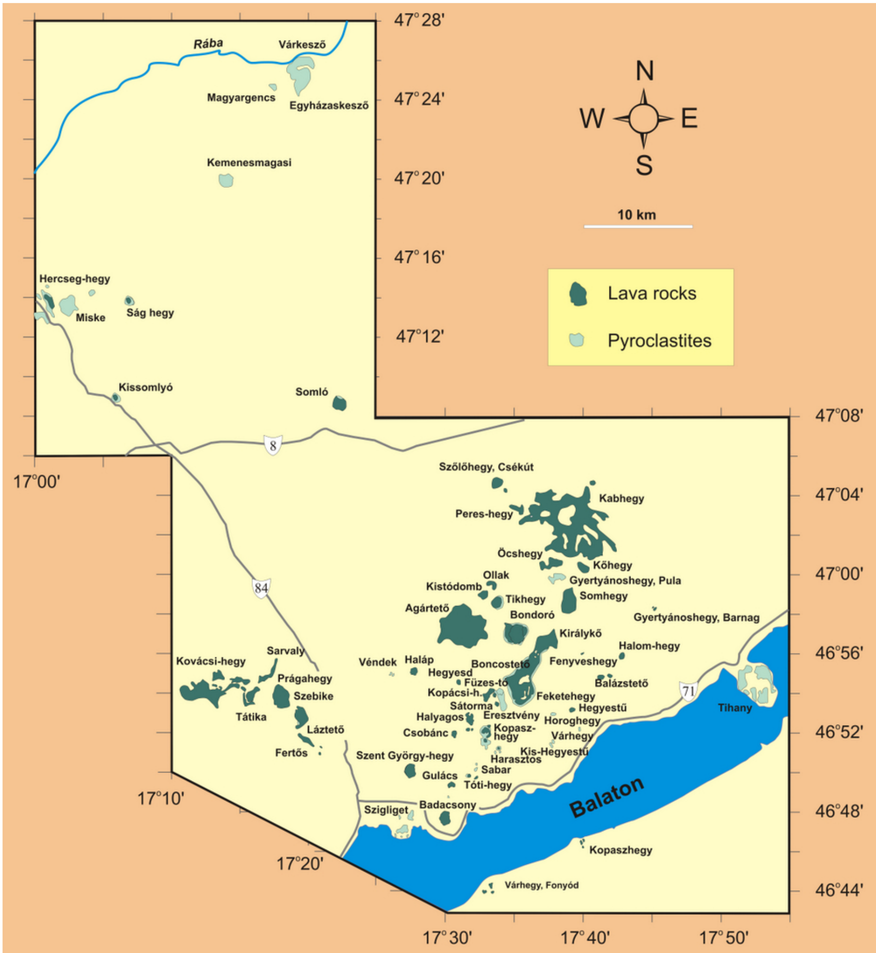


Figure II.63. – Locations of the basaltic rocks (volcanoes) in Kemenesalja and the Bakony-Balaton Upland region.

Figure II.64. – Basaltic volcanoes of Kemenesalja: the Ság hill (left) and Kissomlyó (right; photos: Szabolcs Harangi)

Figure II.65. – Basaltic volcanoes of Kemenesalja: vent-filling basalts (left) and phreatomagmatic pyroclastic sequence (right) in Ság hill (photos: Szabolcs Harangi)

Figure II.66. – Basaltic volcanoes of Kemenesalja: scoria cone cut by a vent-filling basalts (left) and spatter deposit formed by lava fountaining (right) in Ság hill (photos: Szabolcs Harangi)

Figure II.67. – Basaltic volcanoes of Kemenesalja: phreatomagmatic sequence overlain by basaltic pillow lava (left) and a closer view of the pillow lava rock (right) in Kissomlyó (photos: Szabolcs Harangi)

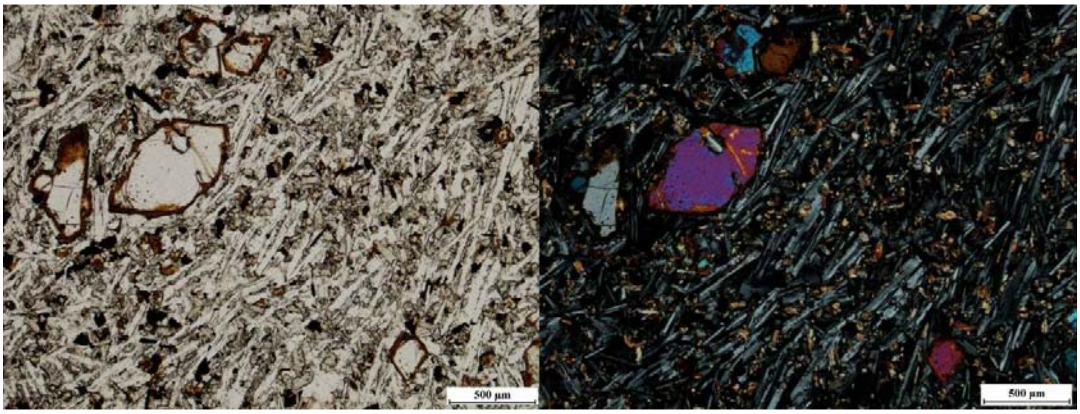


Figure II.68. – Typical microscopic photos of the olivine-phyric basalt from Ság hill. Left with one nicol, right with crossed nicols.

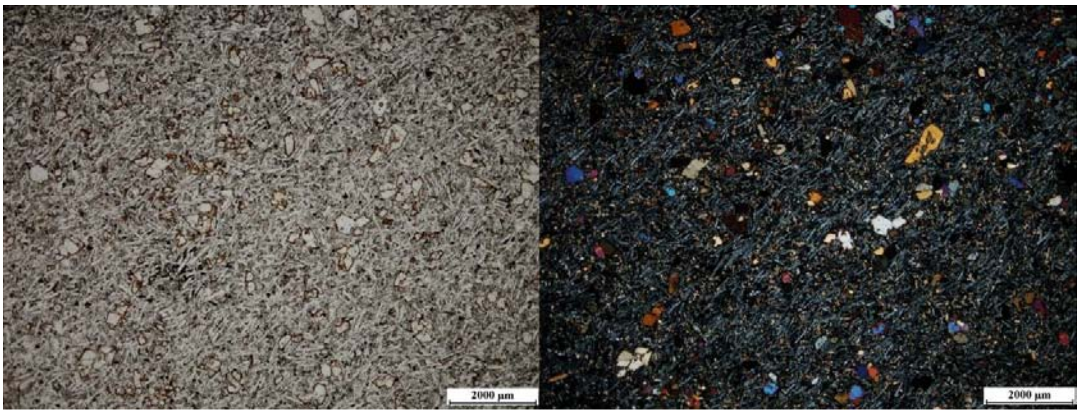


Figure II.69. – Typical microscopic photos of the olivine-phyric basalt from Ság hill. Left with one nicol, right with crossed nicols.

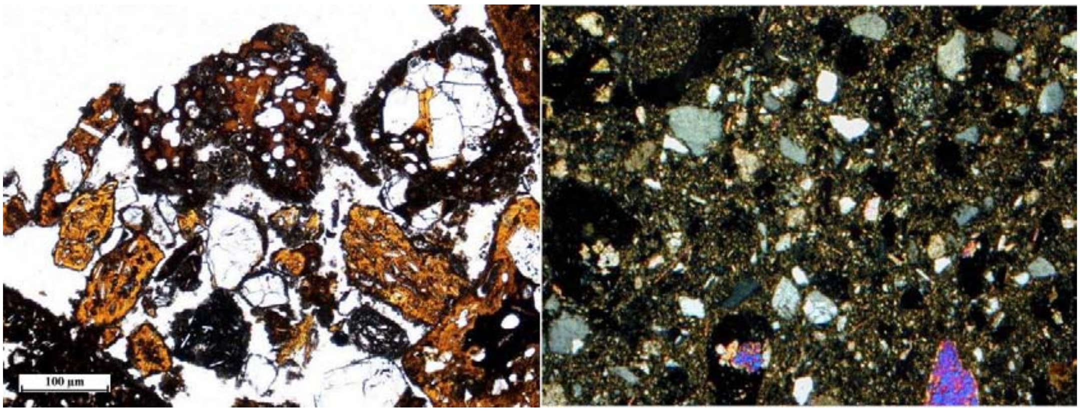


Figure II.70. – Typical microscopic photos of the phreatomagmatic lapilli tuff from Ság hill (left) and the phreatomagmtic tuff from Kissomlyó. Note the angular sideromelan glass shards on left and the abundance of xenocrysts such as quartz and muscovite on right – all of these are typical of phreatomagmatic products. Left with one nicol, right with crossed nicols.

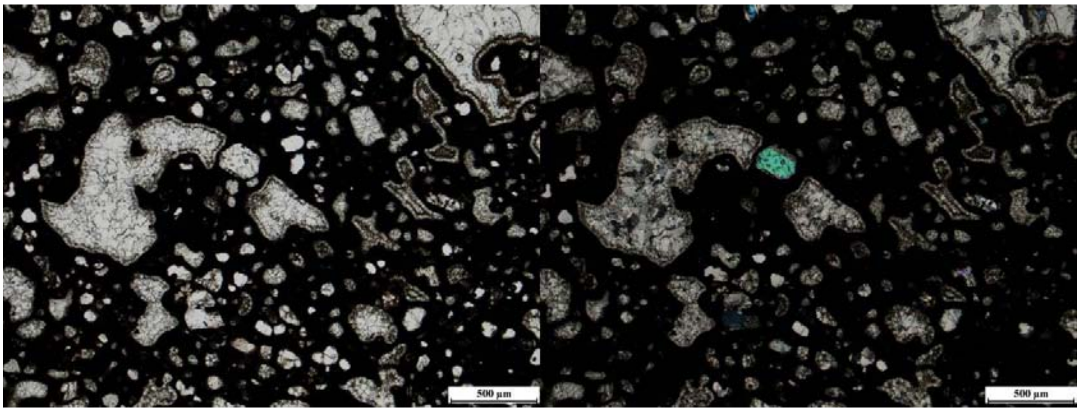


Figure II.71. – Typical microscopic photos of the vesicular basaltic scoria from Sitke. Left with one nicol, right with crossed nicols.

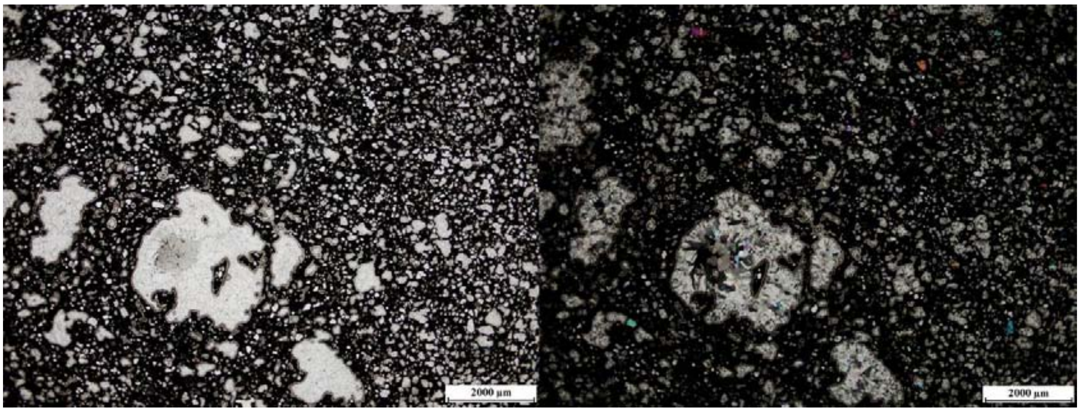


Figure II.72. – Typical microscopic photos of the vesicular basaltic scoria from Sitke. Left with one nicol, right with crossed nicols.

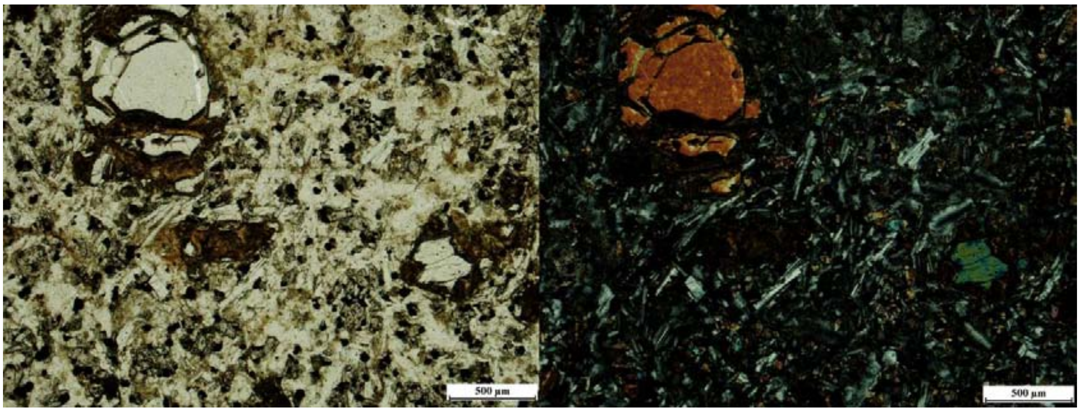


Figure II.73. – Typical microscopic photos of olivine-phyric basalt with porphyritic intergranular texture from Somló. Left with one nicol, right with crossed nicols.

Figure II.74. – The basaltic volcanoes of the Bakony-Balaton Upland volcanic field: from left to right: Halyagos, Csobánc, Tóti hill, Gulács, Badacsony, Szent György hill (photo: Szabolcs Harangi)

Figure II.75. – The basaltic volcanoes of the Bakony-Balaton Upland volcanic field: columnar jointed basalts in Hegyestű (left) and Szent György-hill (right; photo: Szabolcs Harangi)

Figure II.76. – The basaltic volcanoes of the Bakony-Balaton Upland volcanic field: The Kab hill basaltic shield volcano (photo: Szabolcs Harangi)

Figure II.77. – The basaltic volcanoes of the Bakony-Balaton Upland volcanic field: the lithoclast-rich (with Permian red sandstone blocks) maar volcanic product at left and a ballistic block with a deep impact sag (right; photo: Szabolcs Harangi)

Figure II.78. – The basaltic volcanoes of the Bakony-Balaton Upland volcanic field: the lithoclast-rich basaltic pyroclastic flow deposit at left and gas segregation pipes in this deposit (right; photo: Szabolcs Harangi)

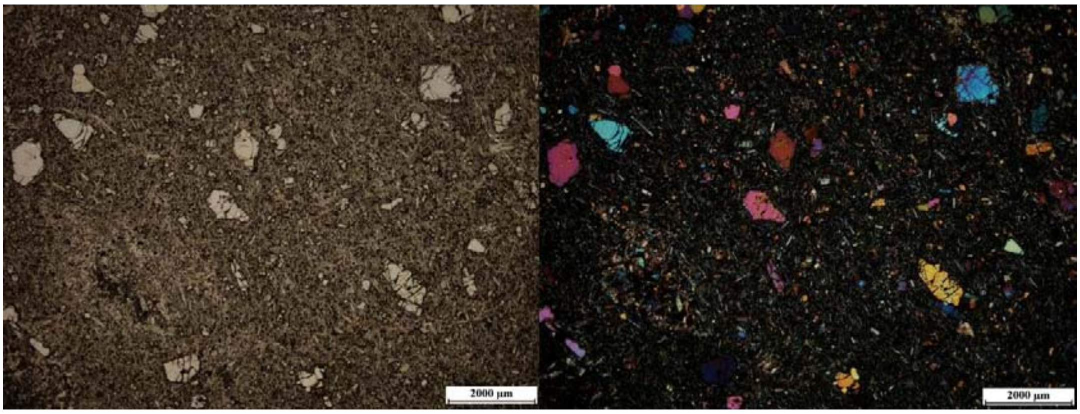


Figure II.79. – Typical microscopic photos of olivine-phyric basalt from Uzsa. Left with one nicol, right with crossed nicols.

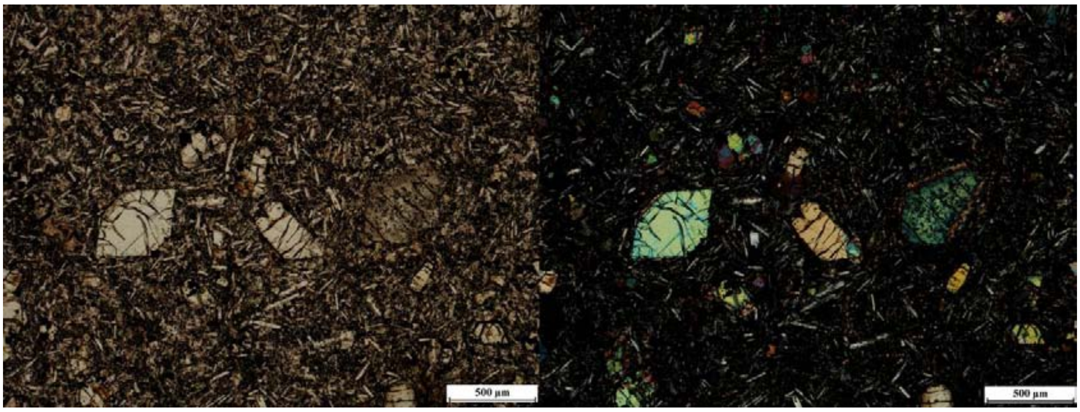


Figure II.80. – Typical microscopic photos of olivine-phyric basalt with porphyritic intergranular texture from Csobánc. Left with one nicol, right with crossed nicols.

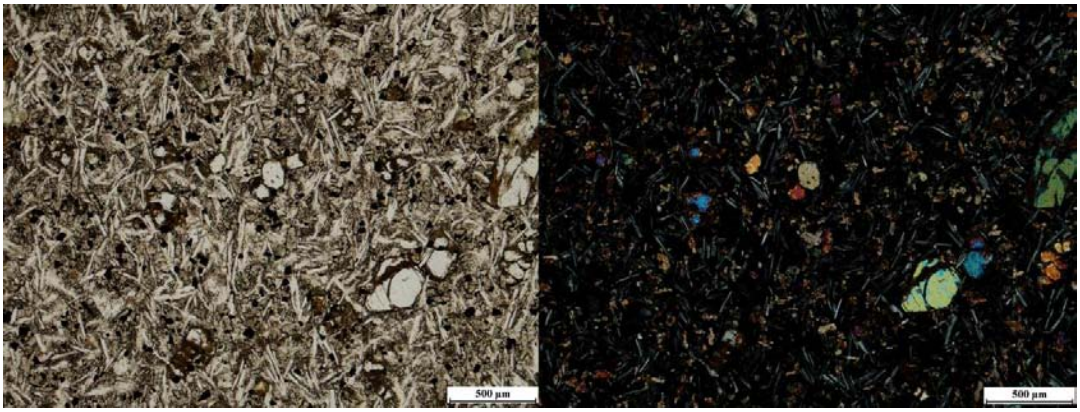


Figure II.81. – Typical microscopic photos of olivine-phyric basalt with porphyritic intergranular texture from Gulács. Left with one nicol, right with crossed nicols.

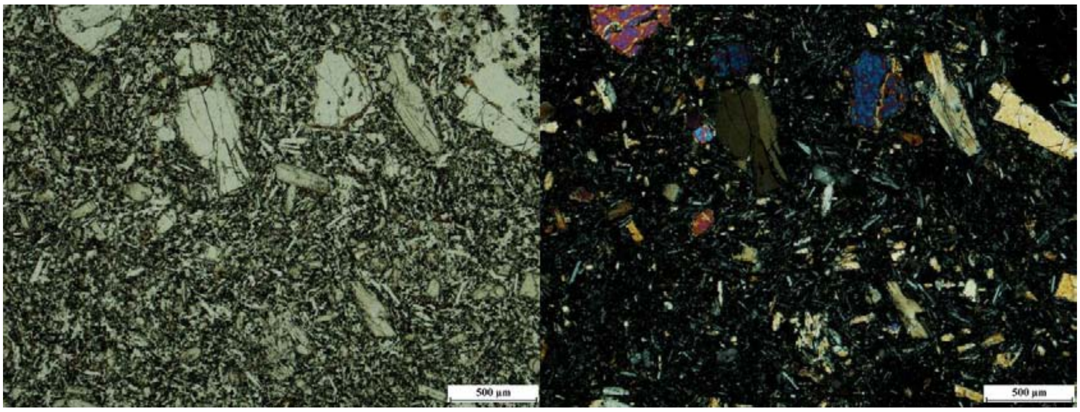


Figure II.82. – Typical microscopic photos of clinopyroxene-phyric basalt from the Halom hill. Left with one nicol, right with crossed nicols.

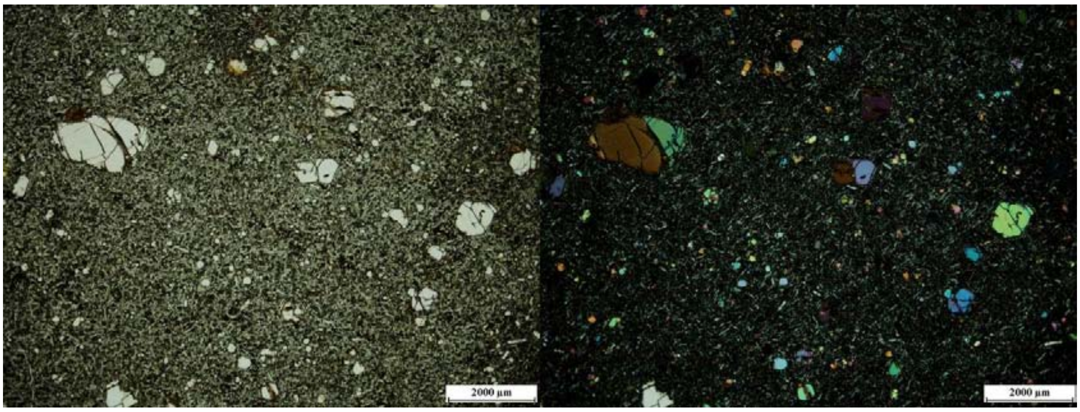


Figure II.83. – Typical microscopic photos of the olivine-phyric basalt from Halyagos. Left with one nicol, right with crossed nicols.

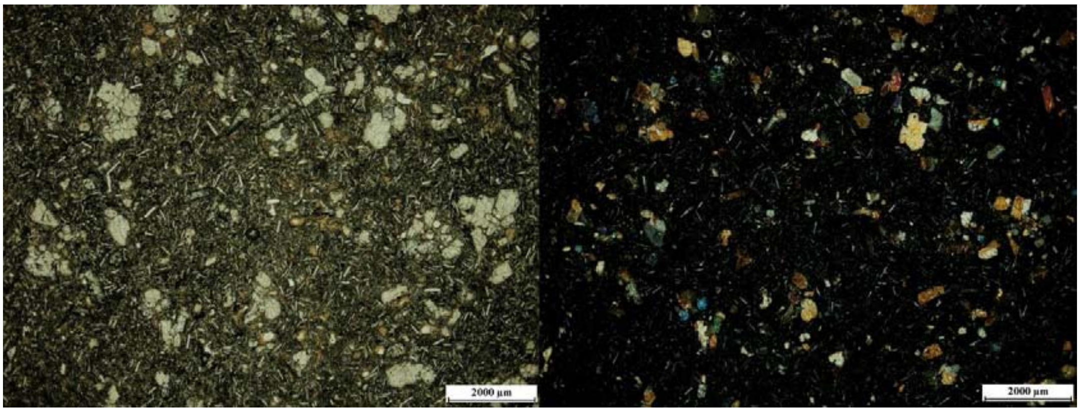


Figure II.84. – Typical microscopic photos of clinpyroxene-phyric basalt from the Hegyesd. Left with one nicol, right with crossed nicols.

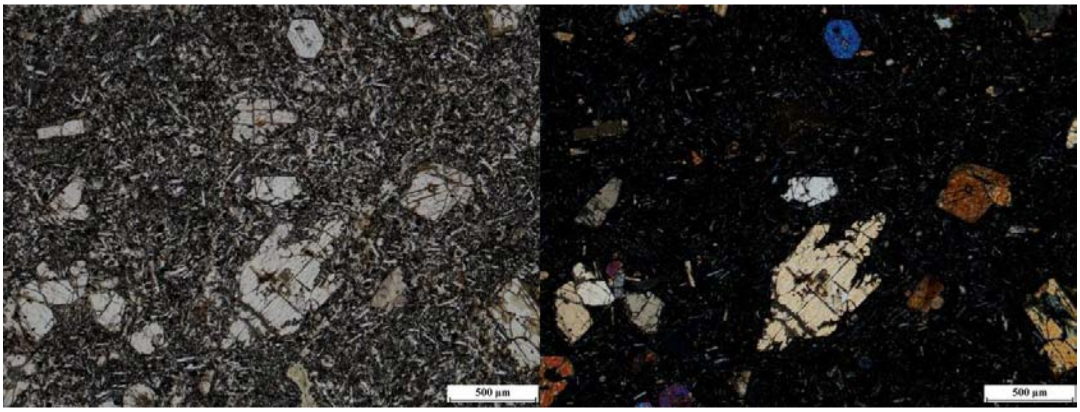


Figure II.85. – Typical microscopic photos of the olivine-phyric basalt from Hegyestű. Left with one nicol, right with crossed nicols.

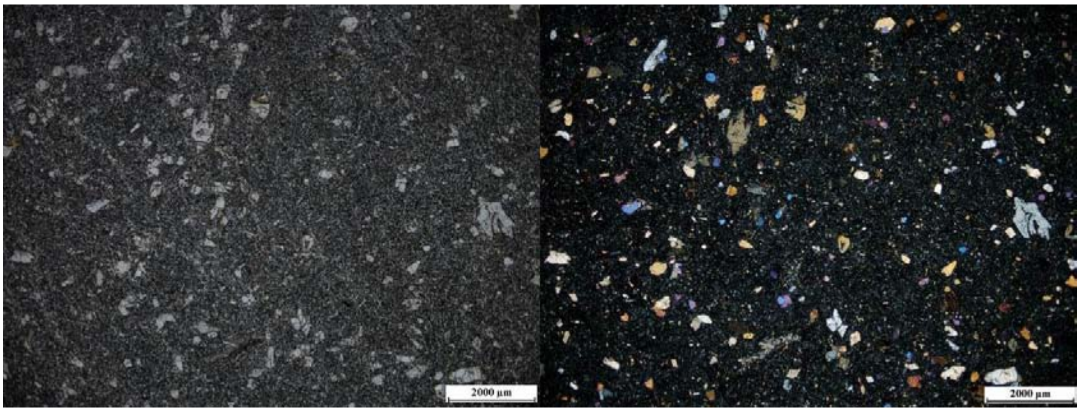


Figure II.86. – Typical microscopic photos of the olivine-phyric basalt from Hegyestű. Left with one nicol, right with crossed nicols.

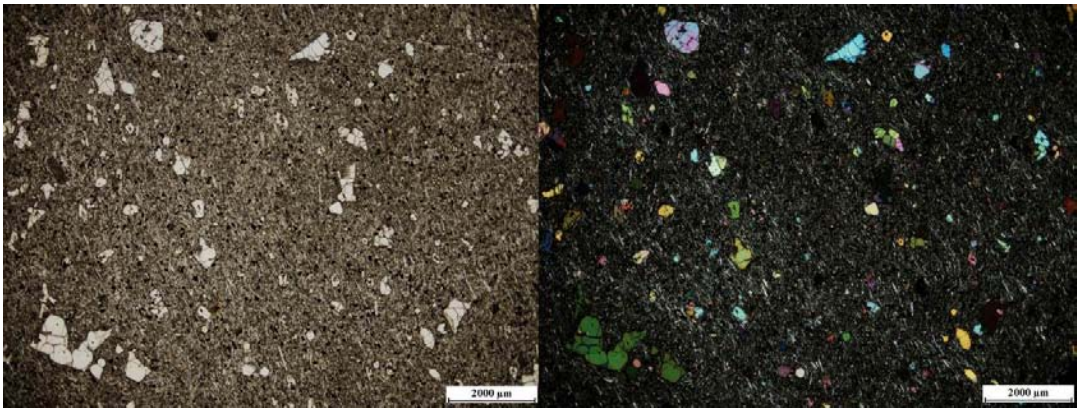


Figure II.87. – Typical microscopic photos of the olivine-phyric basalt from Hegyestű. Left with one nicol, right with crossed nicols.

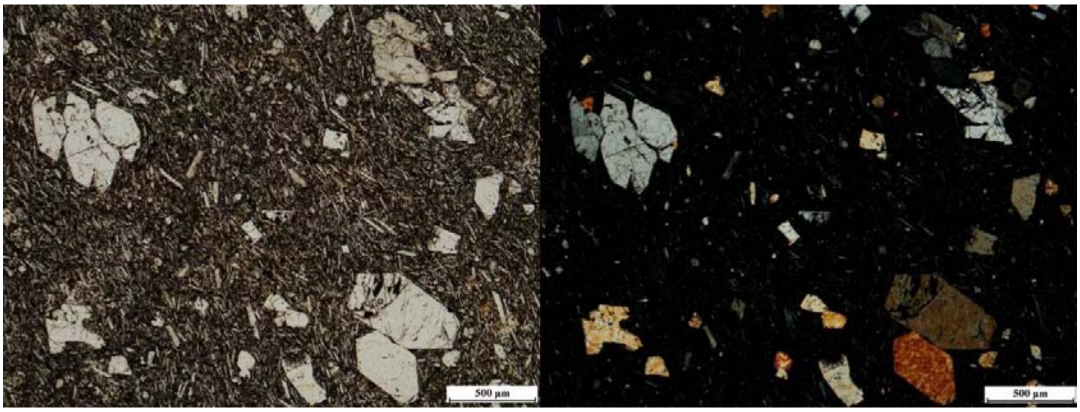


Figure II.87. – Typical microscopic photos of the olivine-phyric basalt from Király-kő, Kapolcs. Left with one nicol, right with crossed nicols.

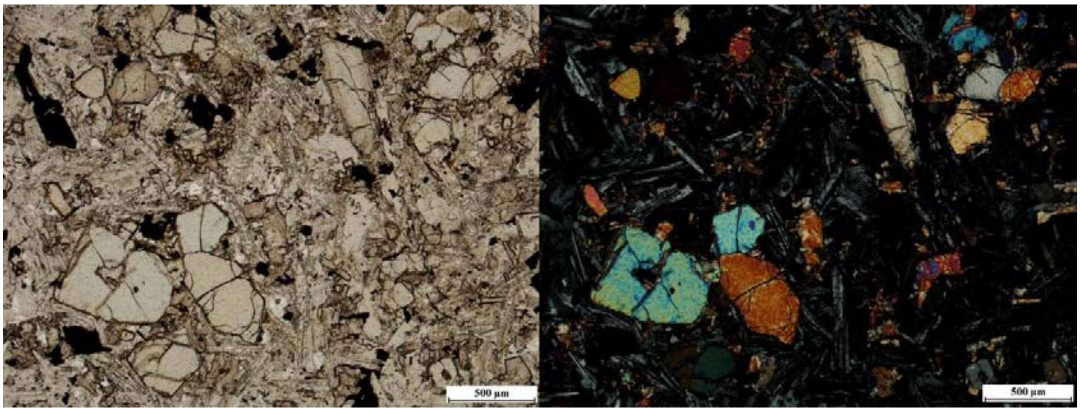


Figure II.87. – Typical microscopic photos of the olivine-phyric basalt from the Kovácsi hill. Left with one nicol, right with crossed nicols.

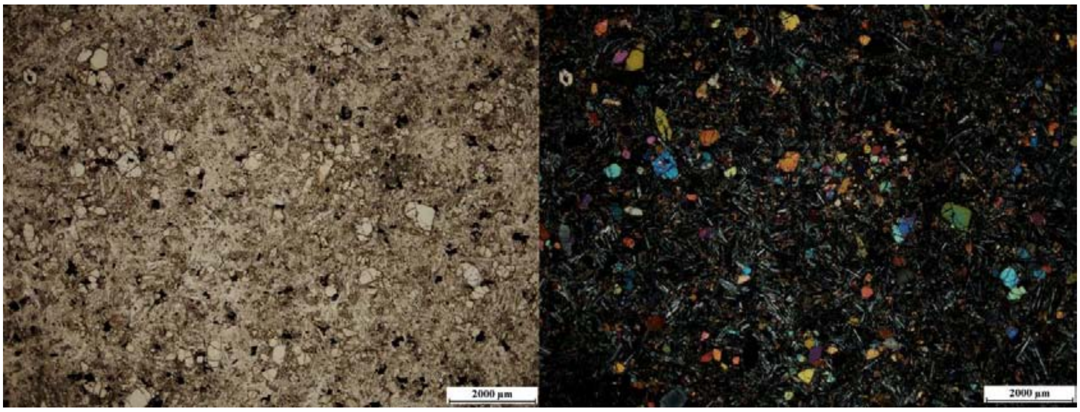


Figure II.88. – Typical microscopic photos of the olivine-phyric basalt from the Kovácsi hill. Left with one nicol, right with crossed nicols.

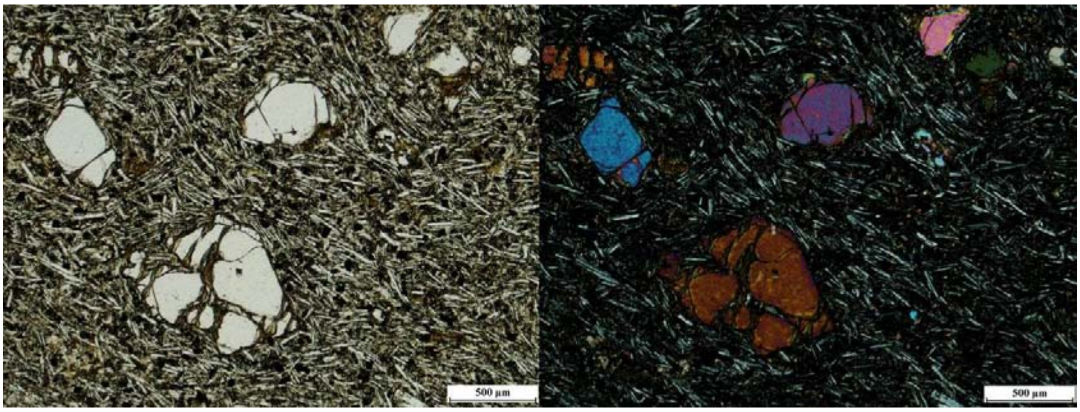


Figure II.89. – Typical microscopic photos of the olivine-phyric basalt from the Szent György hill. Left with one nicol, right with crossed nicols.

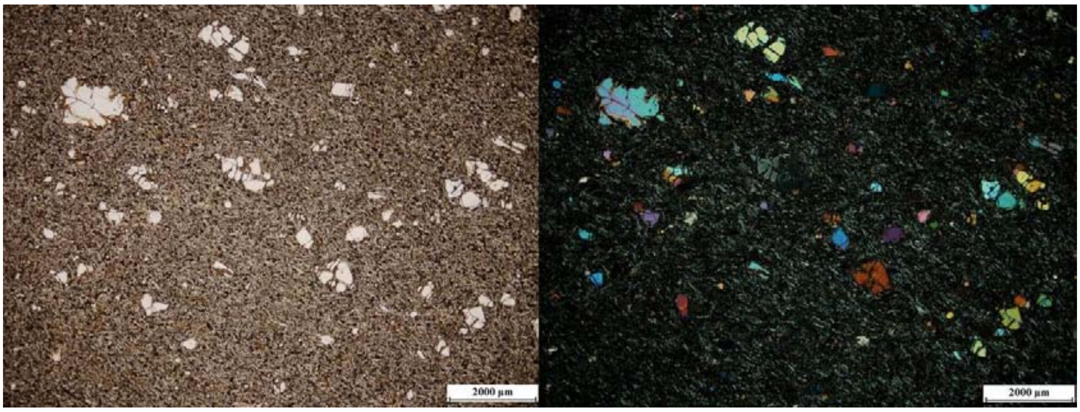


Figure II.90. – Typical microscopic photos of the olivine-phyric basalt from the Szent György hill. Left with one nicol, right with crossed nicols.

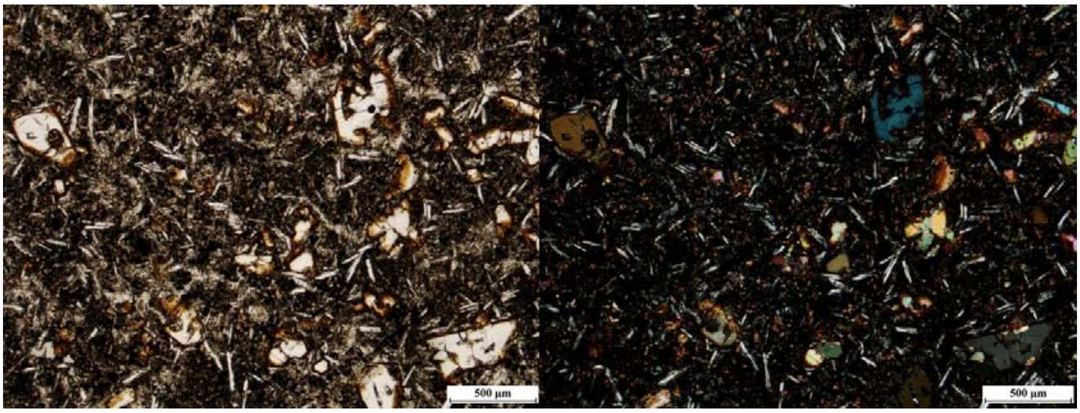


Figure II.91. – Typical microscopic photos of the olivine-phyric basalt from the Badacsony. Left with one nicol, right with crossed nicols.

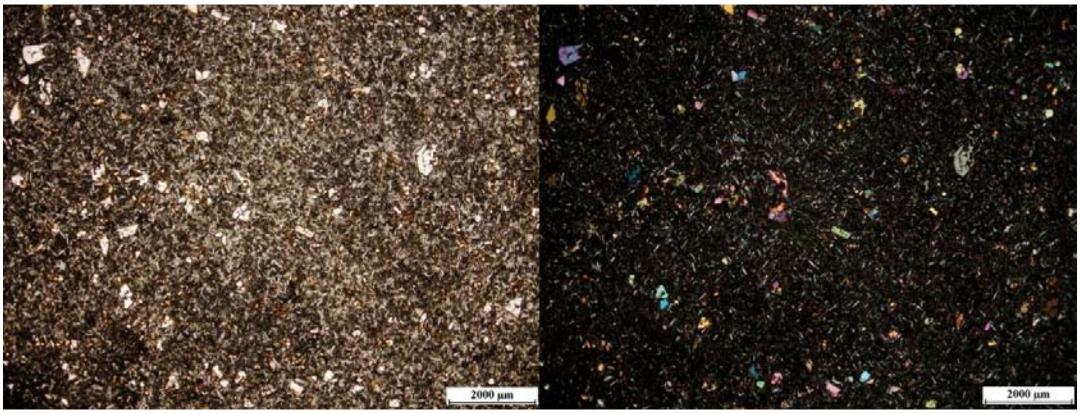


Figure II.92. – Typical microscopic photos of the olivine-phyric basalt from the Badacsony. Left with one nicol, right with crossed nicols.

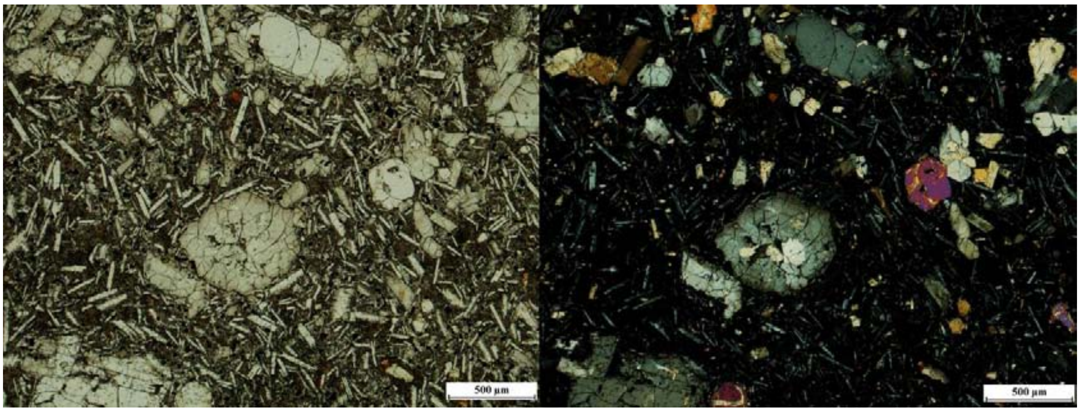


Figure II.92. – Typical microscopic photos of the olivine-and clinopyroxene-phyric basalt from the Szigliget. Left with one nicol, right with crossed nicols.

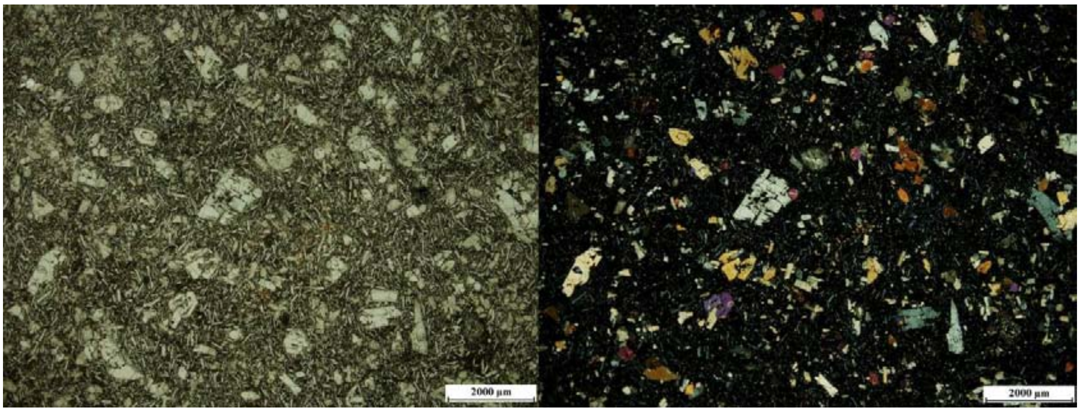


Figure II.93. – Typical microscopic photos of the olivine-and clinopyroxene-phyric basalt from the Szigliget. Left with one nicol, right with crossed nicols.

Figure II.94. – Typical microscopic photos of the olivine-phyric basalt from the Tóti hill. Left with one nicol, right with crossed nicols.

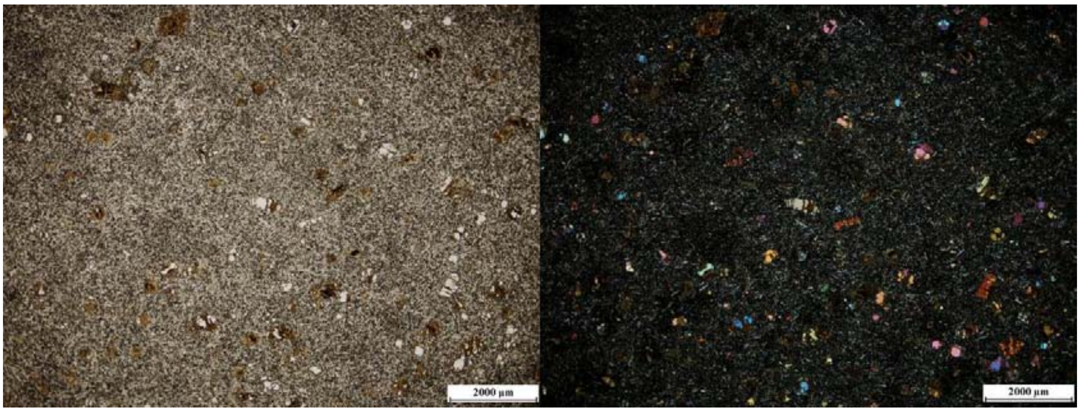
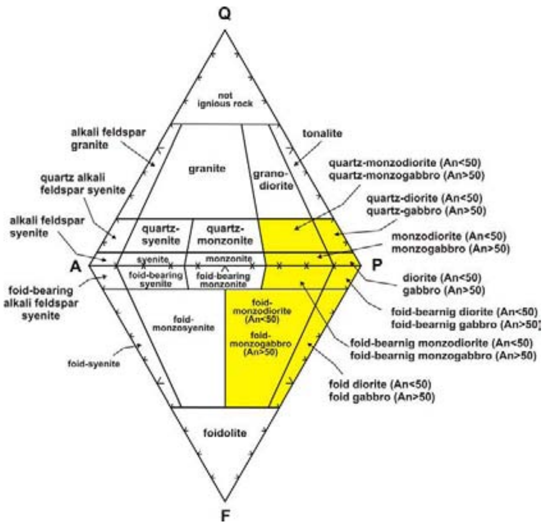


Figure II.95. – Typical microscopic photos of the olivine-phyric basalt from the Tóti hill. Left with one nicol, right with crossed nicols.

II.3. Intermediate igneous rocks

DIORITE



Appearance: Dark, medium to coarse-grained intrusive igneous rock, the intrusive equivalent of andesite. The mineral of this rock type is similar with the gabbros, but the anorthite content of plagioclase is usually less than 50 mol%. It usually can be found in subduction zones.

Mineral content:

Essential minerals: Ca-Na plagioclase, amphibole, less biotite and pyroxene (clino- and/or orthopyroxene). Among the mafic minerals amphibole prevails,

Accessory minerals: minor amount of quartz, alkali-feldspar or olivine and feldspathoids, as well as apatite, magnetite, garnet

Secondary minerals: chlorite, sericite, epidote

Rock types:

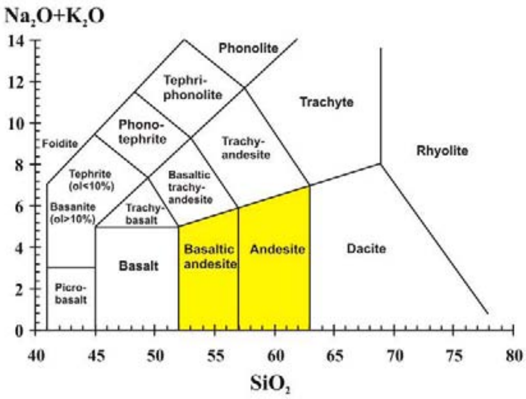
- Quartz-diorite: a variety of diorite containing quartz and alkali feldspar
- Monzodiorite: a variety of diorite containing olivine and feldspathoids
- alkali diorite (essexite): Ca-Na plagioclase > orthoclase-microcline, nepheline, (sodalite, analcime), alkali amphibole, alkali pyroxene, biotite

further varieties of diorites are defined based on the occurrence of quartz or feldspathoids and considering the relative amount of alkali feldspar and plagioclase: quartz-monzodiorite and foid-diorite, foid-bearing diorite, foid-bearing monozodiorite and foid-monzodiorite

Figure II.96. – Diorite

Locations in the Carpathian-Pannonian region: Central-Slovakian volcanic complex, such as in the deeply eroded central part of the Stiavnica, Kremnica and Javorie volcanoes

ANDESITE



Appearance: Dark, grey or red, fine-grained often medium to highly prophyritic volcanic rock. It is common rock type of subduction zones.

Mineral content:

Essential minerals: Ca-Na plagioclase, amphibole, pyroxene (clino- and/or orthopyroxene), occasionally biotite.

Accessory minerals: apatite, magnetite, garnet

Secondary minerals: chlorite, sericite, epidote, carbonat minerals

Rock types:

- Amphibole-andesite: among the mafic mineral, amphibole (hornblende) prevails
- Pyroxene-andesite: among the mafic mineral, pyroxene (clino- and/or orthopyroxene) prevails. When both pyroxene groups occur int he same rock, it is often called two-pyroxene-andesite

- Biotite-andesite: among the mafic mineral, biotite prevails, This type of andesite is usually more silica-rich and could contain minor quartz.
- Basaltic andesite: transitional rock type between basalt and andesite, although this can be recognized only based ont he major element composition. Olivine is often present in this rock type

Figure II.97. – Andesite (Szanda, Cserhát)

Figure II.98. – Typical, grey and red andesite from the Visegrád Mts. Although they have different appearance, they are similar petrographically and geochemically. They could be derived from the same collapsed lava dome and now are the main constituents of block- and ash flow deposits (Thirring-cliffs, Visegrád Mts., photo: Szabolcs Harangi)

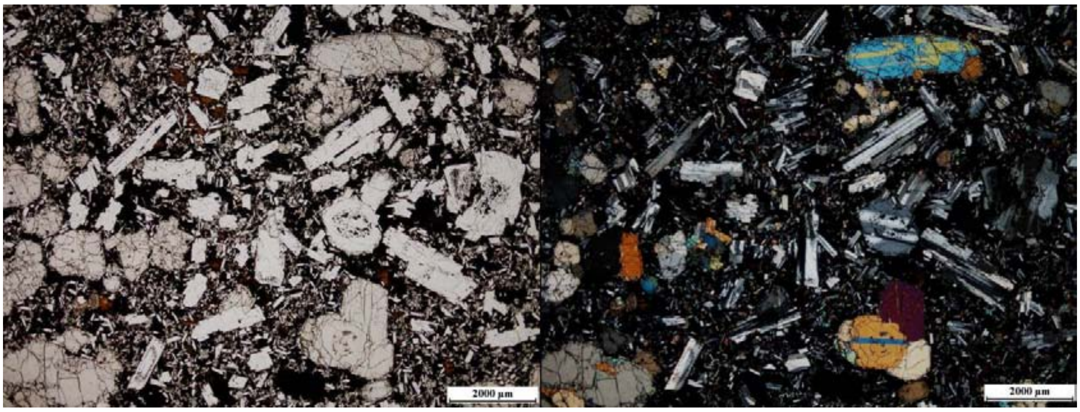


Figure II.99. – Typical microscopic photos of plagioclase- and pyroxene-phyric andesite from Bér, Cserhát. Left with one nicol, right with crossed nicols.

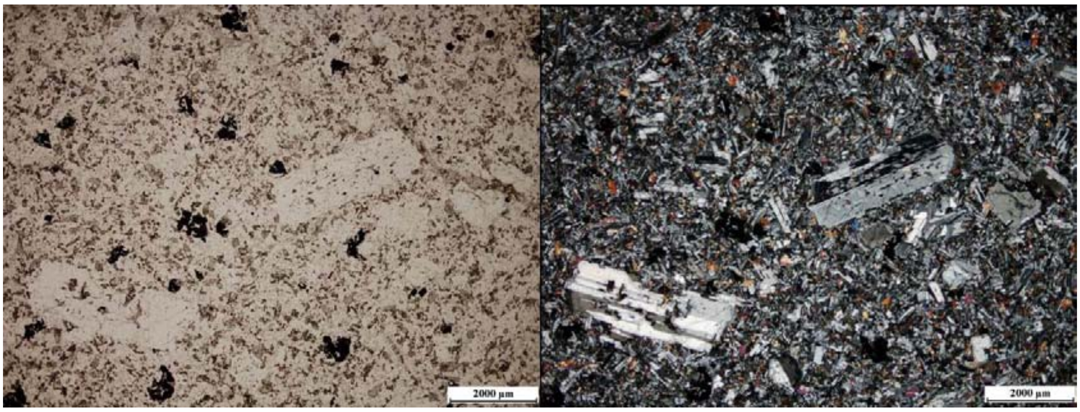


Figure II.100. – Typical microscopic photos of plagioclase-phyric andesite from Zsuny, Cserhát. Left with one nicol, right with crossed nicols.

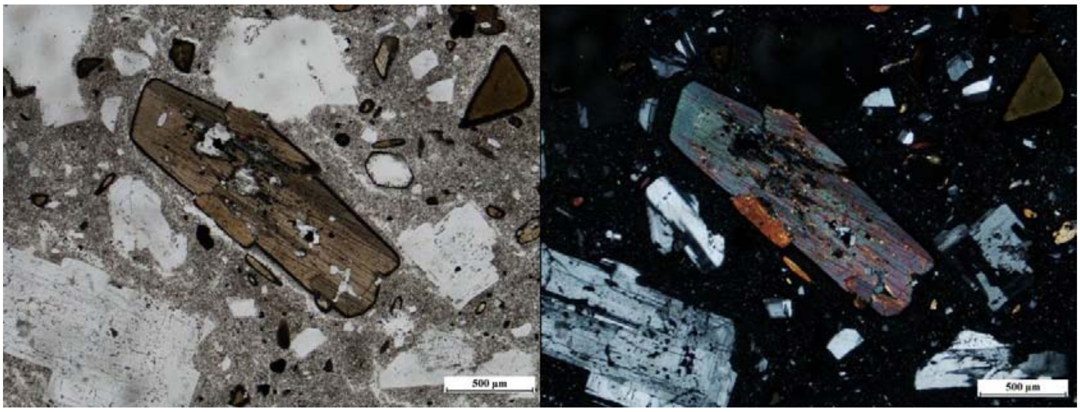


Figure II.101. – Typical microscopic photos of amphibole- and plagioclase-phyric andesite from the Visegrád Mts.. Left with one nicol, right with crossed nicols.

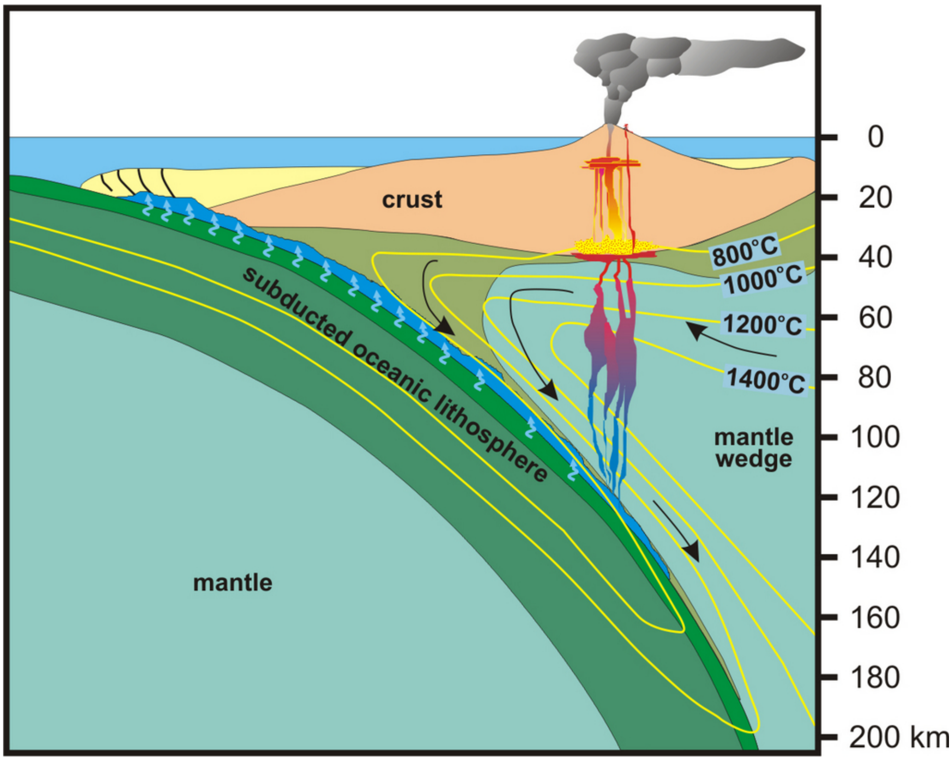


Figure II.102 – A simiplified cross-section of a subduction zone, where most of the andesites are formed via fractional crystallization of primitive mantle-derived high-Al basalts and/or by mixing of mantle-derived mafic and crustal silicic magmas.

Figure II.103. – Characteristic andesite lava rocks: block lava in Nea Kameni, Santorini (left, photo: Szabolcs Harangi) and steep-sided fresh lava dome emerged from the remnant of an old, collapsed lava dome remnant (Soufriére Hills, Montserrat,photo: Richard Roscoe)

Figure II.104. – Characteristic andesite lava rocks: the andesitic lava dome of the Unzen, Japan with a block- and ash flow deposit in the front (photo: Richard Roscoe).

<u>Locations in the Carpathian-Pannonian region</u>: Eastern-Bükk (Triassic), Zala basin, Velence Mts. and Recsk (Eocene-Oligocene); Miocene-Pliocene andesites: Pohorje, Visegrád Mts., Börzsöny; Central-Slovakian volcanic complex (Stiavnica, Kremnica, Javorie, Polyana), Cserhát, Mátra, Cserehát, Tokaj-Slanec Mts., Vihorlat, Gutin, Calimani, Gurghiu, Harghita, Apuseni, Mecsek, basement of the Great Hungarian Plain

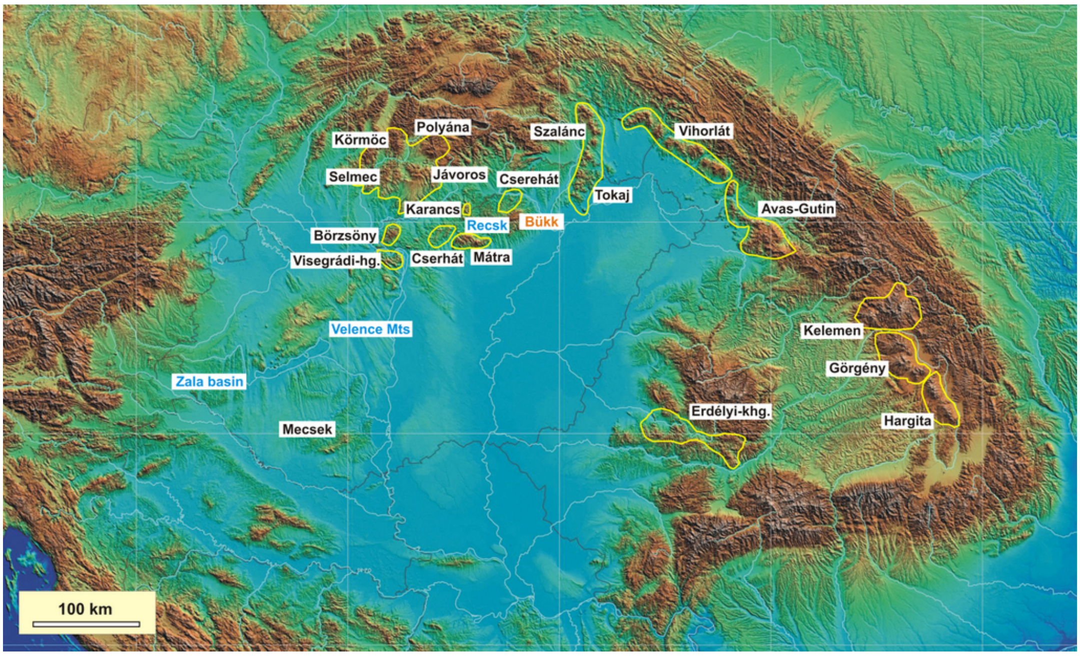


Figure II.105. – Locations of the Triassic (orange), Eocebe-Oligocene (blue) and Miocene-Pliocene andesites (black) in the Carpathian-Pannonian region.

Triassic andesite:

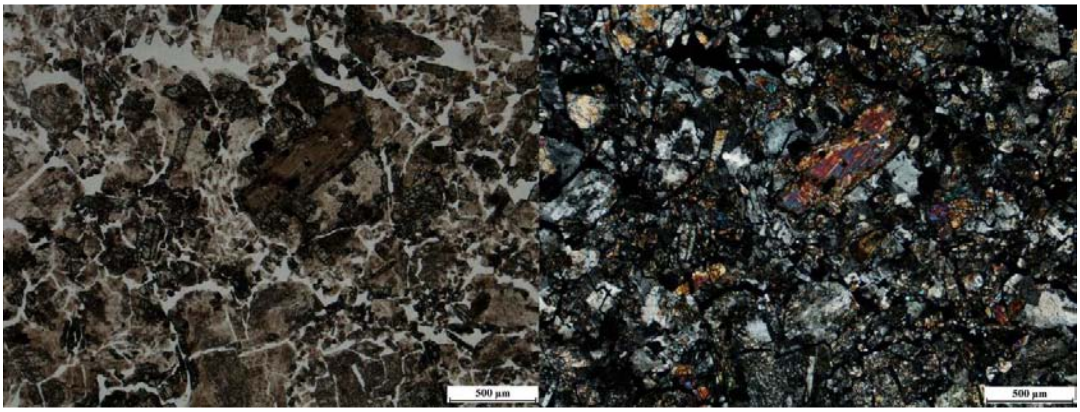


Figure II.106. – Typical microscopic photos of andesite from Polgárdi. The rock is strongly altered. Scarn mineralization belongs to this subvolcanic andesite body. Left with one nicol, right with crossed nicols.

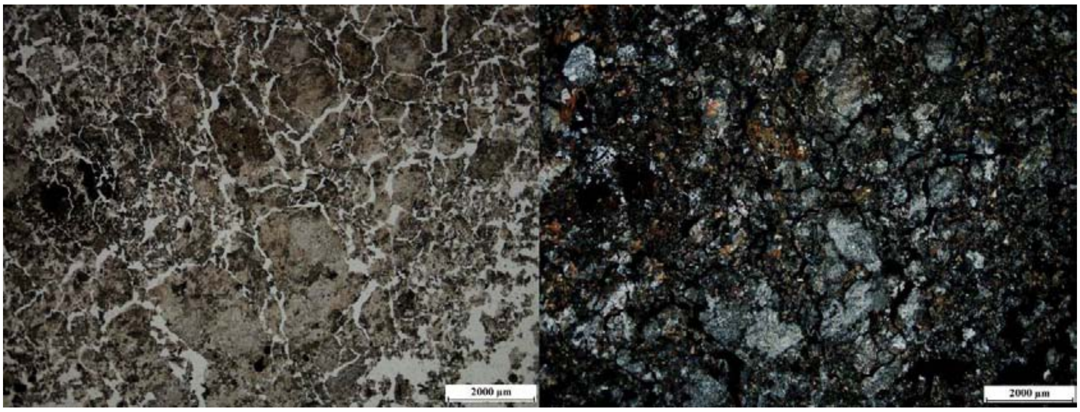


Figure II.107. – Typical microscopic photos of andesite from Polgárdi. The rock is strongly altered. Scarn mineralization belongs to this subvolcanic andesite body. Left with one nicol, right with crossed nicols.

Eocene-Oligocene andesites:

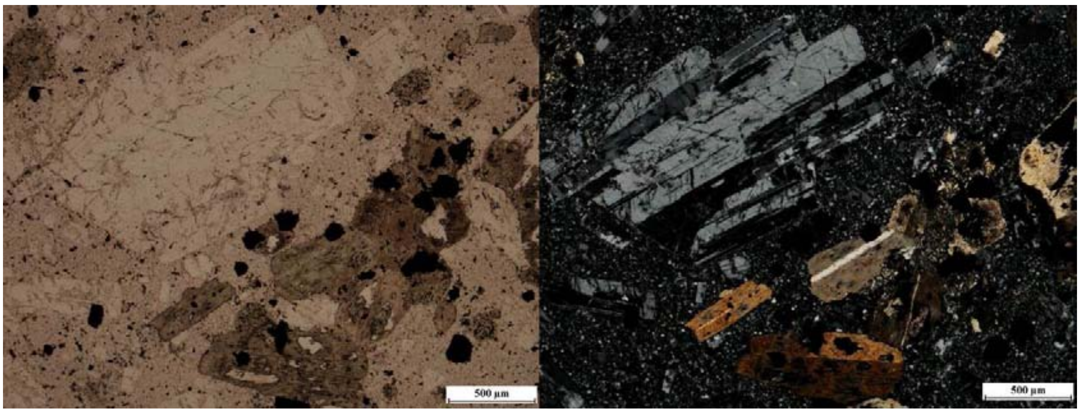


Figure II.108. – Typical microscopic photos of andesite from Nadap (Velence Mts.). Left with one nicol, right with crossed nicols.

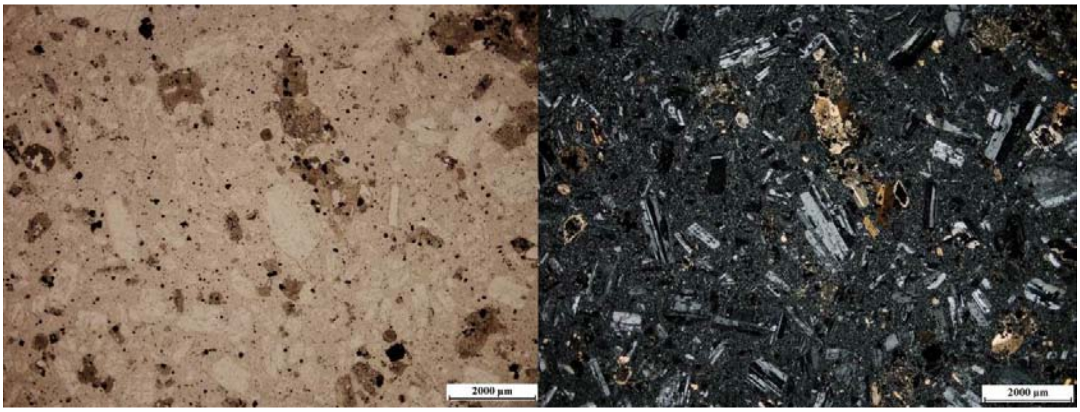


Figure II.109. – Typical microscopic photos of andesite from Nadap (Velence Mts.). Left with one nicol, right with crossed nicols.

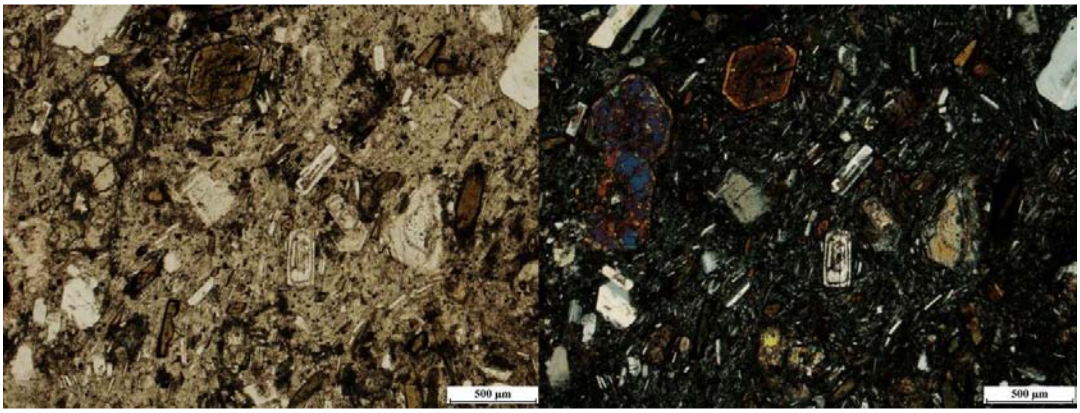


Figure II.110. – Typical microscopic photos of andesite from Kanázsvár (Recsk, Mátra). Left with one nicol, right with crossed nicols.

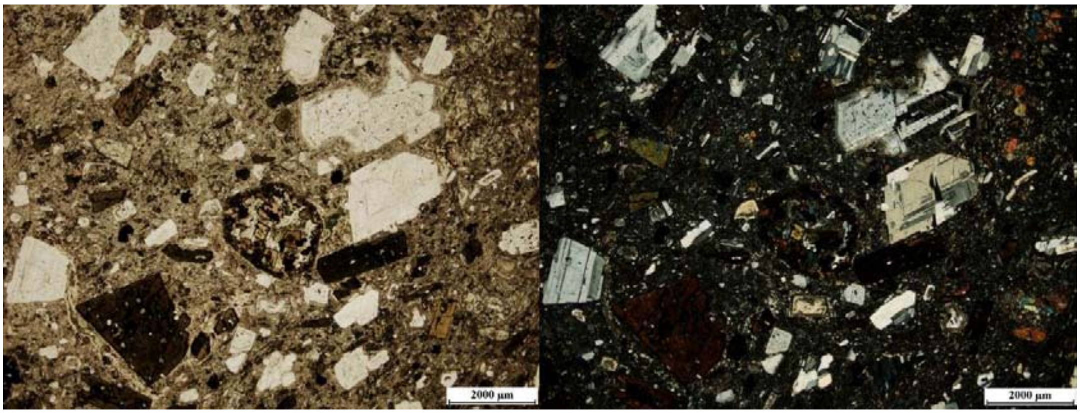


Figure II.111. – Typical microscopic photos of andesite from Kanázsvár (Recsk, Mátra). Left with one nicol, right with crossed nicols.

Miocene-Pliocene andesites

Visegrád Mts. and Börzsöny (13-16 Ma)

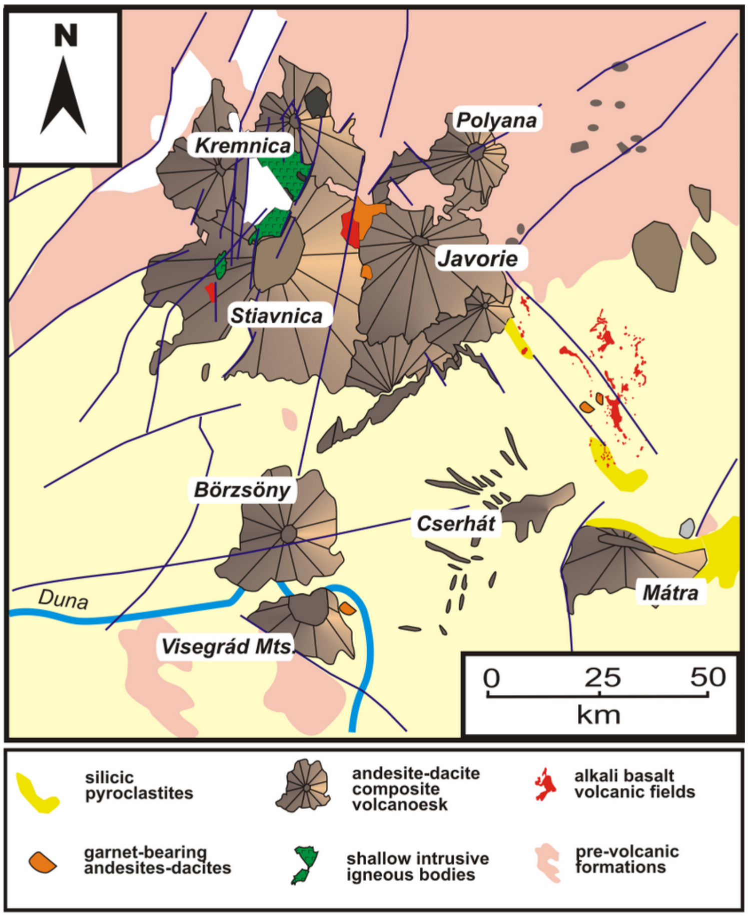


Figure II.112. – Locations of Miocene andesitic rocks in the Northern Pannonian basin.

Figure II.113. – Miocene andesites: a deeply eroded volcano (Keserűs volcano, Visegrád Mts) from the viewpoint of Dobogókő (photo: Szabolcs Harangi).

Figure II.114. – Miocene andesites: rhyodacitic pyroclastic flow deposit and accretionary lapilli-bearing tuff, the oldest volcanic products of the Visegrád Mts. (Holdvilág-valley; photo: Szabolcs Harangi).

Figure II.115. – Miocene andesites: block- and ash flow deposits of nuée ardentes in the Thirring cliffs (Visegrád Mts.; photos: Szabolcs Harangi)

Figure II.116. – Miocene andesites: The Castle hill at Visegrád is composed of huge rock avalanche deposits formed by flank collapse of an andesite volcano (Visegrád Mts.; photos: Szabolcs Harangi)

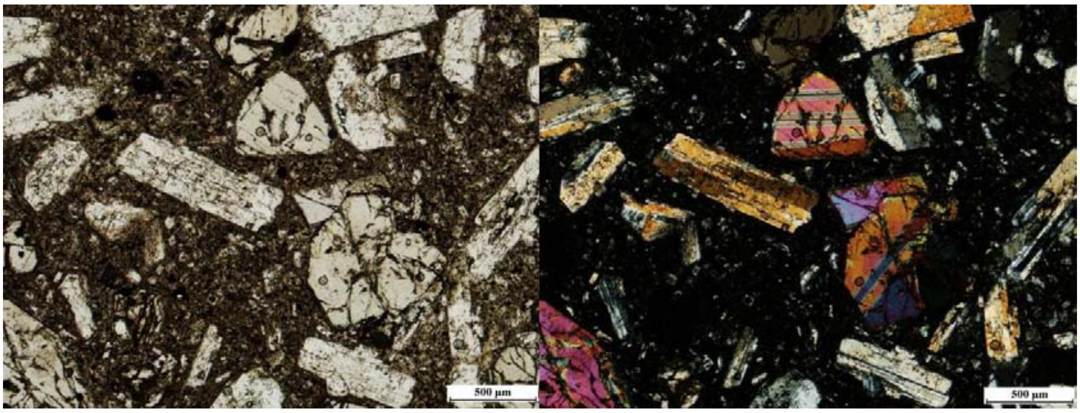


Figure II.117. – Typical microscopic photos of pyroxene-andesite from Dömörkapu (Visegrád Mts.). Left with one nicol, right with crossed nicols.

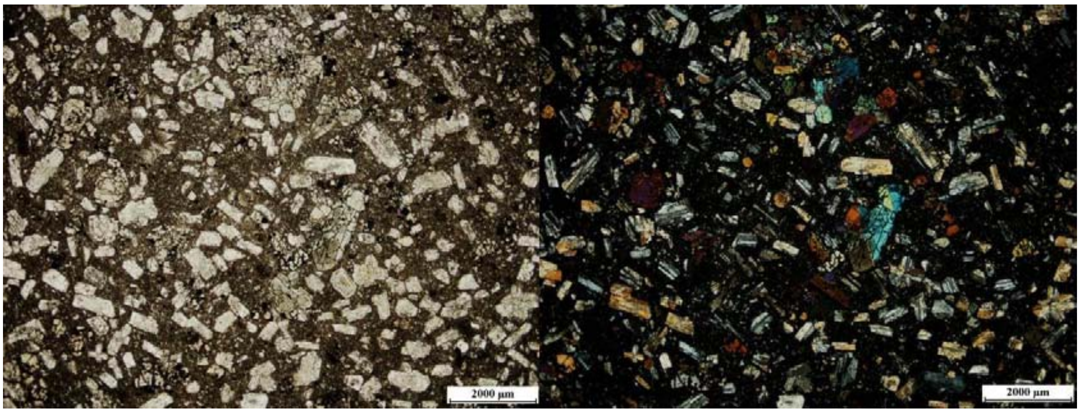


Figure II.118. – Typical microscopic photos of pyroxene-andesite from Dömörkapu (Visegrád Mts.). Left with one nicol, right with crossed nicols.

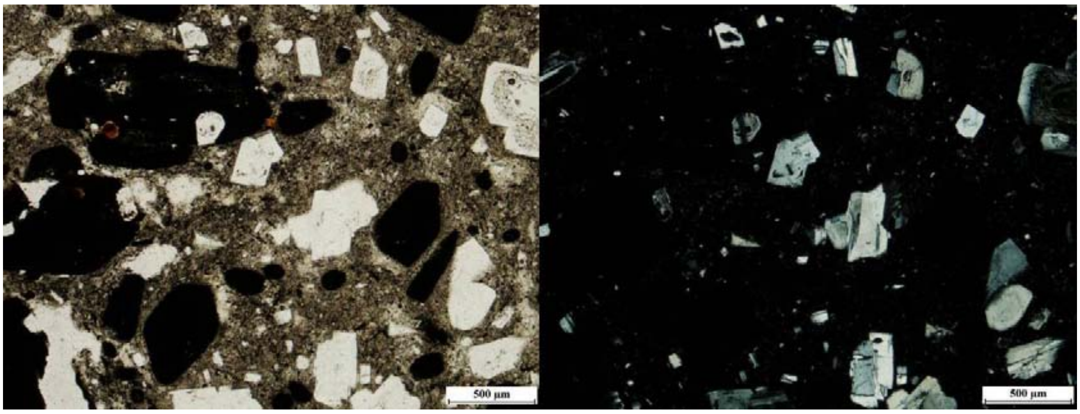


Figure II.119. – Typical microscopic photos of the red andesite from Vadálló-kövek (Visegrád Mts.). Amphiboles show total opacitization. Left with one nicol, right with crossed nicols.

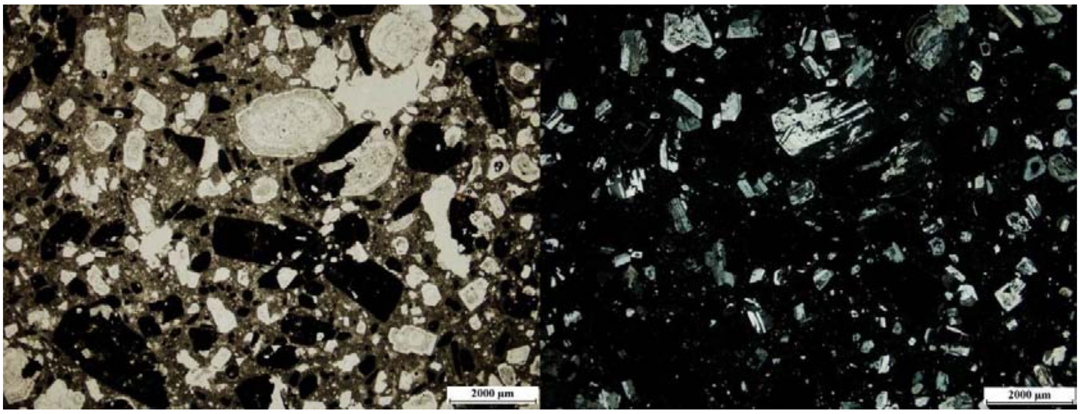


Figure II.120. – Typical microscopic photos of the red andesite from Vadálló-kövek (Visegrád Mts.). Amphiboles show total opacitization. Left with one nicol, right with crossed nicols.

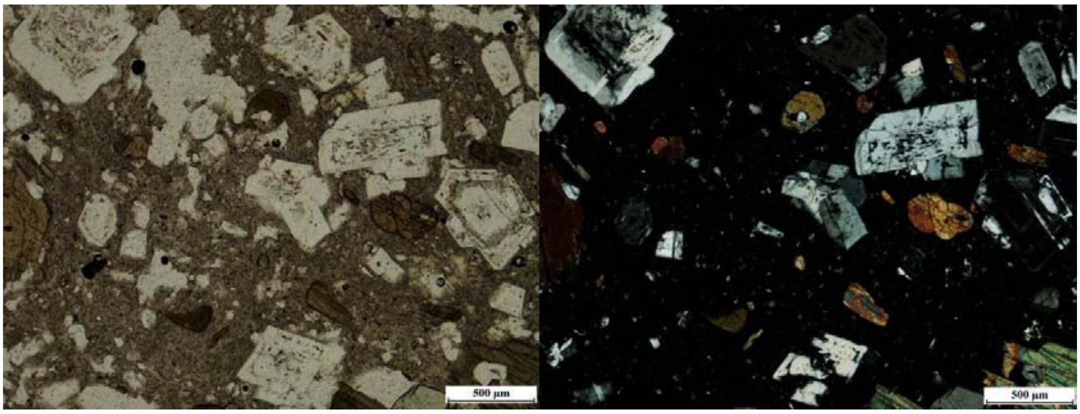


Figure II.121. – Typical microscopic photos of the light grey amphibole andesite from Vadálló-kövek (Visegrád Mts.). Left with one nicol, right with crossed nicols.

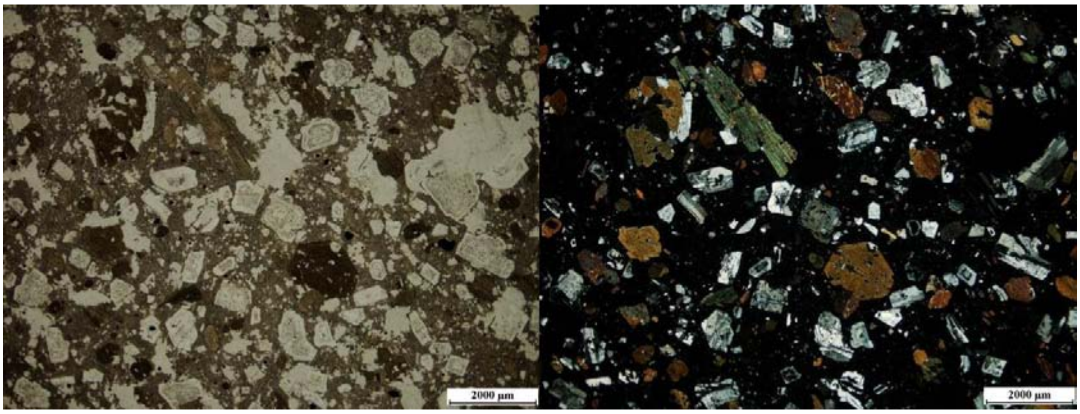


Figure II.122. – Typical microscopic photos of the light grey amphibole-andesite from Vadálló-kövek (Visegrád Mts.). Left with one nicol, right with crossed nicols.

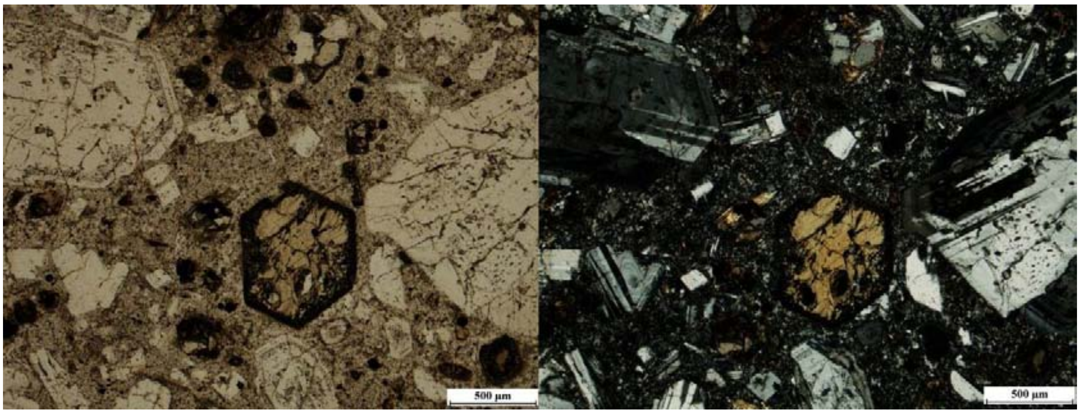


Figure II.123. – Typical microscopic photos of amphibole-andesite from Holdvilág-árok (Visegrád Mts.). Left with one nicol, right with crossed nicols.

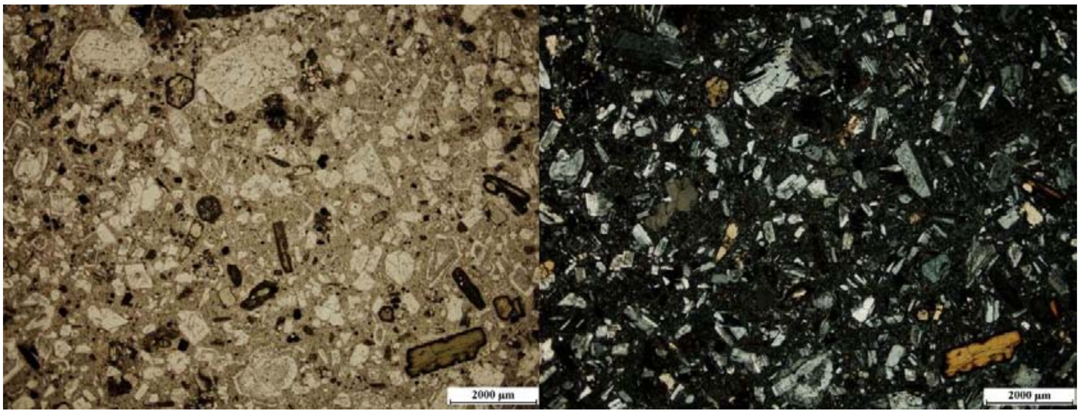


Figure II.124. – Typical microscopic photos of amphibole-andesite from Holdvilág-árok (Visegrád Mts.). Left with one nicol, right with crossed nicols.

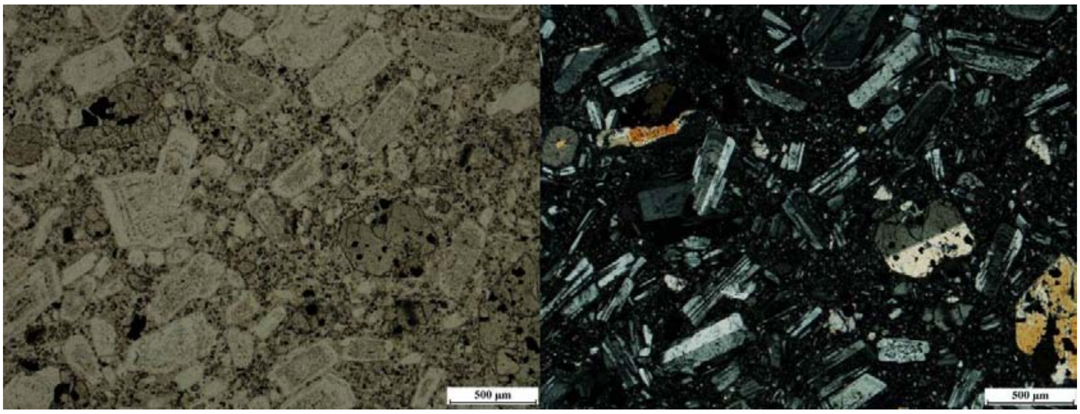


Figure II.125. – Typical microscopic photos of pyroxene-andesite from Prépost-hegy (Visegrád Mts.). Left with one nicol, right with crossed nicols.

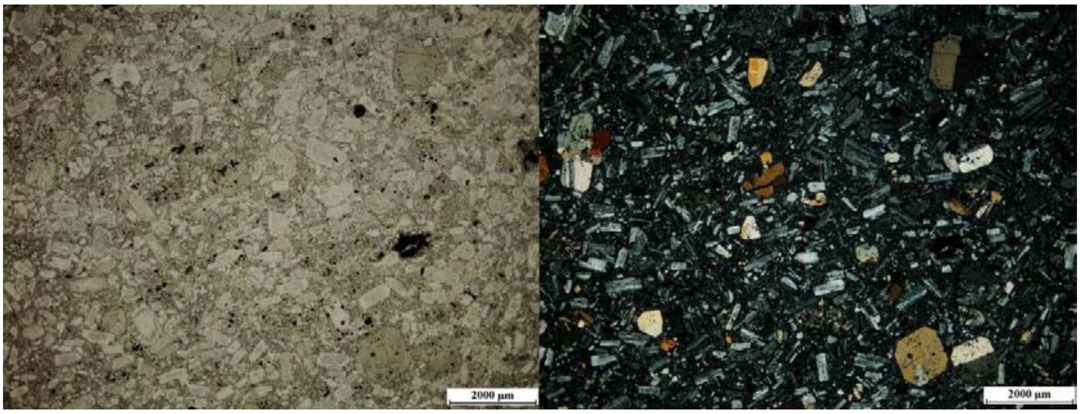


Figure II.126. – Typical microscopic photos of pyroxene-andesite from Prépost-hegy (Visegrád Mts.). Left with one nicol, right with crossed nicols.

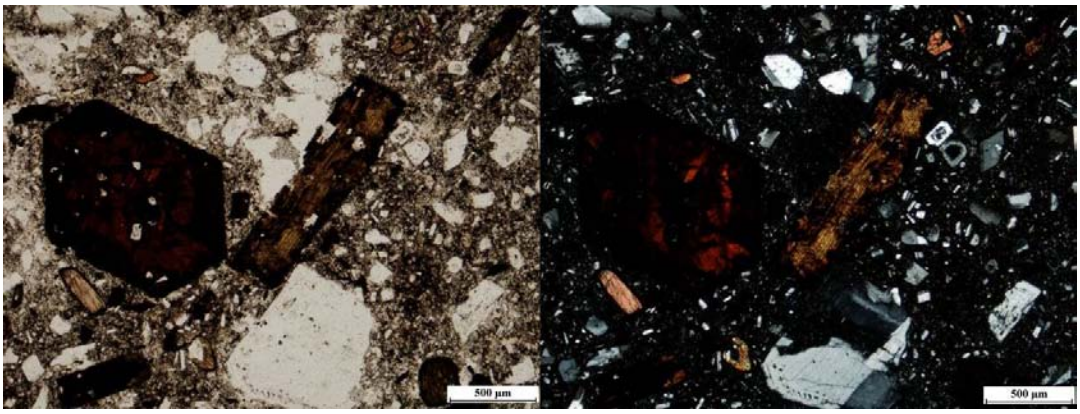


Figure II.127. – Andesites from Börzsöny: Typical microscopic photos of amphibole-andesite from Királyrét. Left with one nicol, right with crossed nicols.

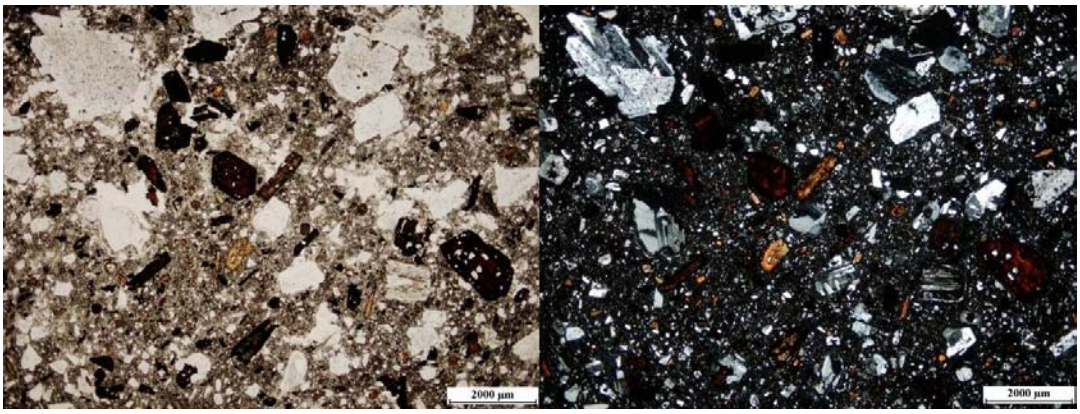


Figure II.128. – Andesites of Börzsöny: Typical microscopic photos of amphibole-oxiandesite from Királyrét. Left with one nicol, right with crossed nicols.

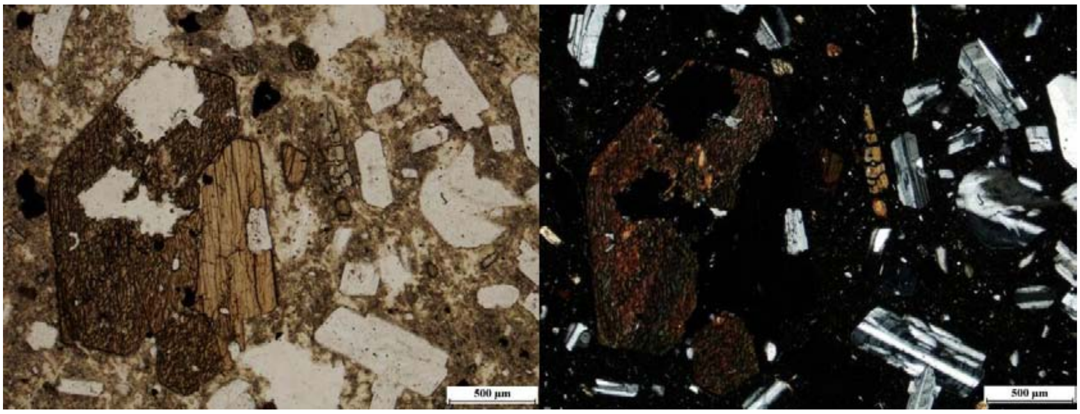


Figure II.129. – Andesites of Börzsöny: Typical microscopic photos of amphibole-andesite from Hártókút. Left with one nicol, right with crossed nicols.

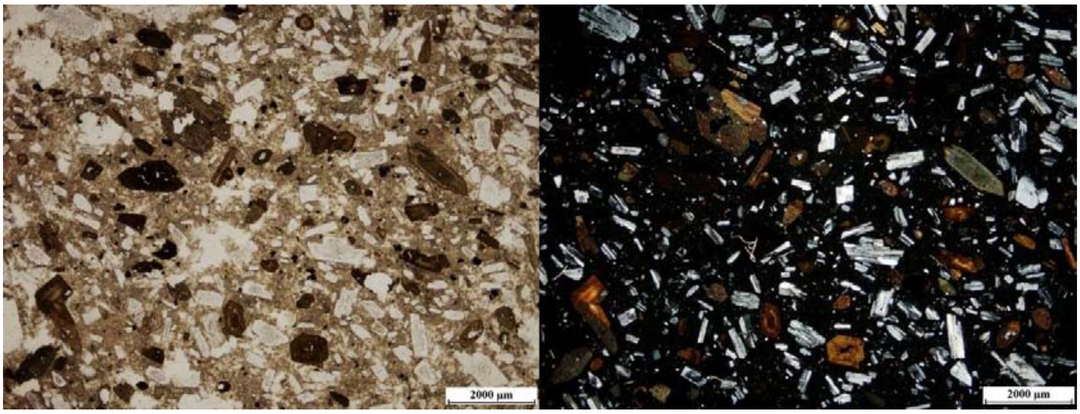


Figure II.130. – Andesites of Börzsöny: Typical microscopic photos of amphibole-andesite from Hártókút. Left with one nicol, right with crossed nicols.

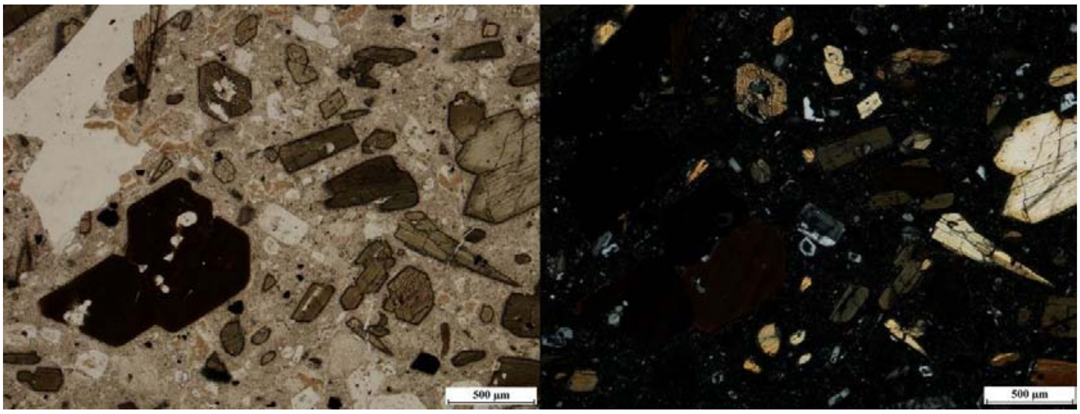


Figure II.131. – Andesites from Börzsöny: Typical microscopic photos of a hypersthene biotite-amphibole andesite from Peres hill. Left with one nicol, right with crossed nicols.

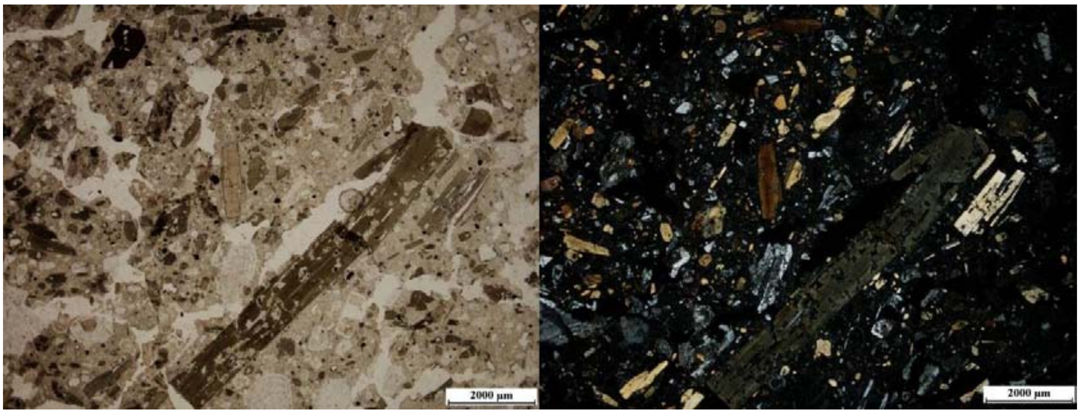


Figure II.132. – Andesites from Börzsöny: Typical microscopic photos of a hypersthene biotite-amphibole andesite from Peres hill. Left with one nicol, right with crossed nicols.

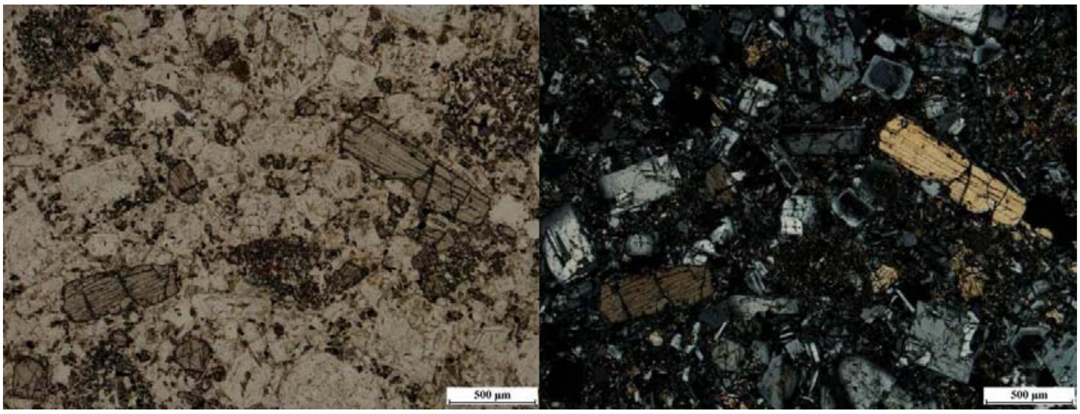


Figure II.133. – Andesites from Börzsöny: Typical microscopic photos of a hypersthene andesite from Nagy-Sas hill. Left with one nicol, right with crossed nicols.

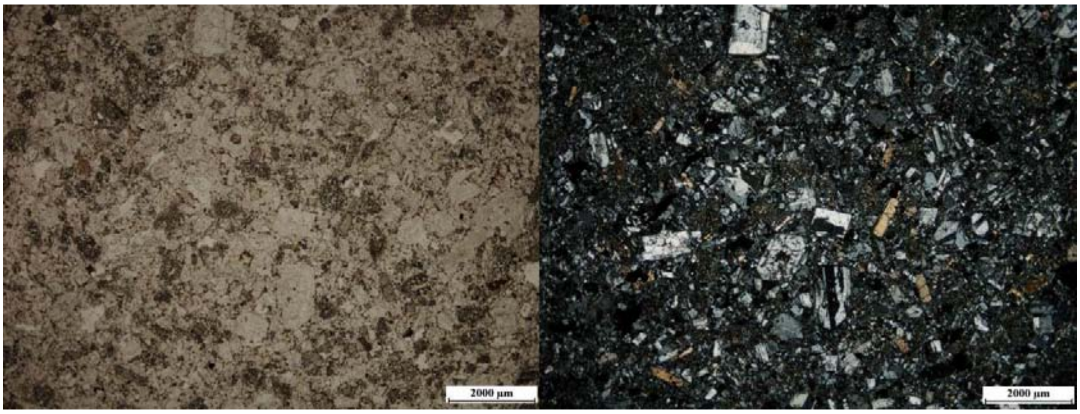


Figure II.134. – Andesites from Börzsöny: Typical microscopic photos of a hypersthene andesite from Nagy-Sas hill. Left with one nicol, right with crossed nicols.

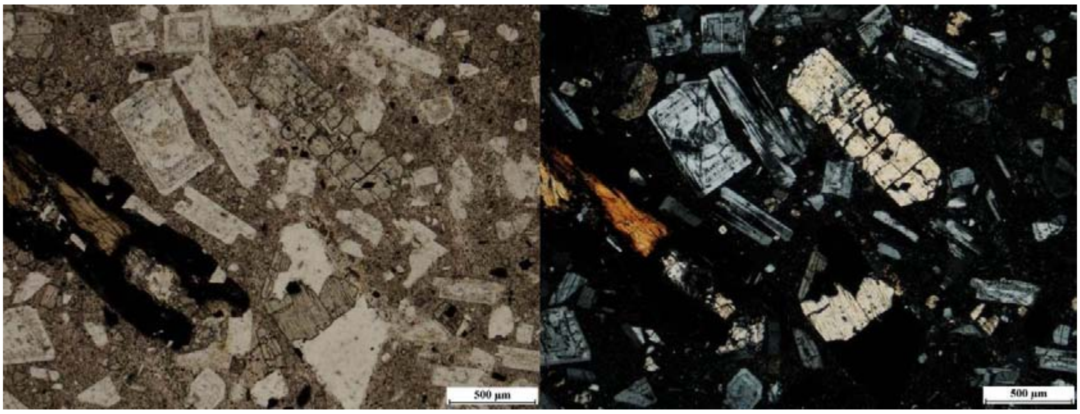


Figure II.135. – Andesites from Börzsöny: Typical microscopic photos of the amphibole-pyroxene andesite from Nagy-Inóc. Left with one nicol, right with crossed nicols.

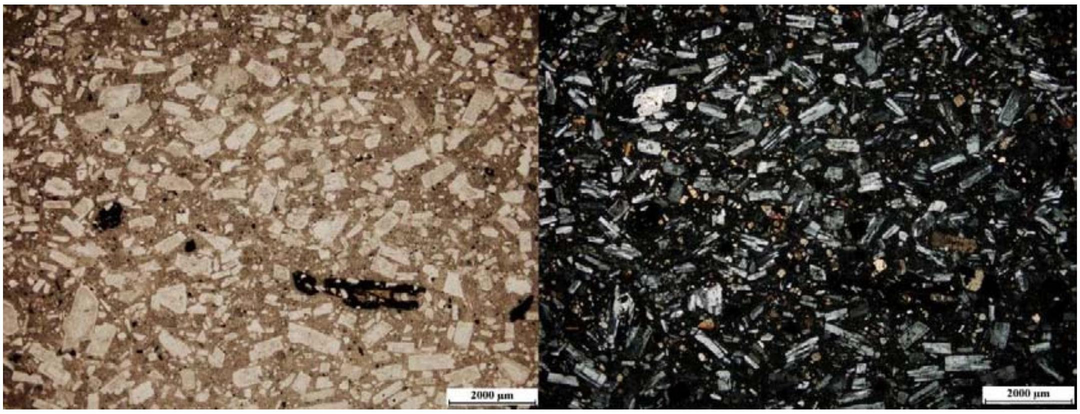


Figure II.136. – Andesites from Börzsöny: Typical microscopic photos of the amphibole-pyroxene andesite from Nagy-Inóc. Left with one nicol, right with crossed nicols.

Stiavnica-Kremnica volcanic complex (10-16 Ma)

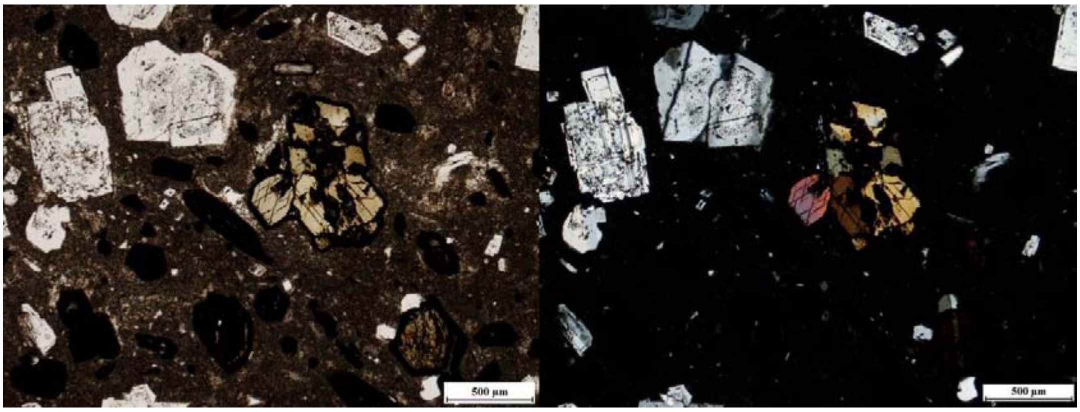


Figure II.137. – Andesites from Central-Slovakia: Typical microscopic photos of the garnet-bearing amphibole andesite from Breziny. Left with one nicol, right with crossed nicols.

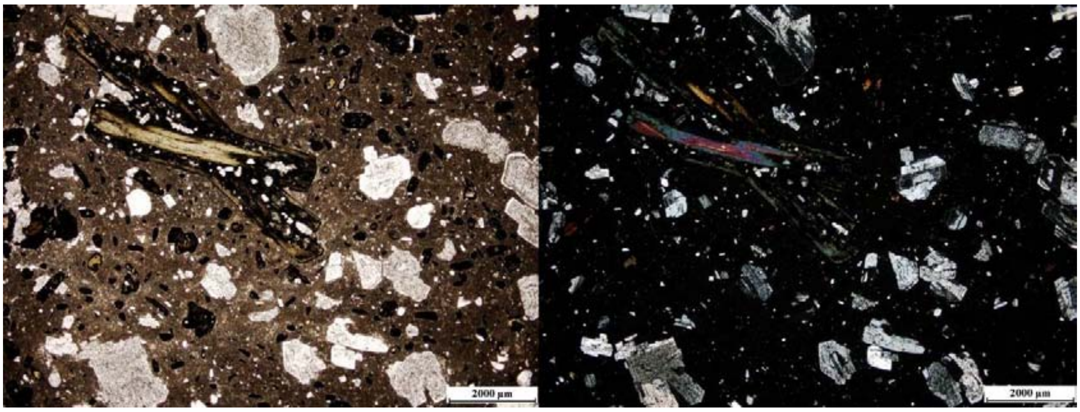


Figure II.137. – Andesites from Central-Slovakia: Typical microscopic photos of the garnet-bearing amphibole andesite from Breziny. Left with one nicol, right with crossed nicols.

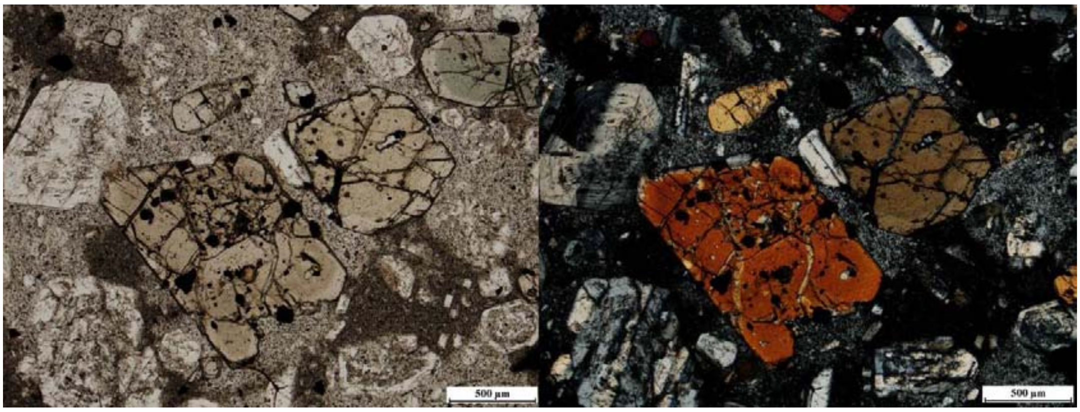


Figure II.138. – Andesites from Central-Slovakia: Typical microscopic photos of the pyroxene andesite from Ladzany. Left with one nicol, right with crossed nicols.

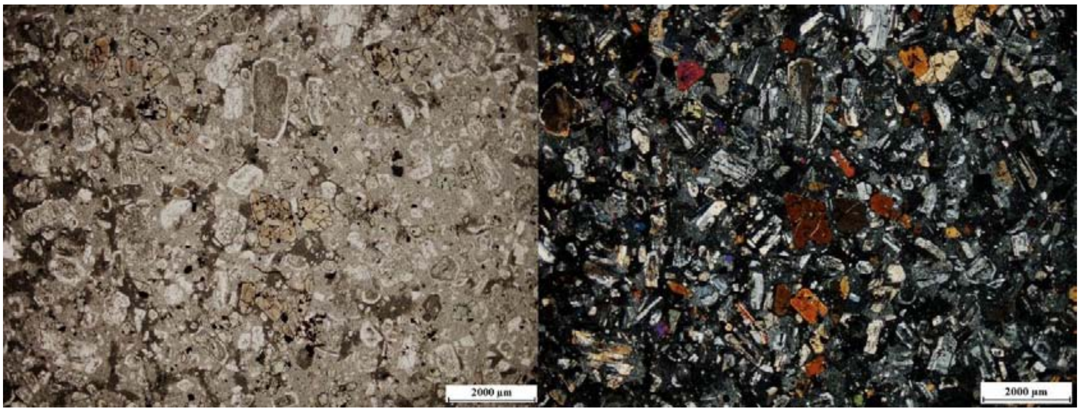


Figure II.139. – Andesites from Central-Slovakia: Typical microscopic photos of the pyroxene andesite from Ladzany. Left with one nicol, right with crossed nicols.

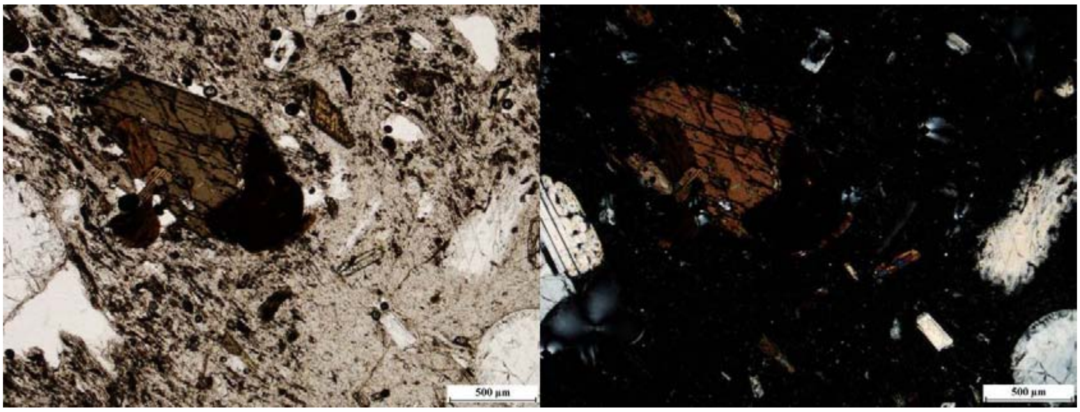


Figure II.140. – Andesites from Central-Slovakia: Typical microscopic photos of the amphibole andesite from Ihráč. Left with one nicol, right with crossed nicols.

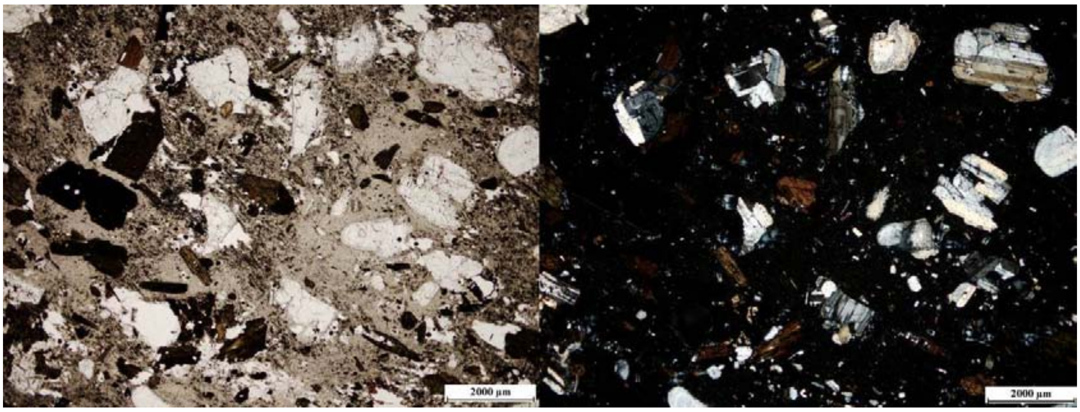


Figure II.141. – Andesites from Central-Slovakia: Typical microscopic photos of the amphibole andesite from Ihráč. Left with one nicol, right with crossed nicols.

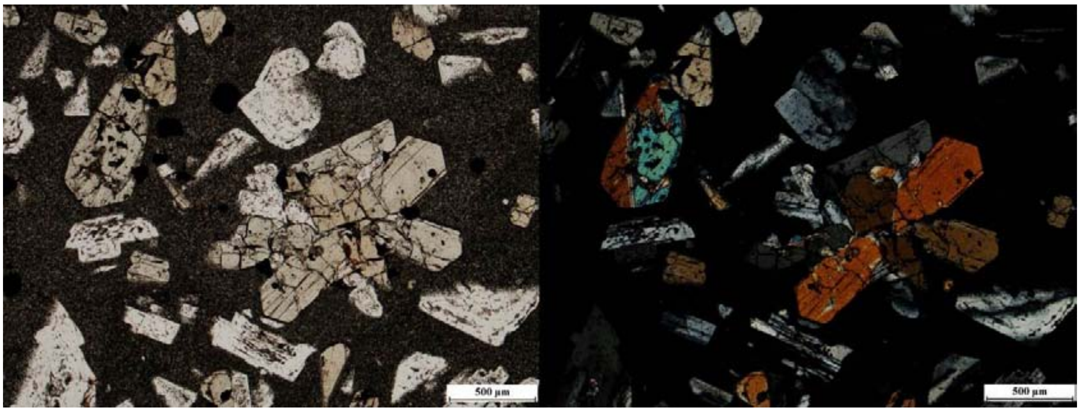


Figure II.142. – Andesites from Central-Slovakia: Typical microscopic photos of the pyroxene andesite from Hrušov. Left with one nicol, right with crossed nicols.

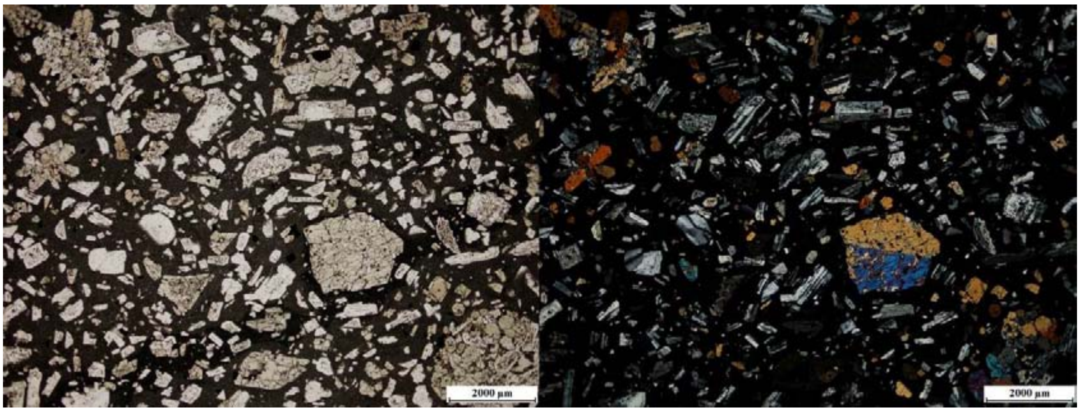


Figure II.143. – Andesites from Central-Slovakia: Typical microscopic photos of the pyroxene andesite from Hrušov. Left with one nicol, right with crossed nicols.

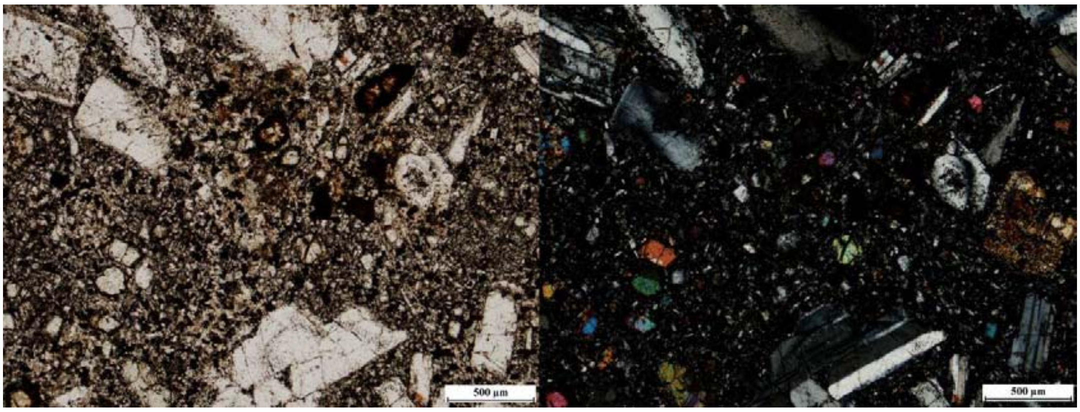


Figure II.144. – Andesites from Central-Slovakia: Typical microscopic photos of the basaltic andesite from Vlci Vrch. Left with one nicol, right with crossed nicols.

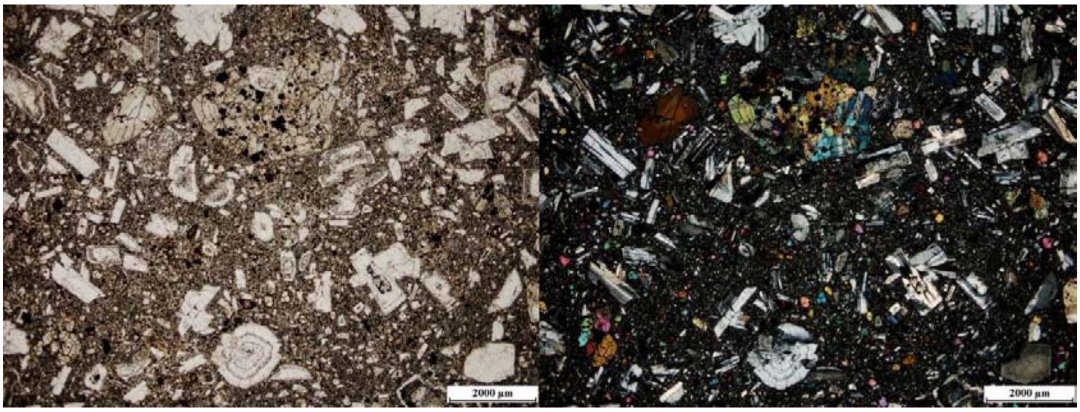


Figure II.145. – Andesites from Central-Slovakia: Typical microscopic photos of the basaltic andesite from Vlci Vrch. Left with one nicol, right with crossed nicols.

Cserhát (13-16 Ma)

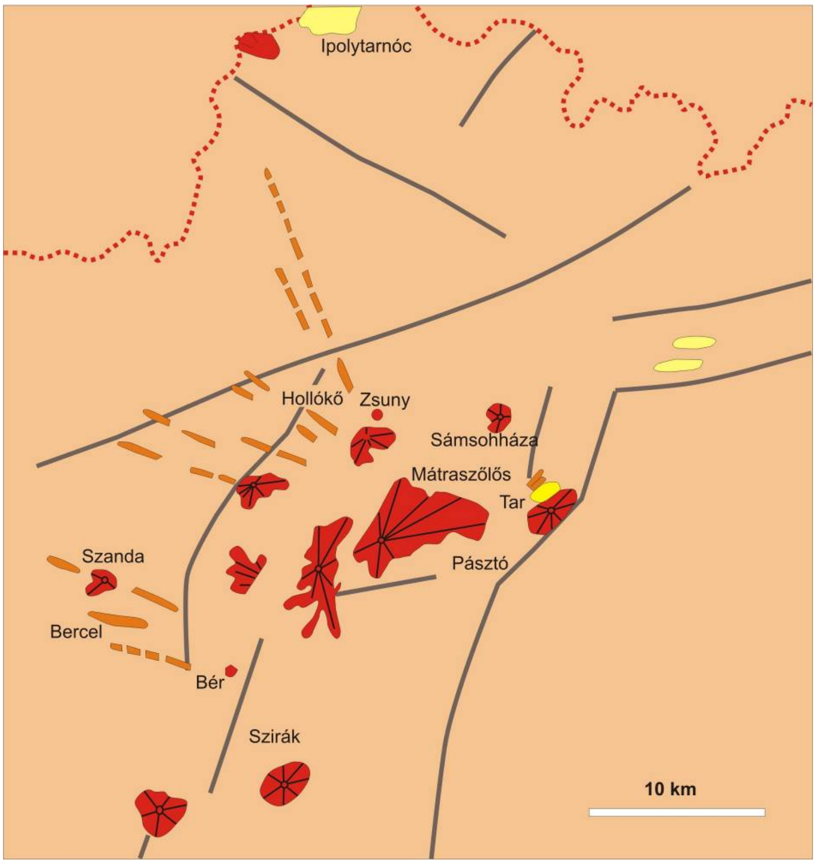


Figure II.146. – Locations of the andesitic volcanic rocks (red) in the Cserhát

Figure II.147. – Columnar jointed andesites (Szanda and Bér; photos: Szabolcs Harangi)

Figure II.148. – Andesitic lava flows and silicic pyroclastic deposits at Sámsonháza (photo: Szabolcs Harangi)

Figure II.149. – Andesites from Cserhát: Typical microscopic photos of the pyroxene andesite from Szanda. Left with one nicol, right with crossed nicols.

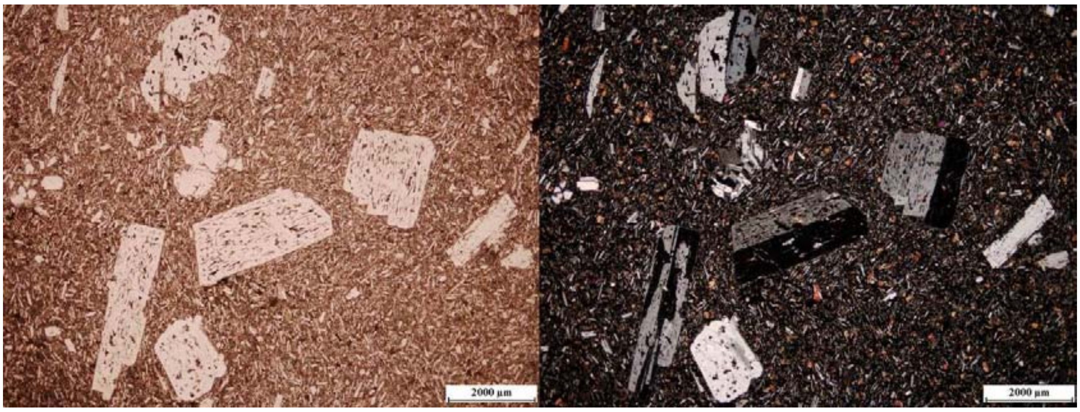


Figure II.150. – Andesites from Cserhát: Typical microscopic photos of the pyroxene andesite from Szanda. Left with one nicol, right with crossed nicols.

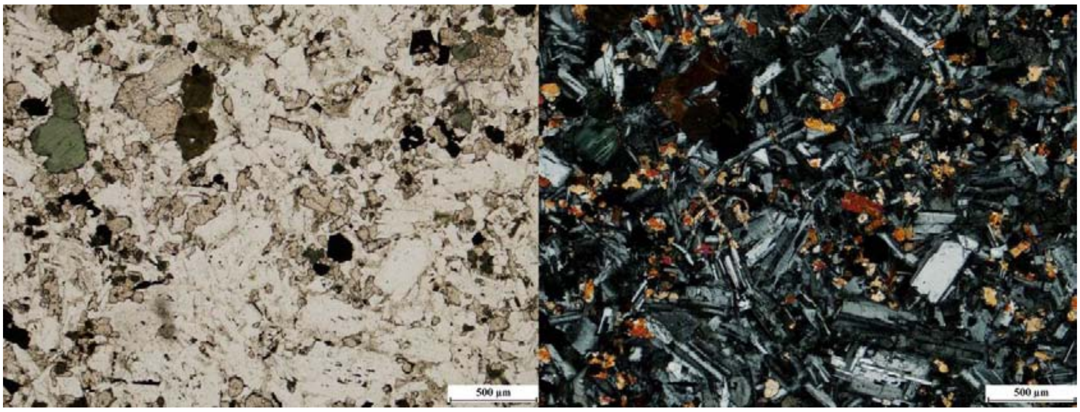


Figure II.151. – Andesites from Cserhát: Typical microscopic photos of the pyroxene andesite from Bercel. Left with one nicol, right with crossed nicols.

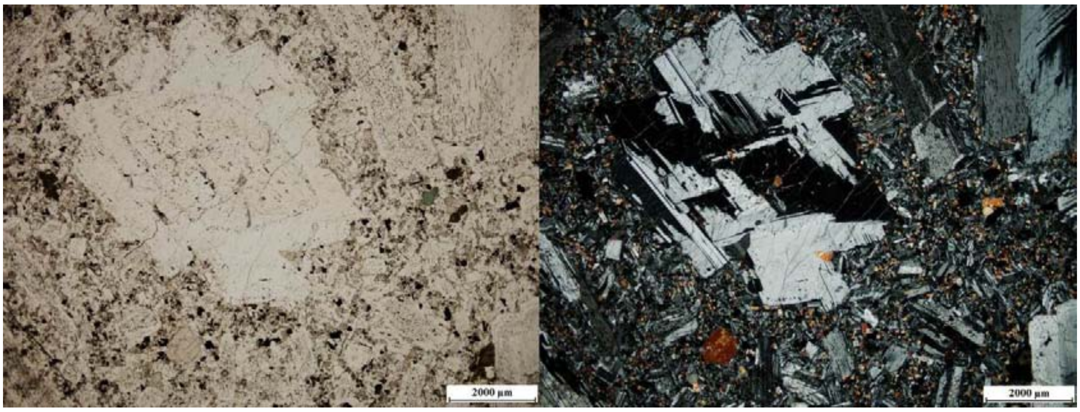


Figure II.152. – Andesites from Cserhát: Typical microscopic photos of the pyroxene andesite with large plagioclase phenpcryst from Bercel. Left with one nicol, right with crossed nicols.

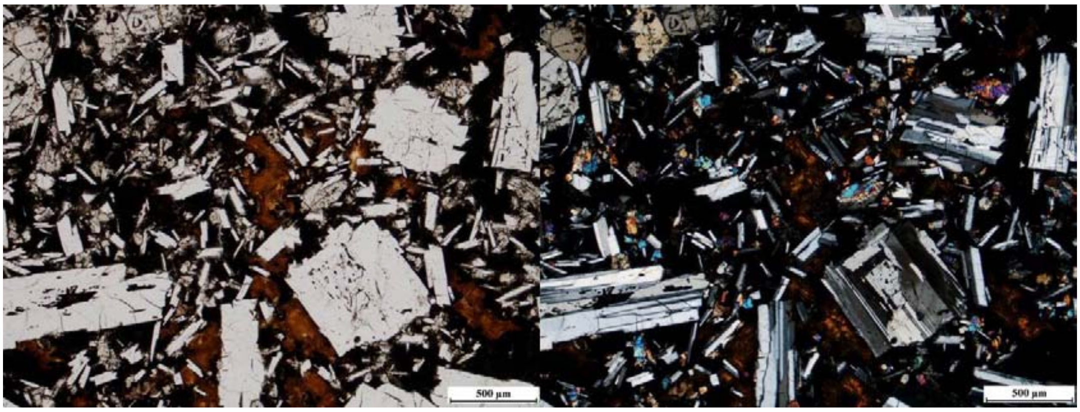


Figure II.153. – Andesites from Cserhát: Typical microscopic photos of the crystal-rich pyroxene andesite from Bér. Left with one nicol, right with crossed nicols.

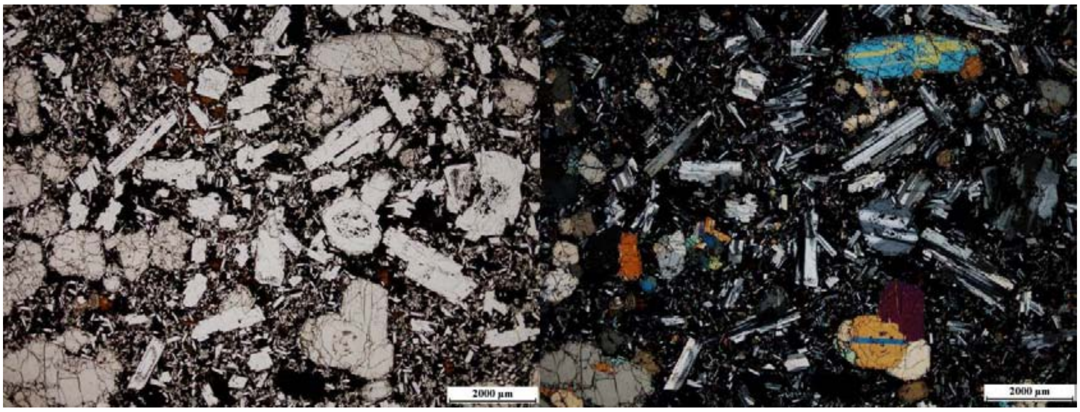


Figure II.154. – Andesites from Cserhát: Typical microscopic photos of the crystal-rich pyroxene andesite from Bér. Left with one nicol, right with crossed nicols.

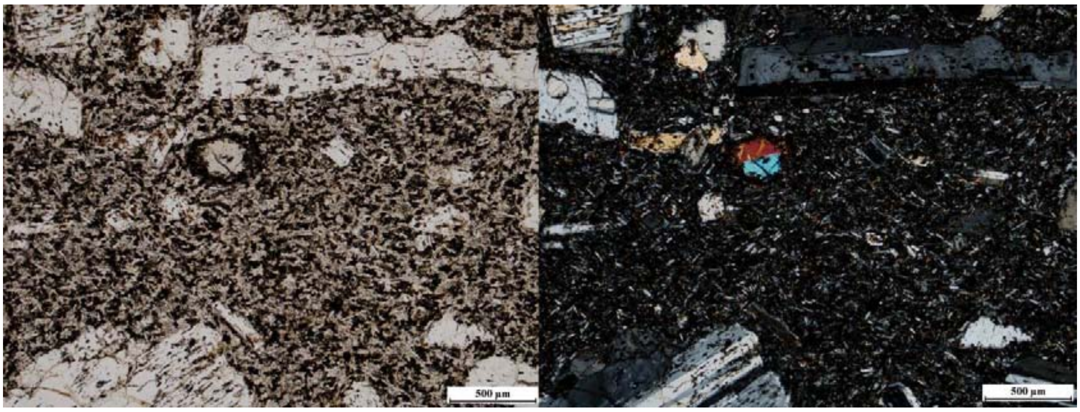


Figure II.155. – Andesites from Cserhát: Typical microscopic photos of the pyroxene andesite from Buják. Left with one nicol, right with crossed nicols.

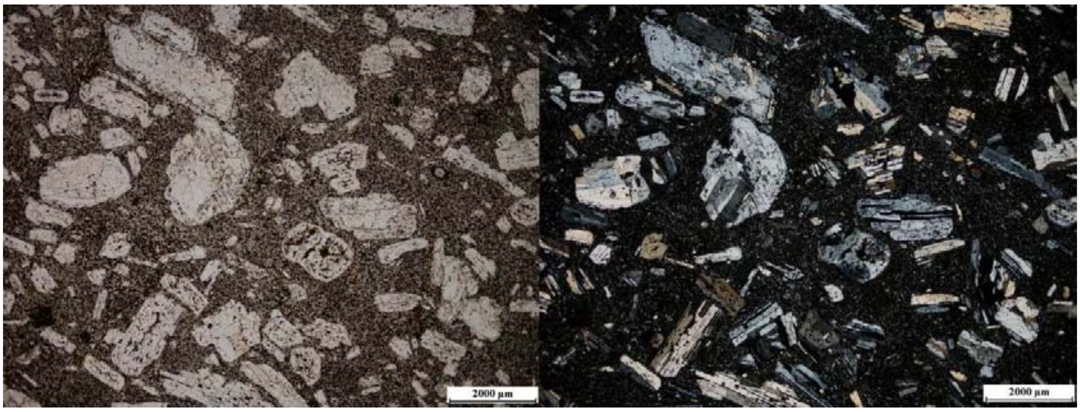


Figure II.156. – Andesites from Cserhát: Typical microscopic photos of the plagioclase-phyric pyroxene andesite from Buják. Left with one nicol, right with crossed nicols.

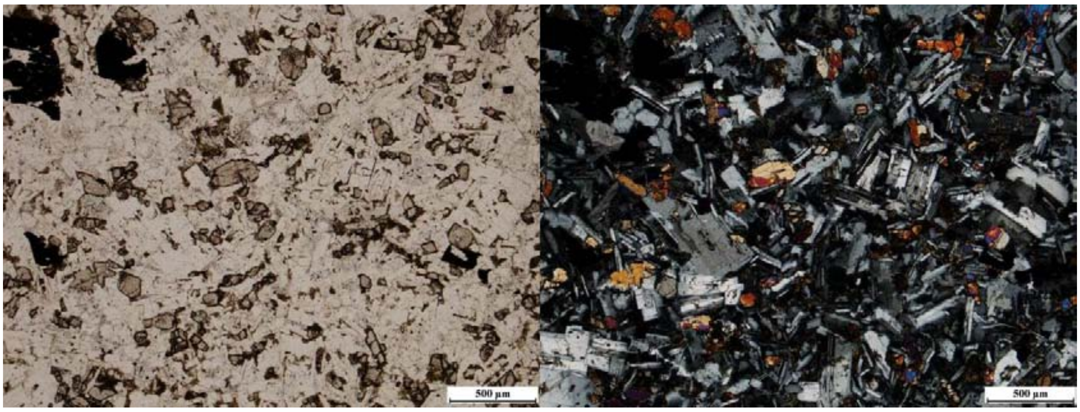


Figure II.157. – Andesites from Cserhát: Typical microscopic photos of the plagioclase-phyric pyroxene andesite from Zsuny. Left with one nicol, right with crossed nicols.

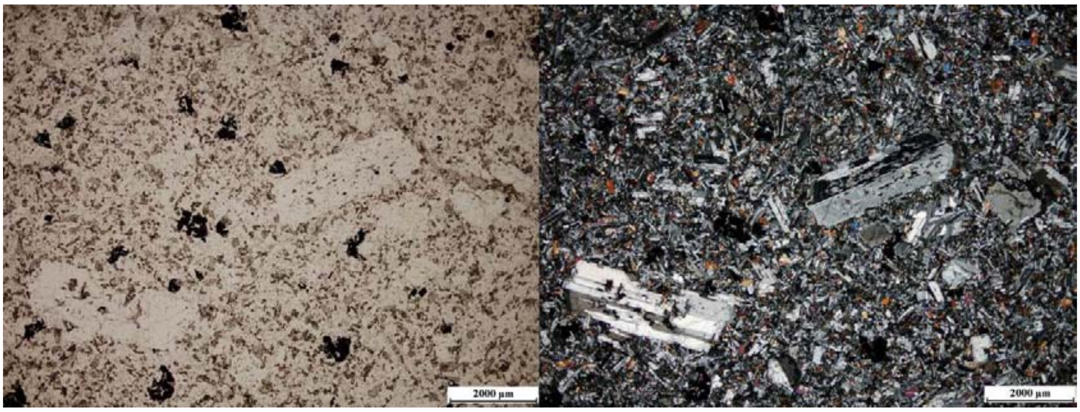


Figure II.158. – Andesites from Cserhát: Typical microscopic photos of the plagioclase-phyric pyroxene andesite from Zsuny. Left with one nicol, right with crossed nicols.

Mátra (13-17 Ma)

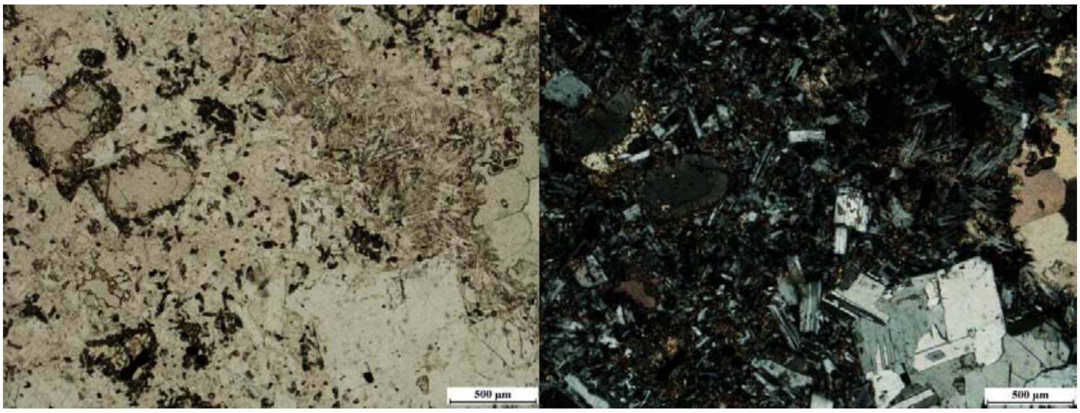


Figure II.159. – Andesites from Mátra: Typical microscopic photos of the andesite from Csákánykő. Left with one nicol, right with crossed nicols.

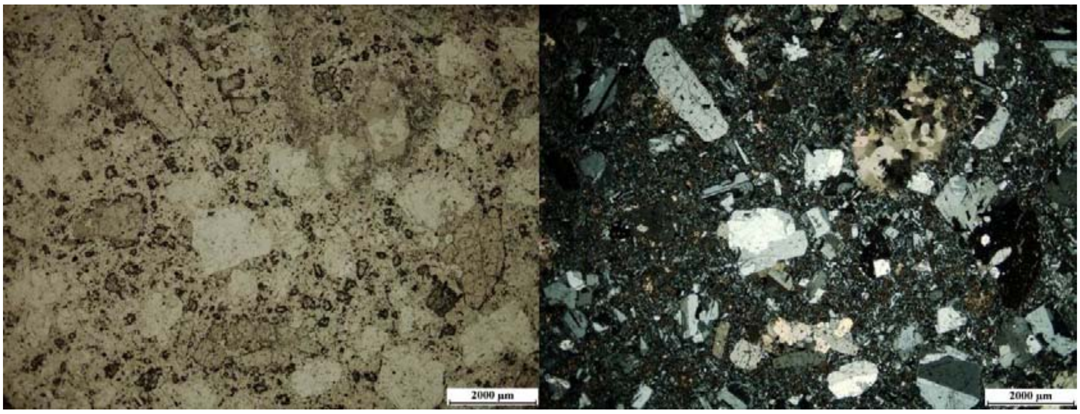


Figure II.160. – Andesites from Mátra: Typical microscopic photos of the andesite from Csákánykő. Left with one nicol, right with crossed nicols.

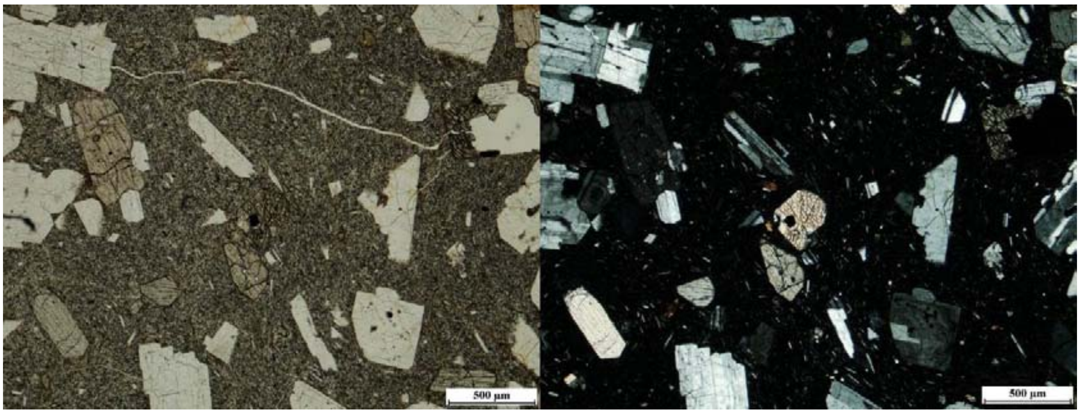


Figure II.161. – Andesites from Mátra: Typical microscopic photos of the plagioclase-phyric pyroxene andesite from Károlyvár. Left with one nicol, right with crossed nicols.

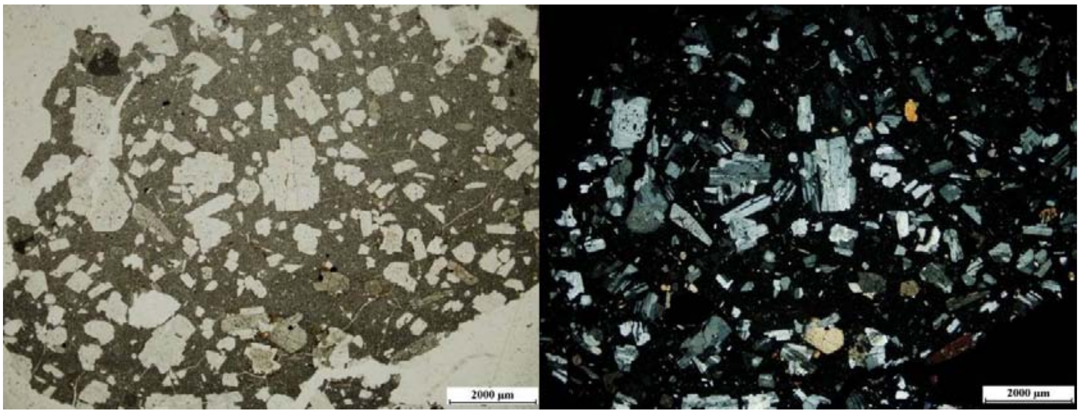


Figure II.162. – Andesites from Mátra: Typical microscopic photos of the plagioclase-phyric pyroxene andesite from Károlyvár. Left with one nicol, right with crossed nicols.

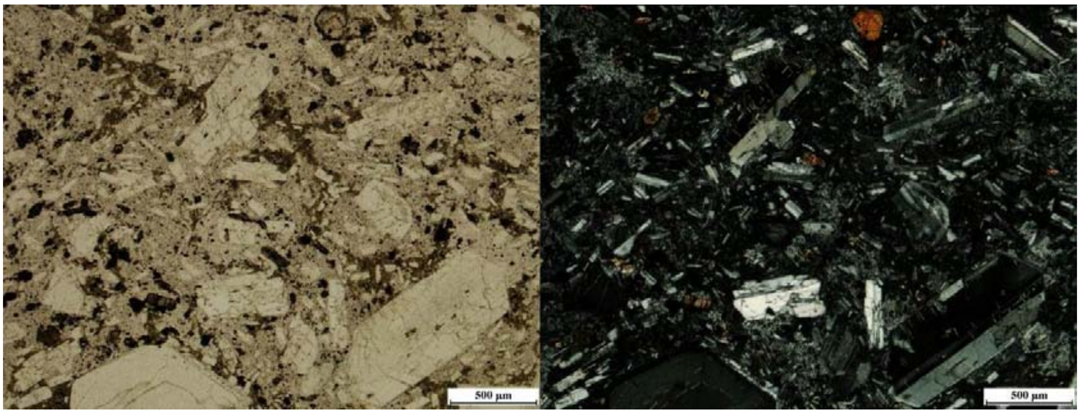


Figure II.163. – Andesites from Mátra: Typical microscopic photos of the plagioclase-phyric amphibole andesite from Nagyátalkő. Left with one nicol, right with crossed nicols.

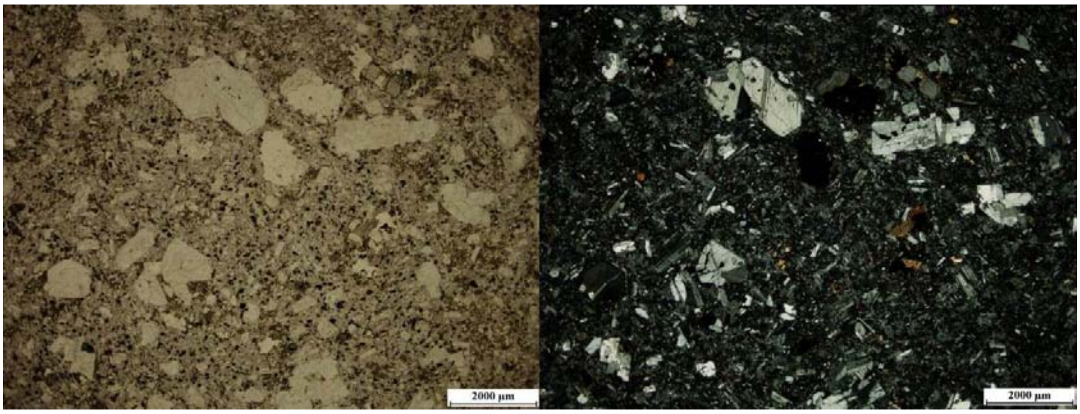


Figure II.164. – Andesites from Mátra: Typical microscopic photos of the plagioclase-phyric amphibole andesite from Nagyátalkő. Left with one nicol, right with crossed nicols.

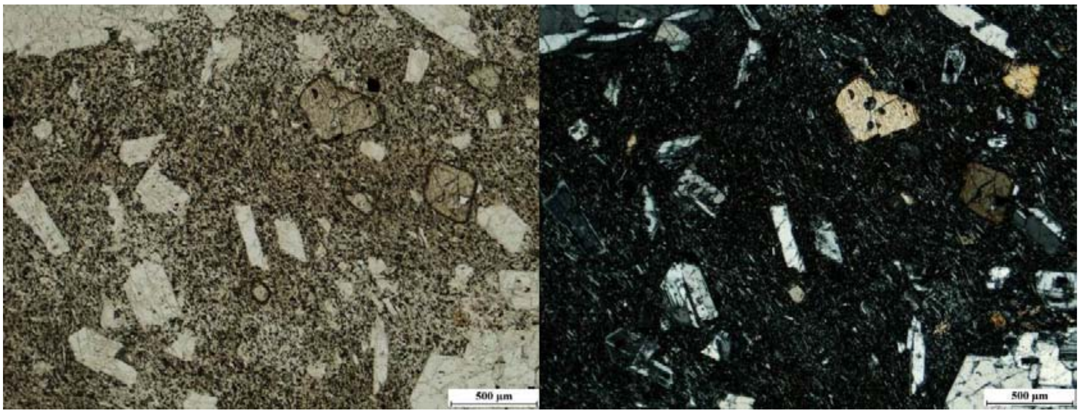


Figure II.165. – Andesites from Mátra: Typical microscopic photos of th epyroxene andesite from Sás-tó. Left with one nicol, right with crossed nicols.

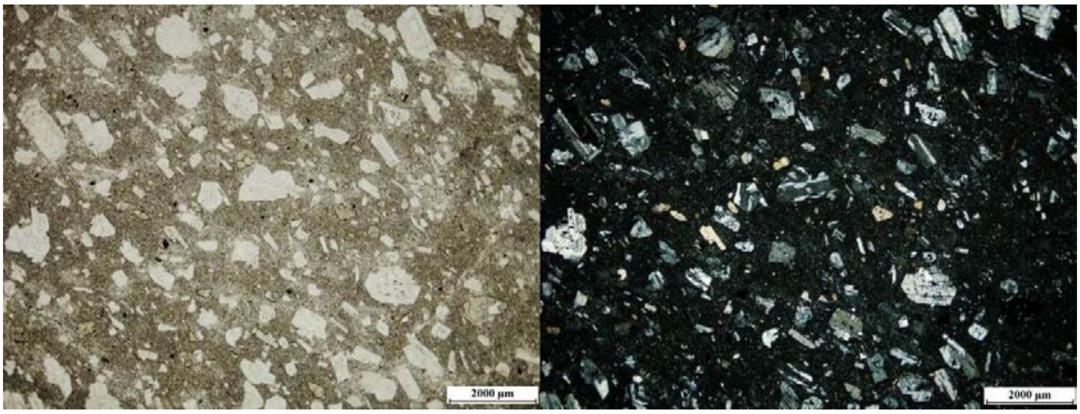


Figure II.166. – Andesites from Mátra: Typical microscopic photos of the pyroxene andesite from Sás-tó. Left with one nicol, right with crossed nicols.

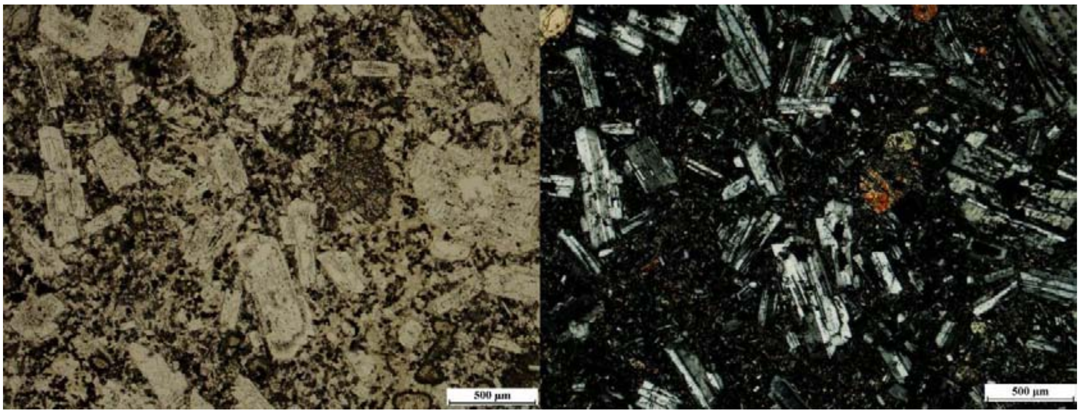


Figure II.167. – Andesites from Mátra: Typical microscopic photos of the plagioclase-phyric amphibole andesite from Tar. Left with one nicol, right with crossed nicols.

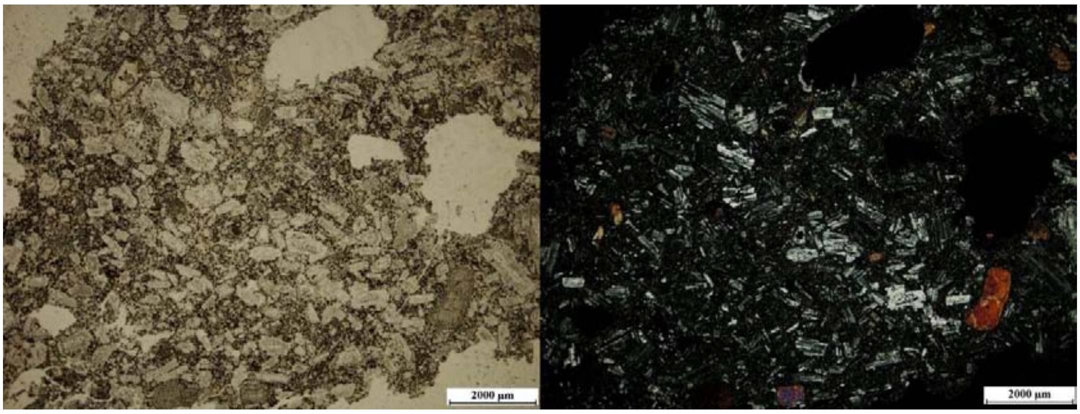


Figure II.168. – Andesites from Mátra: Typical microscopic photos of the plagioclase-phyric amphibole andesite from Tar. Left with one nicol, right with crossed nicols.

Karancs (15-16 Ma)

Figure II.169. – The exposed subvolcanic andesite body of Karancs

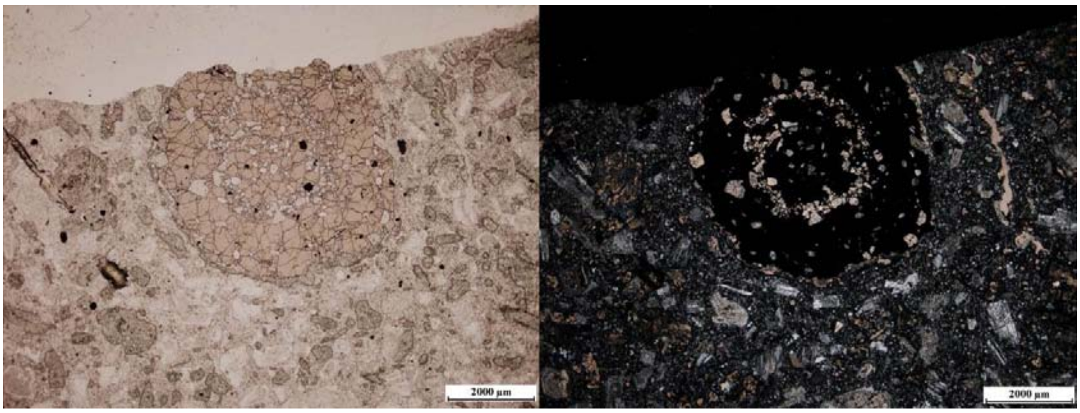


Figure II.170. – Andesites from Karancs: Typical microscopic photos of the garnet-bearing amphibole andesite from Farkaslyuk. Note the inclusion-rich large garnet phenocryst. Left with one nicol, right with crossed nicols.

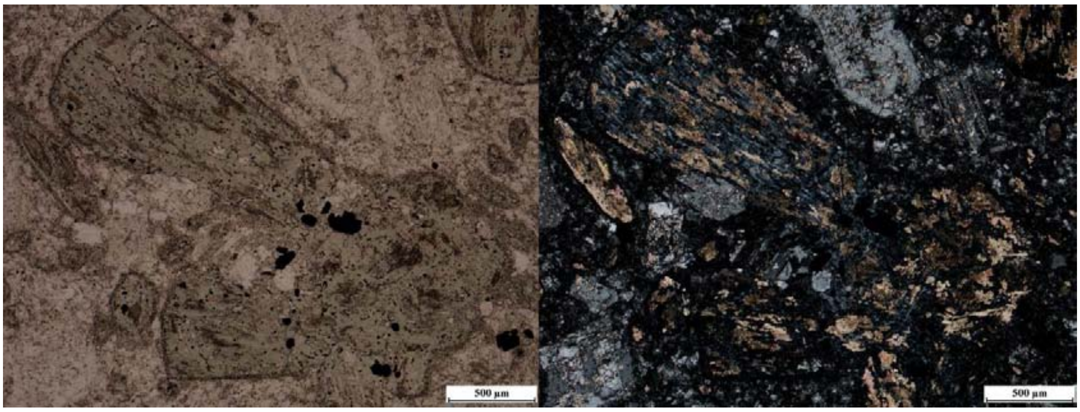


Figure II.171. – Andesites from Karancs: Typical microscopic photos of the garnet-bearing amphibole andesite from Farkaslyuk. Left with one nicol, right with crossed nicols.

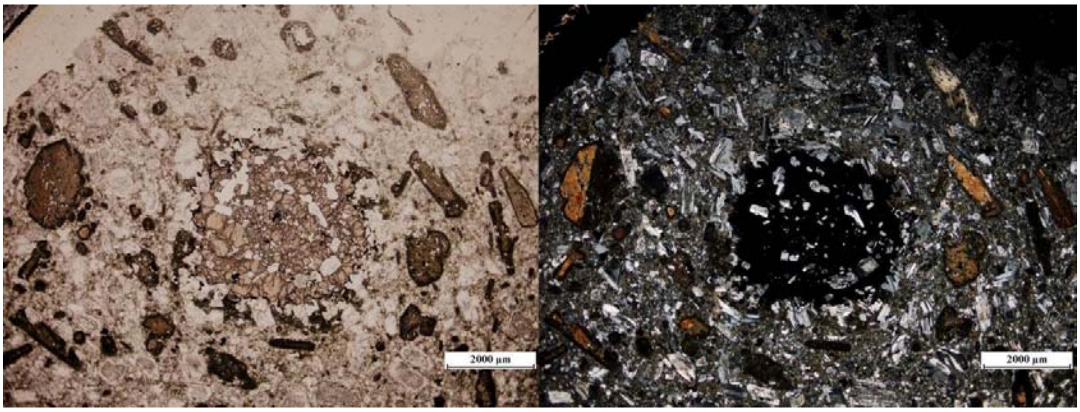


Figure II.172. – Andesites from Karancs: Typical microscopic photos of the garnet-bearing amphibole andesite from Siatoros. Left with one nicol, right with crossed nicols.

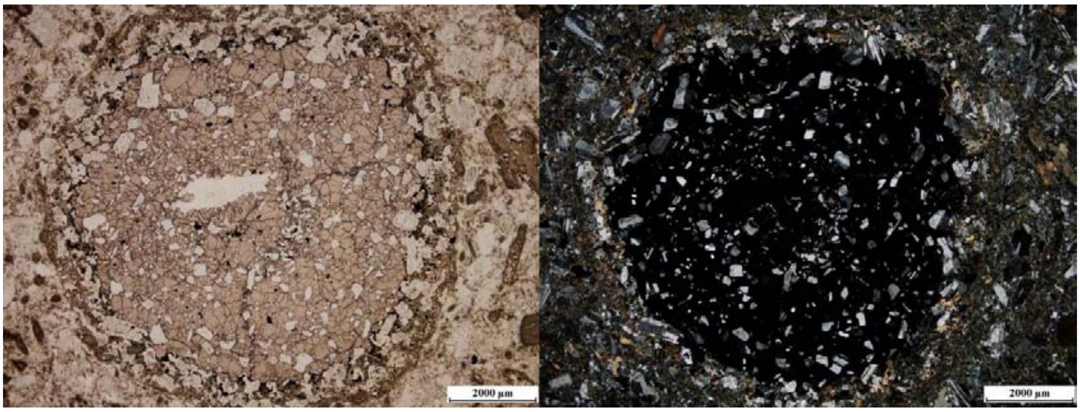


Figure II.173. – Andesites from Karancs: Typical microscopic photos of the garnet-bearing amphibole andesite from Siatoros. Note the inclusion-rich large garnet phenocryst. Left with one nicol, right with crossed nicols.

Tokaj Mts. (10-16 Ma)

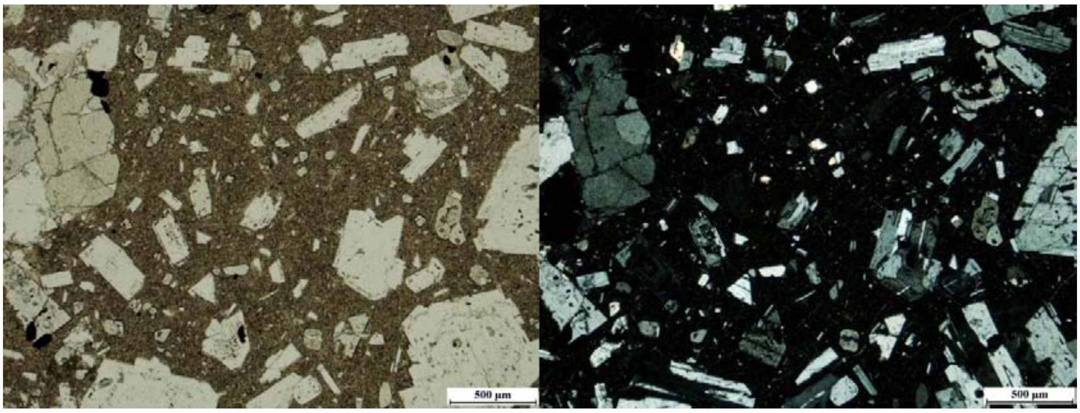


Figure II.174. – Andesites from Tokaj Mts.: Typical microscopic photos of the plagioclase-phyric pyroxene andesite from Mulató hill. Left with one nicol, right with crossed nicols.

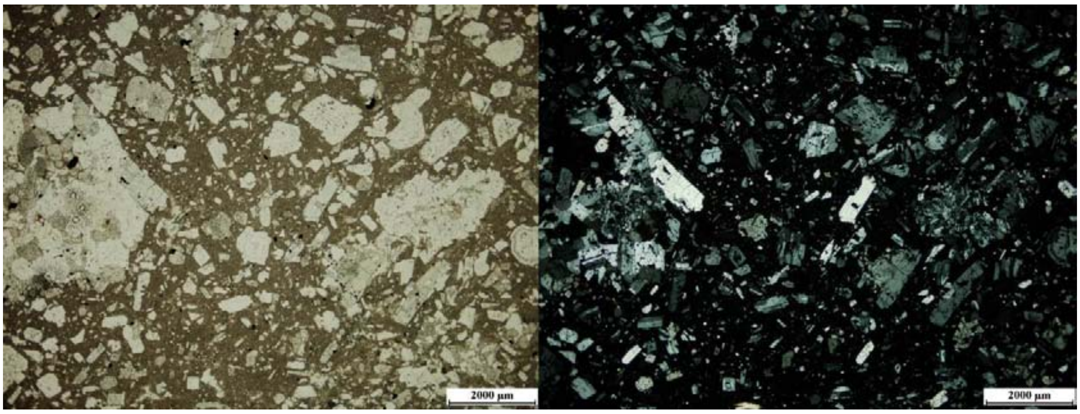


Figure II.175. – Andesites from Tokaj Mts.: Typical microscopic photos of the plagioclase-phyric pyroxene andesite from Mulató hill. Left with one nicol, right with crossed nicols.

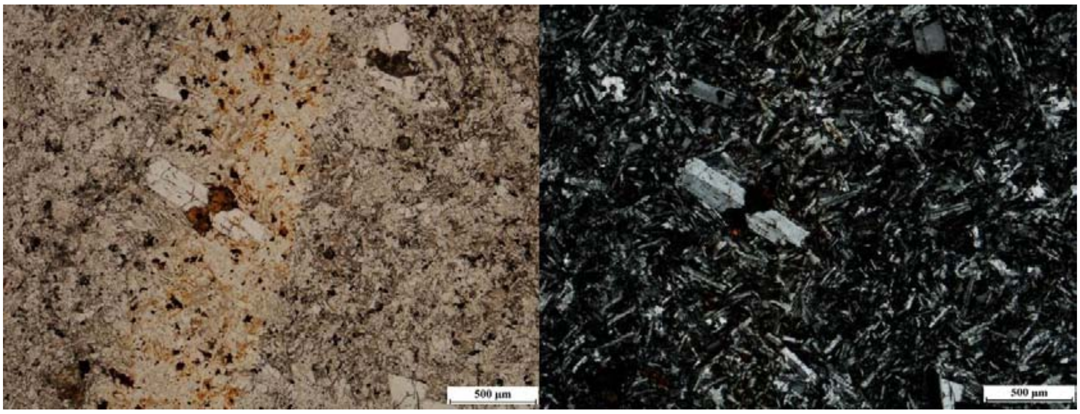


Figure II.176. – Andesites from Tokaj Mts.: Typical microscopic photos of the plagioclase-phyric banded andesite from Mulató hill. Left with one nicol, right with crossed nicols.

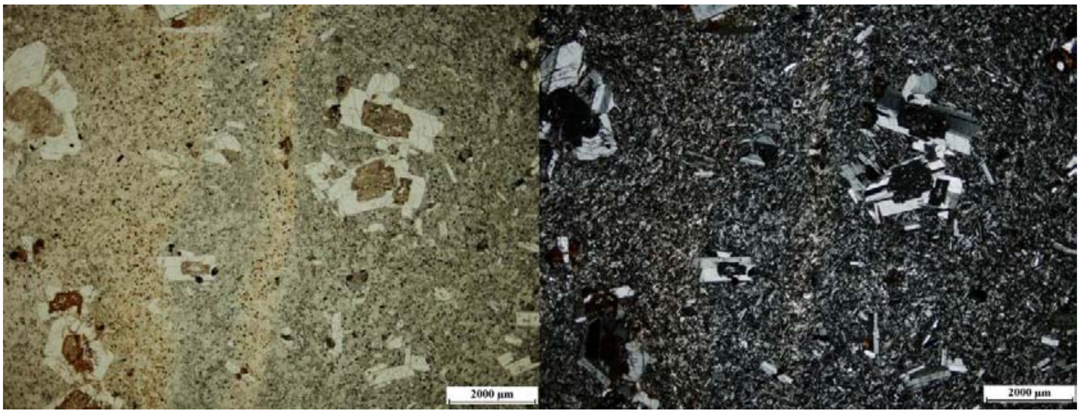


Figure II.177. – Andesites from Tokaj Mts.: Typical microscopic photos of the plagioclase-phyric banded andesite from Mulató hill. Left with one nicol, right with crossed nicols.

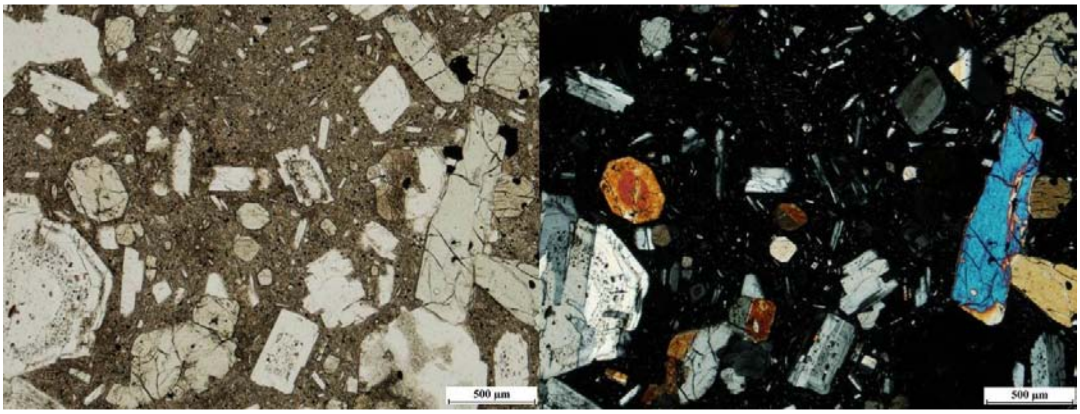


Figure II.178. – Andesites from Tokaj Mts.: Typical microscopic photos of the plagioclase-phyric pyroxene andesite from Fony. Left with one nicol, right with crossed nicols.

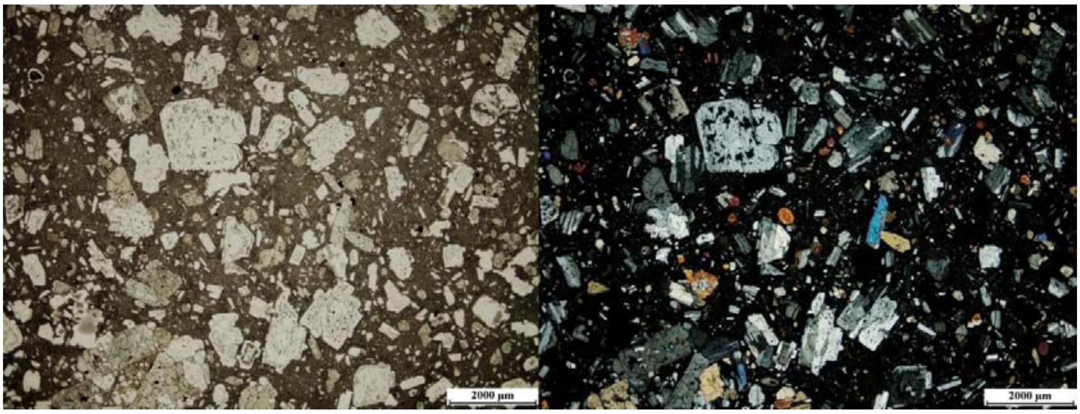


Figure II.179. – Andesites from Tokaj Mts.: Typical microscopic photos of the plagioclase-phyric pyroxene andesite from Fony. Left with one nicol, right with crossed nicols.

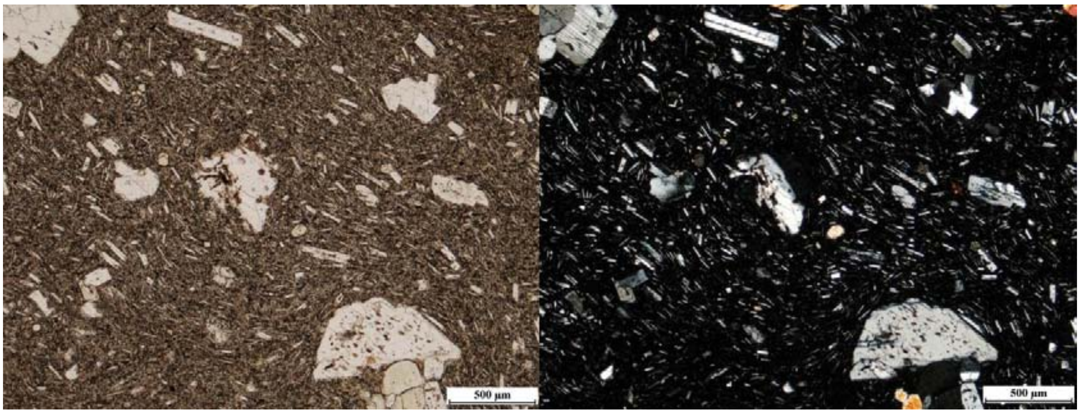


Figure II.180. – Andesites from Tokaj Mts.: Typical microscopic photos of the plagioclase-phyric pyroxene andesite from Regéc. Left with one nicol, right with crossed nicols.

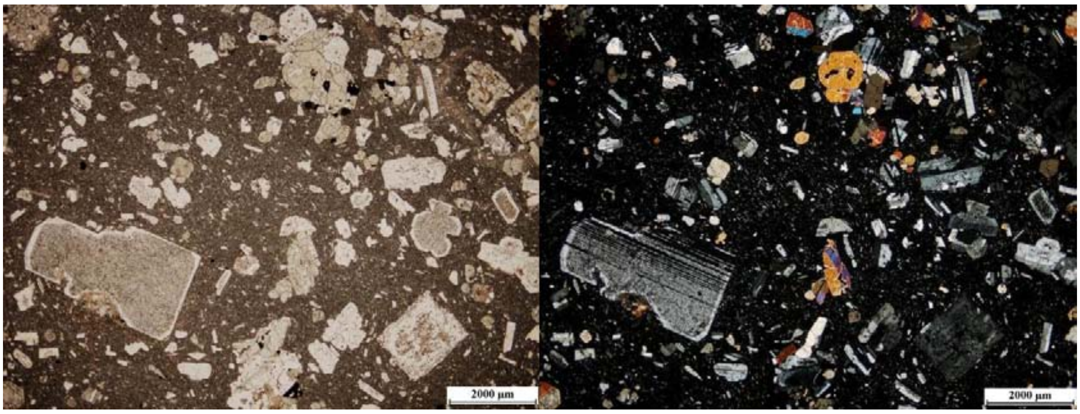
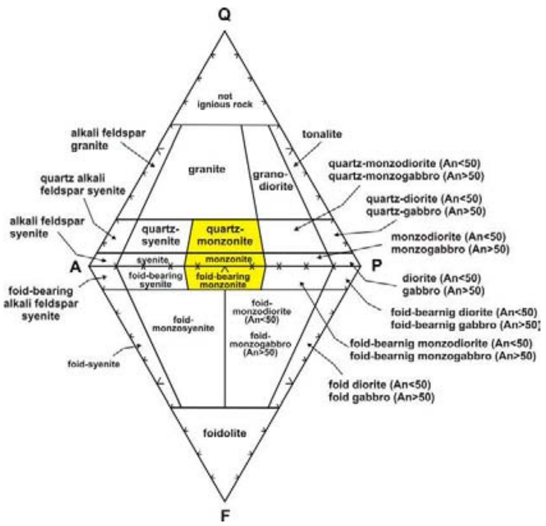


Figure II.181. – Andesites from Tokaj Mts.: Typical microscopic photos of the plagioclase-phyric pyroxene andesite from Regéc. Left with one nicol, right with crossed nicols.

MONZONITE



<u>Appearance</u>: Light coloured medium- to coarse-grained intrusive rock with less than 20% quartz and approximately the same amount of plagioclase and alkali feldspar, respectively. The mafic minerals are represented by clinopyroxene, orthopyroxene, amphibole and biotite. In rare monzonite variety, felspathoids could occur instead of quartz. It is the intrusive equivalent of tracybasalt and latite. It is formed mostly at subduction zones.

Mineral content:

Essential minerals: Ca-Na plagioclase ≈ K-feldspar, amphibole, pyroxene, biotite

Accessory minerals: quartz (<20%) or feldspathoid, apatite, magnetite, zircon

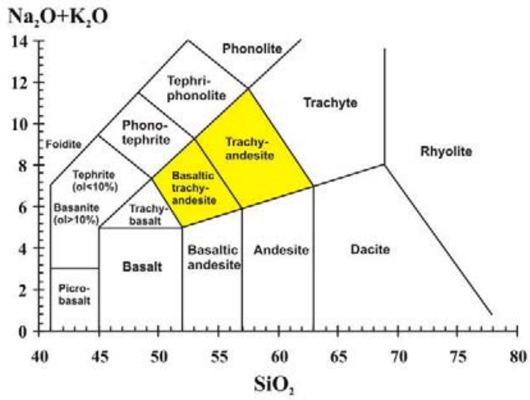
Secondary minerals: chlorite, sericite, epidote

Figure II.182. – Monzonite

Figure II.183. – Monzonite (Mórágy)

Locations in the Carpathian-Pannonian region: Mórágy

TRACHYANDESITE



Appearance: Light-grey, often aphyric or slightly to medium porphyritic fien-grained volcanic rock. Plagioclase and alkali feldspar occur in approximately the same amount and it could contain minor amount of quartz or feldspathoid. The mafic minerals are represented mostly by pyroxene or amphibole with less biotite (mostly in latite). It is formed at subduction and collision zones (the famous 1815 Tambora eruption was fed by tracyandesitic magma), but could occur also in intra-plate settings zones (e.g. mugearites).

Mineral content:

Essential minerals: Ca-Na plagioclase ≈ K-feldspar, amphibole, pyroxene, biotite

Accessory minerals: quartz (<20%) or feldspathoid, apatite, magnetite, zircon

Secondary minerals: chlorite, sericite, epidote

Rock types:

- Mugearite: Na-rich – (Na_2O-2)>K_2O – basaltic trachyandesite, quartz usually does not appear, neither feldspathoid
- Latite: K-rich - K_2O>(Na_2O-2) – trachyandesite
- Benmoreite: Na-rich – (Na_2O-2)>K_2O – trachyandesite, quartz usually does not appear, but it may contain feldspathoid

Locations in the Carpathian-Pannonian region: Gleichenberg (Styrian-basin), Balatonmária (in borehole) and Pásztori (in boreholes)

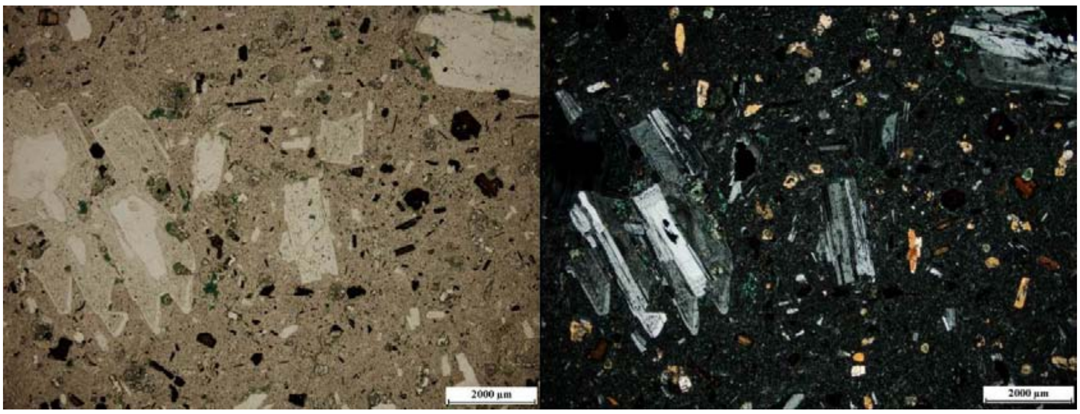


Figure II.184. – Typical microscopic photos of a latite from Gleichenberg. It contains large plagioclase phenocrysts and pyroxene and biotite microphenocrysts. Left with one nicol, right with crossed nicols.

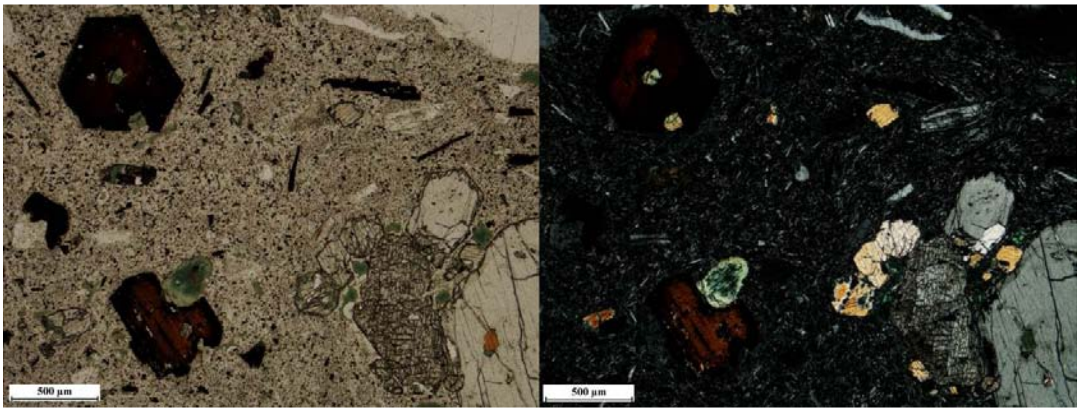


Figure II.185. – Typical microscopic photos of a latite from Gleichenberg. It contains large plagioclase and biotite phenocrysts and pyroxene and biotite microphenocrysts. Left with one nicol, right with crossed nicols.

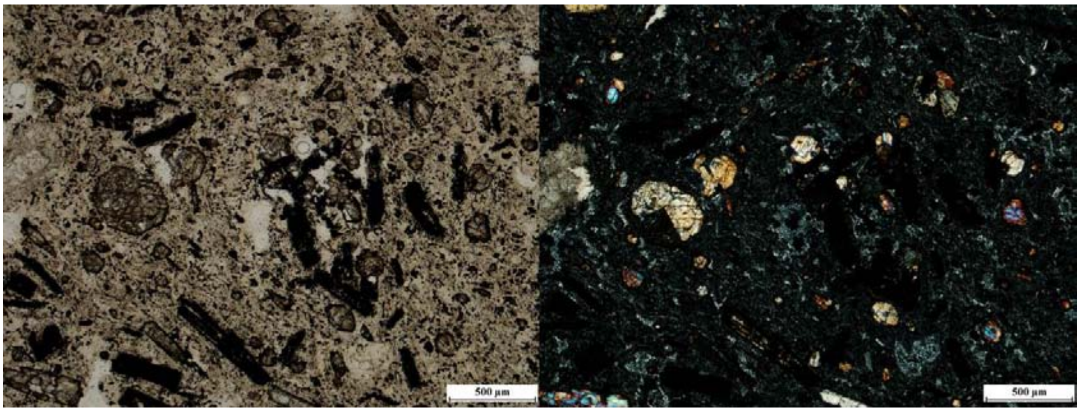


Figure II.186. – Typical microscopic photos of a latite from Balatonmária-1 borehole (at 394 m). It contains clinopyroxene phenocrysts and strongly opacitized biotites. Left with one nicol, right with crossed nicols.

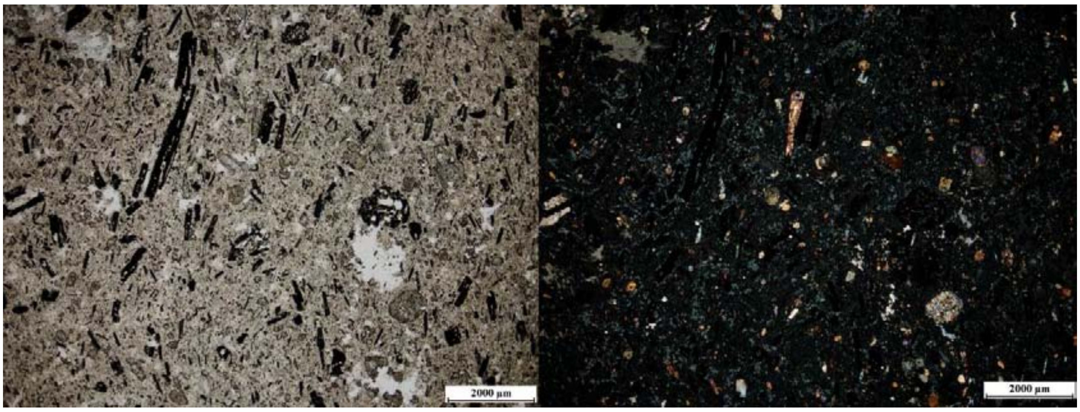


Figure II.187. – Typical microscopic photos of a latite from Balatonmária-1 borehole (at 394 m). It contains clinopyroxene phenocrysts and strongly opacitized biotites. Left with one nicol, right with crossed nicols.

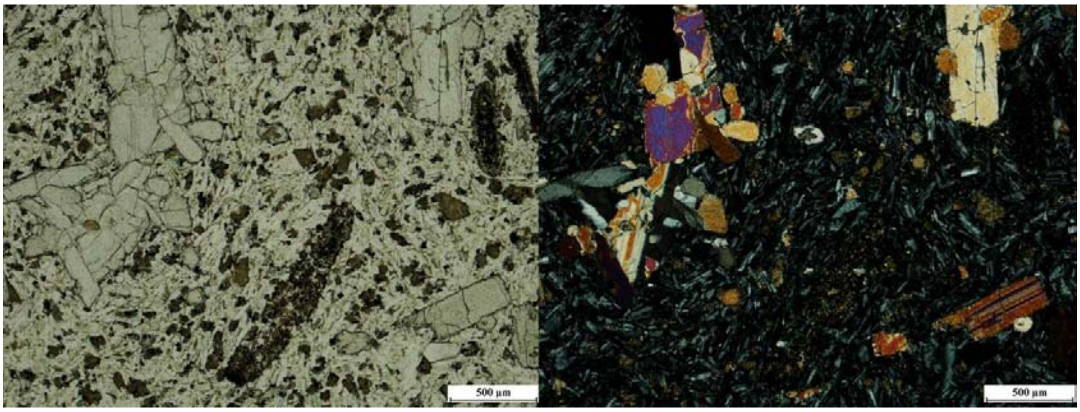


Figure II.188. – Typical microscopic photos of a latite from Balatonmária-1 borehole (at 438 m). It contains clinopyroxene phenocrysts and strongly opacitized biotites. Left with one nicol, right with crossed nicols.

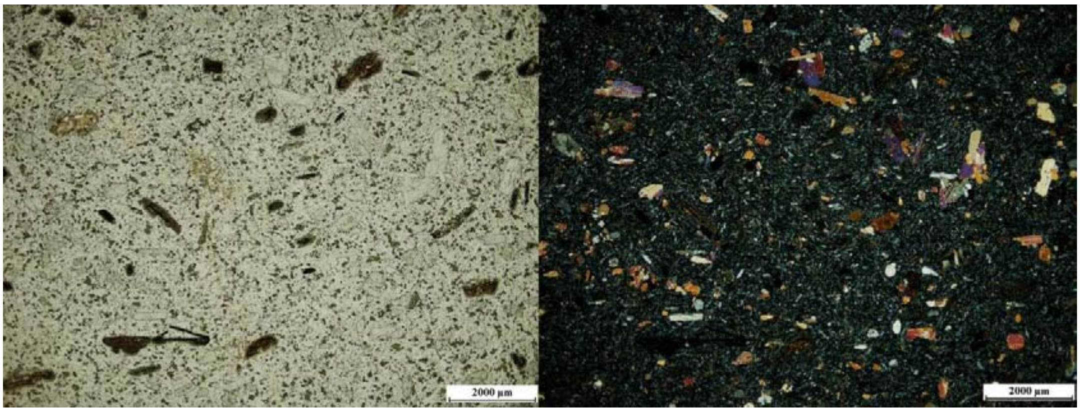
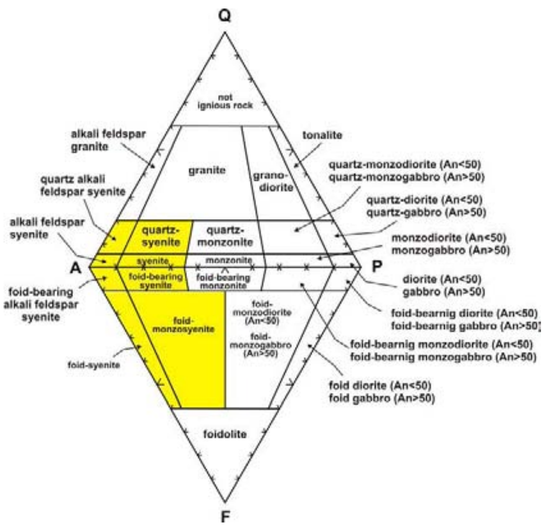


Figure II.189. – Typical microscopic photos of a latite from Balatonmária-1 borehole (at 438 m). It contains clinopyroxene phenocrysts and strongly opacitized biotites. Left with one nicol, right with crossed nicols.

SYENITE



Appearance: Light coloured, medium- to coarse-grained intrusive igneous rock, where alkali feldspar prevails. The mafic minerals are represented by small amount of pyroxenes (usually aegirineaugite and aegirine), amphibole and biotite. Plagioclase occurs also in small amount. Quartz or feldspathoid could be found in minor amount. It is the intrusive equivalent of trachyte and phonolite. It is formed mostly in continental rift zones.

Mineral content:

Essential minerals: K-feldspar >> Ca-Na plagioclase, amphibole, pyroxene, biotite

Accessory minerals: quartz or felspathoid, titanite, apatite, magnetite, zircon

Secondary minerals: chlorite, sericite

Rock types:

Quartz-syenite or nepheline-syenite depending on the occurrence of quartz (Si-saturated variety) or feldspathoids (Si-undersaturated variety)

- foyaite: orthoclase-microcline > Ca-Na plagioclase, nepheline, alkali amfibole, alkali pyroxene, biotite
- ditróite: sodalite-bearing foyaite

Locations in the Carpathian-Pannonian region: Ditró (nepheline- and sodalite-syenite=ditróite; Jurassic), Moravian-Silesian Beskidy (Czech Republic; Early Createaceous, it has close relationship with the Early Cretaceous alkali basalt – phonolite suite of the Mecsek Mts.).

Figure II.190. – Syenite

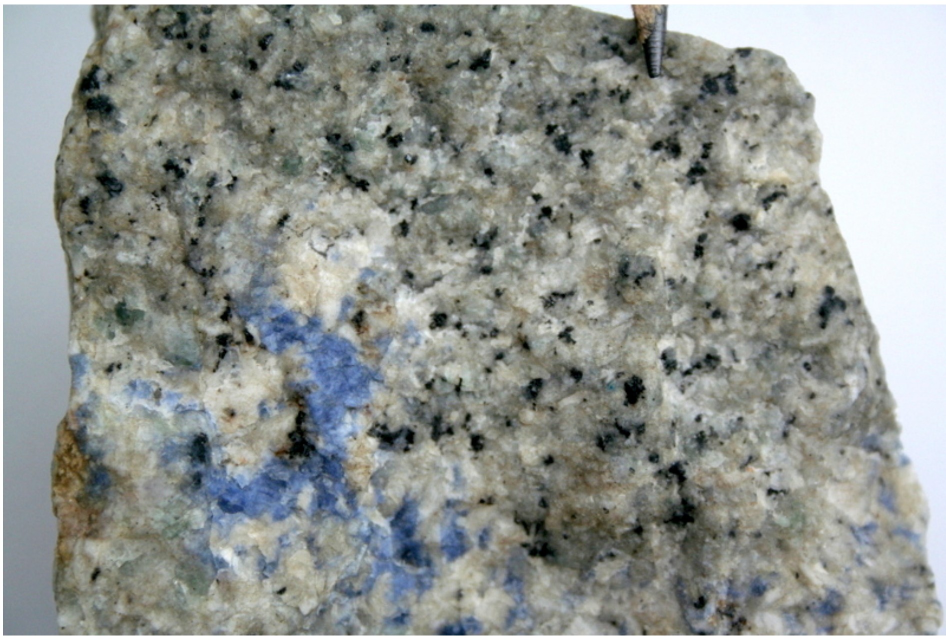
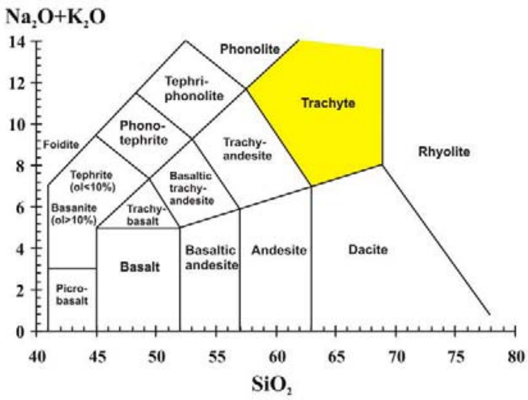


Figure II.191. – Sodalite-bearing syenite (ditróite) from Ditró.

TRACHYTE



Appearance: Light coloured, porphyritic volcanic rocks. The trachytic texture means that feldspar crystals are aligned in one direction. Among the feldspars, alkali feldspars prevail over plagioclases. The mafic minerals are represented by pyroxenes, amphiboles and/or biotite. Some trachyte varieties contain quartz or feldspathoids. Trachytes are most commonly associated with ocean island and continental rift magmatism and evolve by crystal fractionation of alkali basalt magmas.

Mineral content:

Essential minerals: K-feldspar >> Ca-Na plagioclase, amphibole, pyroxene, biotite

Accessory minerals: quartz or felspathoid, titanite, apatite, magnetite, zircon

Secondary minerals: chlorite, sericite

Rock types:

Quartz-trachyte or alkali trachyte depending on the occurrence of quartz (Si-saturated) or feldspathoids (Si-undersaturated variety)

Locations in the Carpathian-Pannonian region: Pásztori (in borehole).

Figure II.192. – trachyte

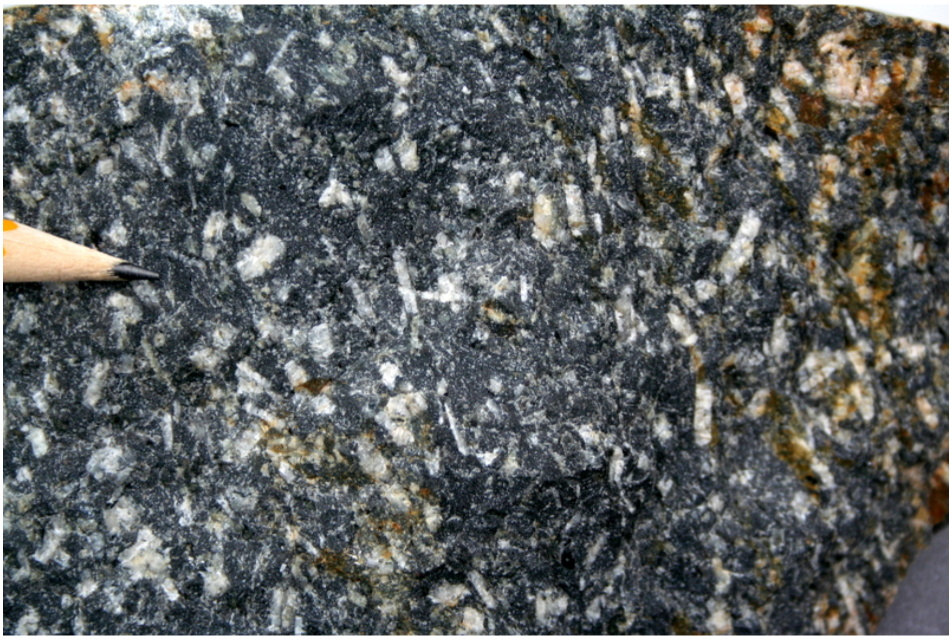
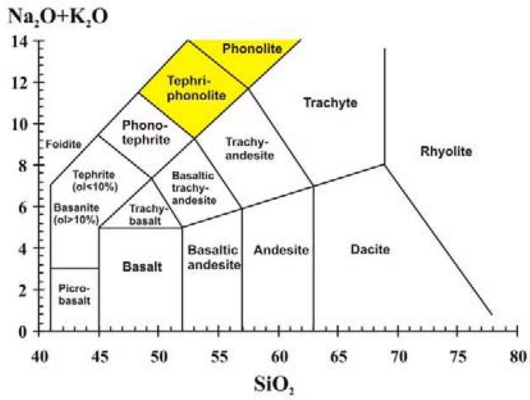


Figure II.193. – trachyte

PHONOLITE



Appearance: Light-grey-grey, often aphyric or slightly porphyritic volcanic rock. K-feldspar (sanidine or anorthoclase) prevails in this rocks that show often perthitic texture. The mafic minerals are alkali pyroxene (aegirinaugite and aegirine), alkali amphibole and rarely biotite. It contains typically feldpathoids such as nepheline or leucite. They could occur also as phenocrysts. Its name – singing rock- refers to the clinking sound given by the rock when the hammer hits it. Phonolite is commonly found in continental rift zones (e.g., Kilimanjaro; East African rift zone; Laacher-see, Eifel, Germany; Massif Central, Czech Republic) and in ocean islands (e.g., Teide, Tenerife, Canary islands; St. Helena). It forms by crystal fractionation of basanitic parental magma.

Mineral content:

Essential minerals: K-feldspar (sanidine) >> Ca-Na plagioclase, nepheline or leucite, alkali pyroxene, rarely alkali amphibole and biotite

Accessory minerals: titanite, sodalite, apatite, magnetite, zircon

Secondary minerals: analcime, chlorite, sericite

Locations in the Carpathian-Pannonian region: Köves hill and Szamár hill, Máza valley (Eastern Mecsek)

Figure II.194. – Phonolite (Mecsek)

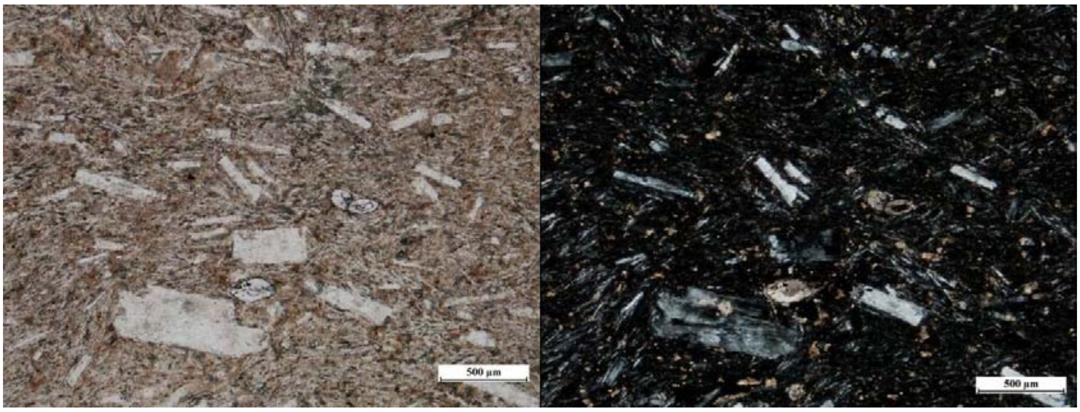


Figure II.195. – Typical microscopic photos of the phonolite from Szamár hill, Mecsek Mts. Left with one nicol, right with crossed nicols.

Figure II.196. – Teide in Tenerife (Canary islands) a huge phonolitic volcano (left) and typical phonolitic lava flows (coulee; right) (photos: Szabolcs Harangi)

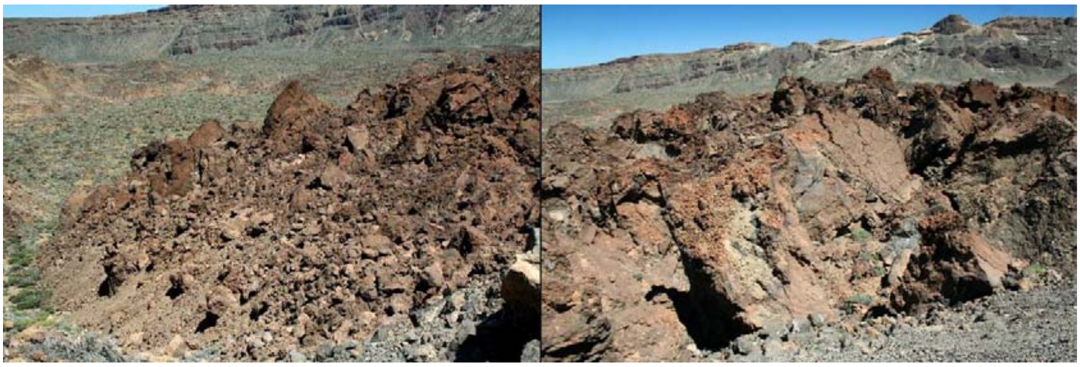


Figure II.197. – Typical thick phonolitic obsidian lava flow at the fott of the Teide. (photos: Szabolcs Harangi)

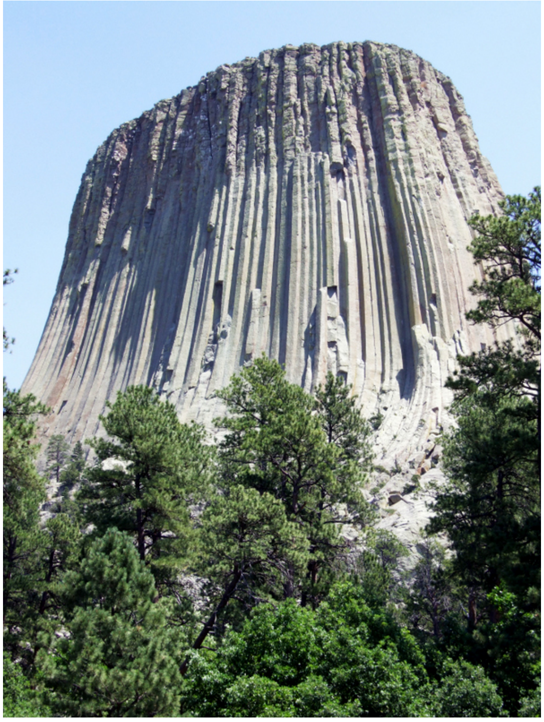
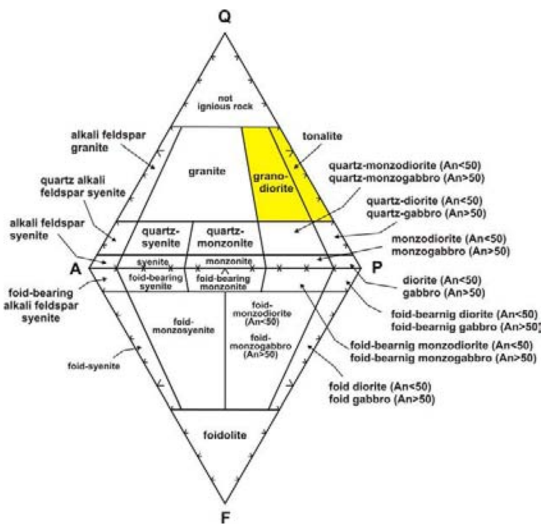


Figure II.198. – The Devils Tower in Wyoming (USA) with its spectacular columnar jointing is composed by phonolite.

II.4. Acidic (silicic) igneous rocks

GRANODIORITE



Appearance: Light coloured, medium- to coarse-grained intrusive igneous rocks with more than 20% of quartz. Within feldspars, the Na-rich plagioclase prevails over K-feldspar (orthoclase). The mafic minerals are represented by amphibole, pyroxene and biotite. This is the intrusive equivalent of dacite. It is formed mostly in subduction zones (active continental margins) and collisional settings (e.g., Alps along the Insubric-Periadriatic line). It forms also small volume shallow intrusive bodies of andesitic to dacitic volcanoes.

Mineral content:

Essential minerals: Na-rich plagioclase > K-feldspar (orthoclase), quartz, biotite, amphibole

Accessory minerals: apatite, magnetite, zircon

Secondary minerals: sericite, chlorite, epidot

Rock types:

- tonalite: Feldspars are represented almost exclusively by Na-rich plagioclase.

Locations in the Carpathian-Pannonian region: Mórágy; Calimani, Stiavnica-Kremnica (Central Slovakian volcanic complex).

Figure II.199. – Granodiorite

Figure II.200. – Granodiorite

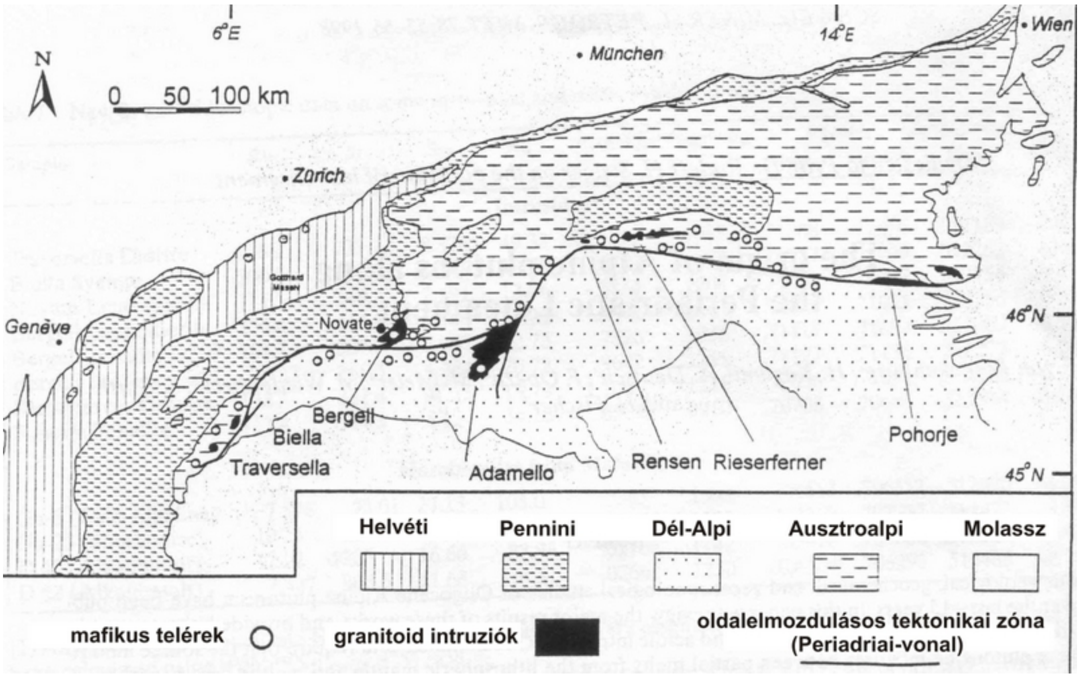
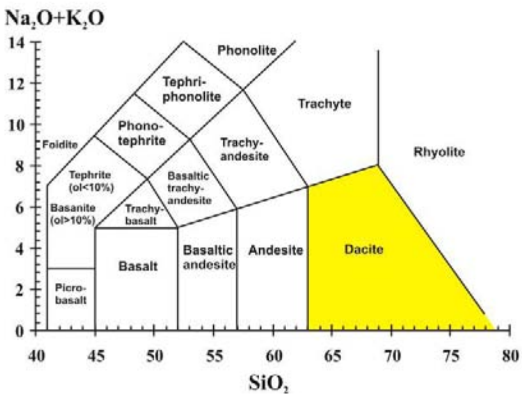


Figure II.201. – Granitoid (mostly granodiorite, tonalite) intrusive bodies along the Periadriatic tectonic line in the Alps

DACITE



Appearance: Ligth grey coloured, often crystal-rich volcanic rock. The most abundant phenocrysts are plagioclase, the mafic minerals are usually represented by amphibole and biotite, occasionally orthopyroxene. It contains much less alkali feldspar and quartz. It occur most commonly in subduction zone volcanoes. The known largest volume pyroclastic deposit in the Earth (Fish Canyon Tuff) is composed by dacite.

Mineral content:

Essential minerals: Na-rich plagioclase > K-feldspar (sanidine), biotite, amphibole, pyroxene

Accessory minerals: quartz, titanite, apatite, magnetite, zircon

Secondary minerals: sericite, chlorite, epidot

Locations in the Carpathian-Pannonian region: Visegrád Mts. (Holdvilág creek, Pilisszentlélek, Csódi hill), Börzsöny (Bajdázó), Central Slovakian volcanic complex, Tokaj Mts., Vihorlát, Calimani, Harghita, Ciomadul

Figure II.202. – Dcaitic lava dome of Mt. St. Helens (Washington, USA). Note that the dacitic magma erupts almost in solidified form (photo: USGS)

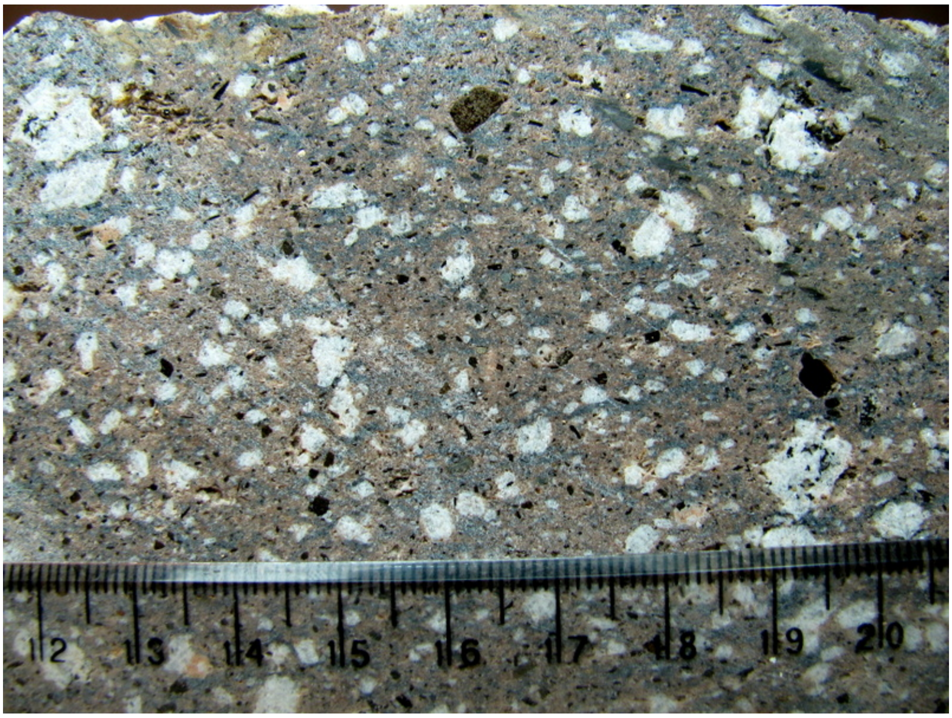


Figure II.203. – Crystal-rich dacite with plagioclase, amphibole and biotite phenocrysts from Csomád

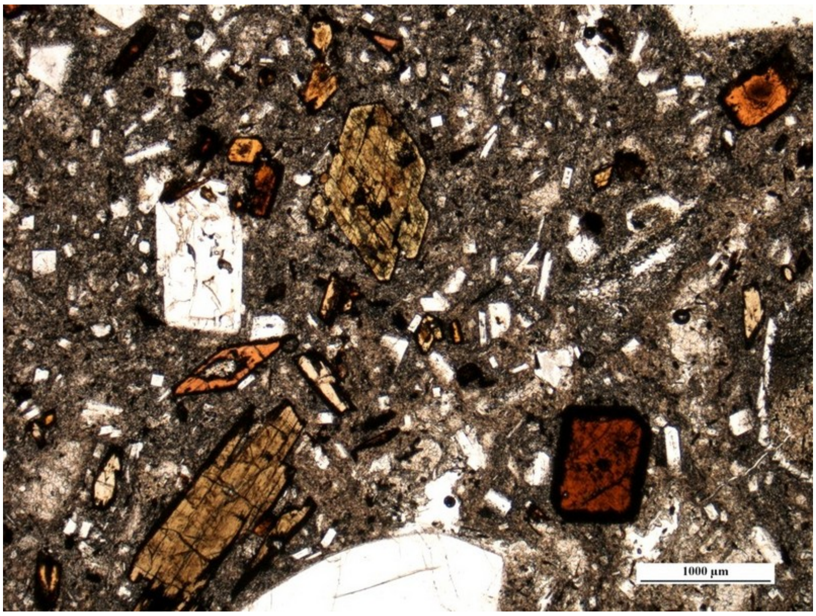


Figure II.204. – Typical microscopic photo of the dacite with plagioclase, amphibole and biotite phenocrysts from Kis-Csomád, Ciomadul (photo with one nicol).

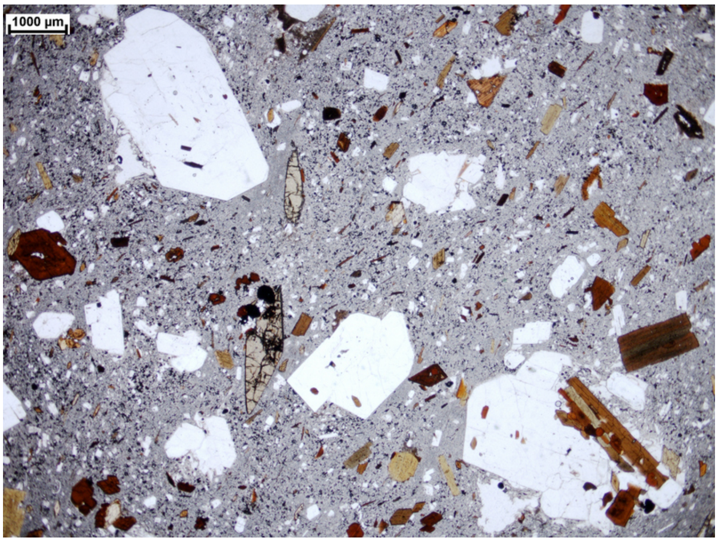


Figure II.205. – Typical microscopic photo of the dacite with plagioclase, amphibole and biotite phenocrysts from Kövesponk, Ciomadul (photo with one nicol).

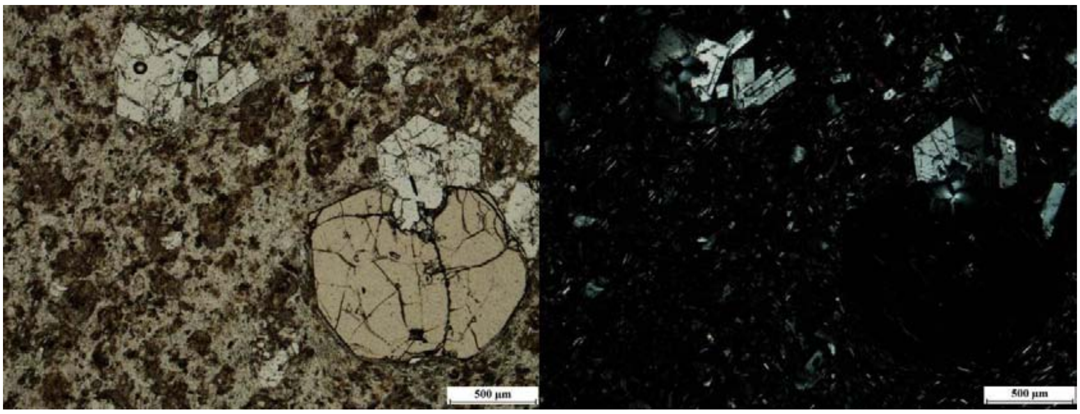


Figure II.206. – Typical microscopic photos of the garnet-bearing rhyodacite from Pilisszentkereszt (Visegrád Mts.). Left with one nicol, right with crossed nicols.

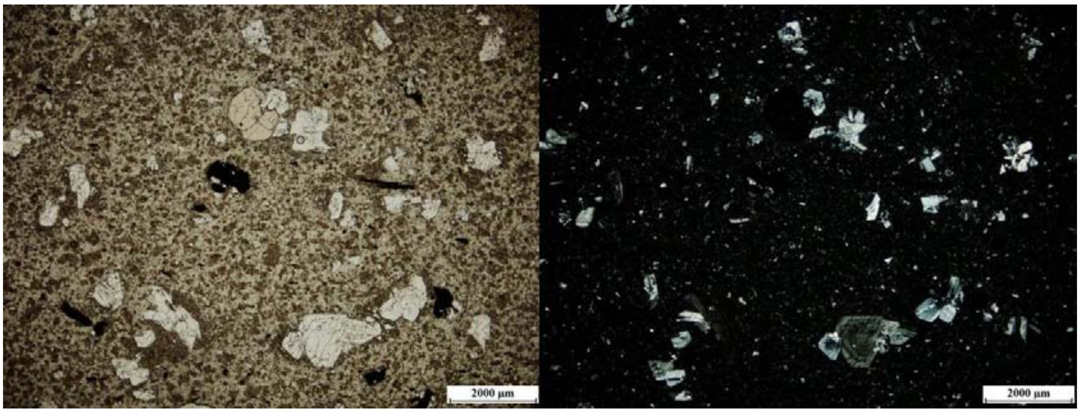


Figure II.207. – Typical microscopic photos of the garnet-bearing rhyodacite from Pilisszentkereszt (Visegrád Mts.). Left with one nicol, right with crossed nicols.

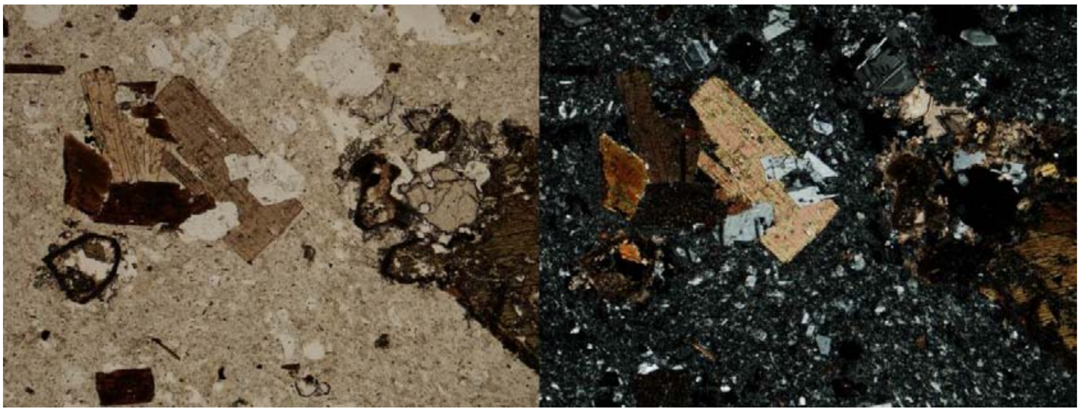


Figure II.208. – Typical microscopic photos of the amphibole-biotite dacite from Királyrét (Börzsöny). Left with one nicol, right with crossed nicols.

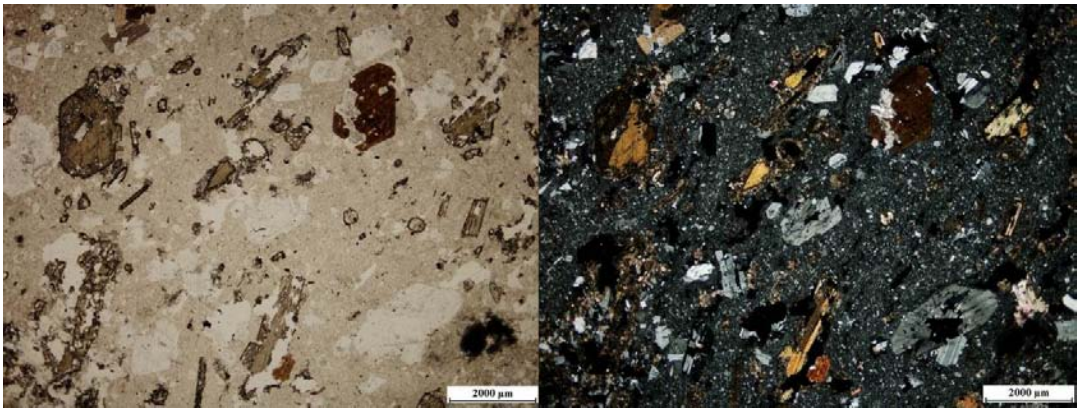


Figure II.209. – Typical microscopic photos of the amphibole-biotite dacite from Királyrét (Börzsöny). Left with one nicol, right with crossed nicols.

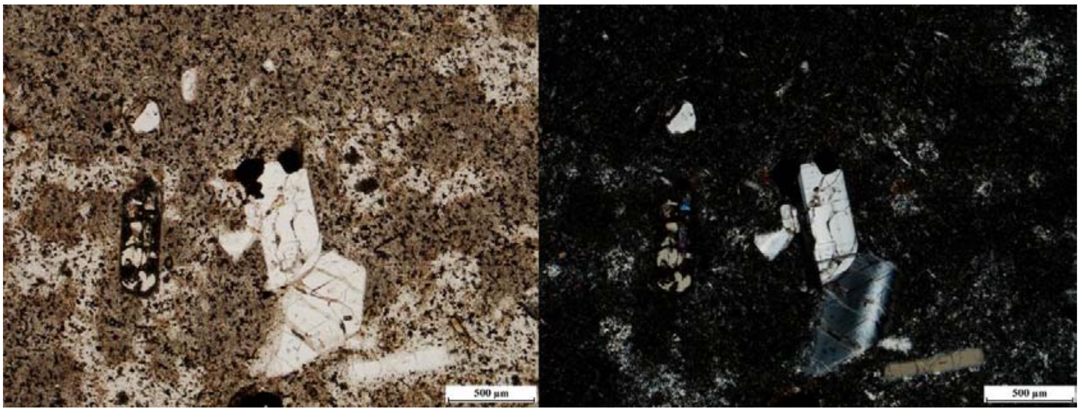


Figure II.210. – Typical microscopic photos of the dacite from Bad'an, (Slovakia). Left with one nicol, right with crossed nicols.

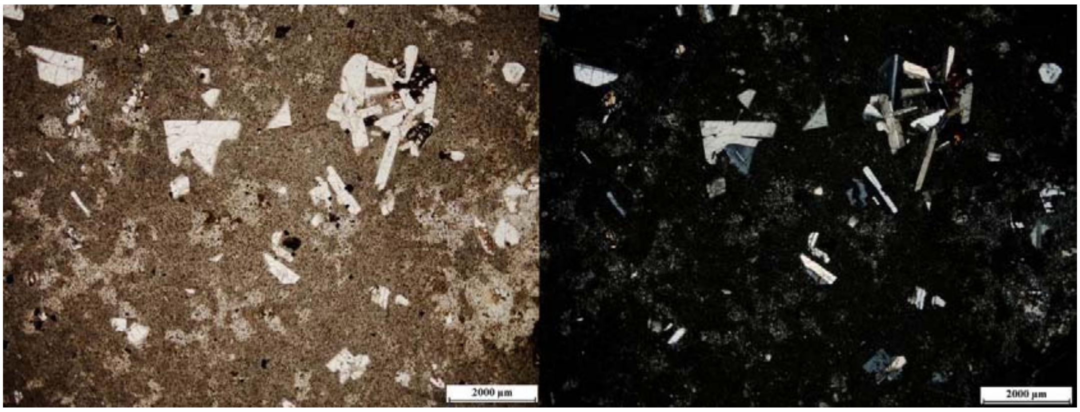


Figure II.211. – Typical microscopic photos of the dacite from Bad'an, (Slovakia). Left with one nicol, right with crossed nicols.

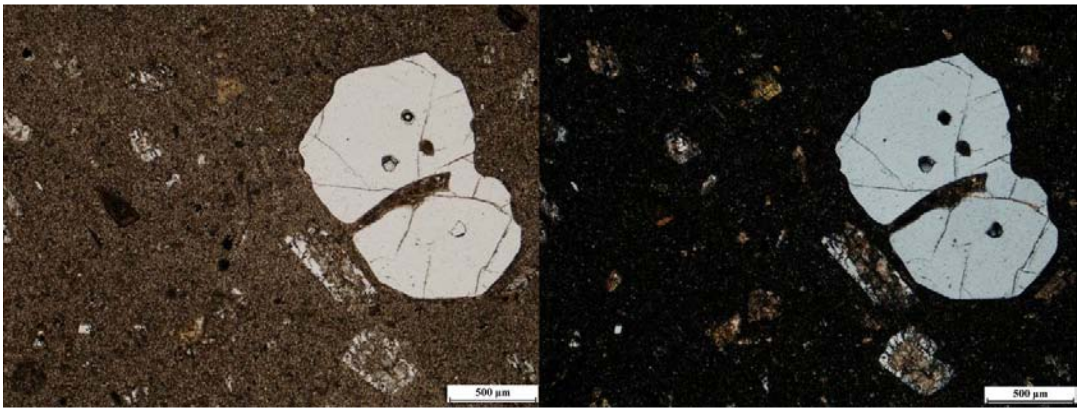


Figure II.212. – Typical microscopic photos of the dacite from Kyslinki, (Slovakia). Left with one nicol, right with crossed nicols.

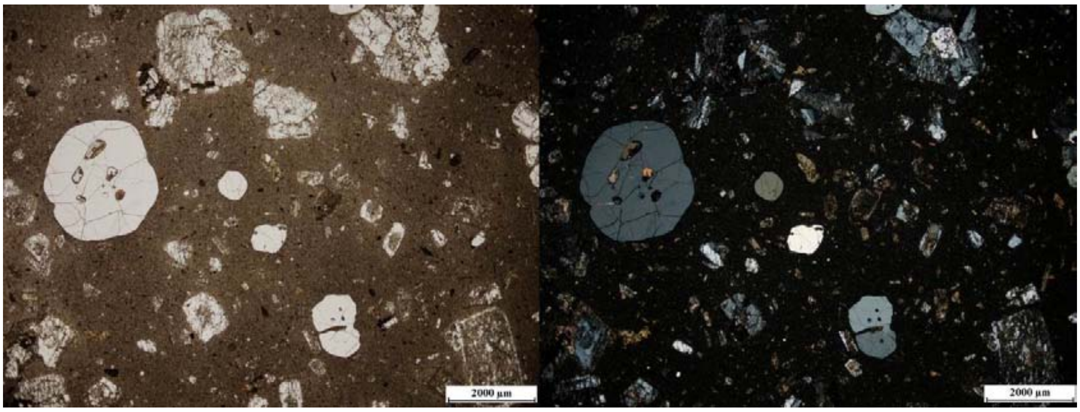


Figure II.213. – Typical microscopic photos of the dacite from Kyslinki, (Slovakia). Left with one nicol, right with crossed nicols.

Figure II.214. – The dacitic lava dome complex of Ciomadul from north (photo: Szabolcs Harangi).

Figure II.215. – The dacitic lava dome of Vár-tető in Ciomadul (left) and a closer view of the dacite at right (photo: Szabolcs Harangi).

Figure II.216. – Dacitic pumice fall tephra layer at Kézdivásárhely, about 20 km from Ciomadul and a closer view of the well-sorted pumiceous tephra (photos: Szabolcs Harangi).

Figure II.217. – The Ciomadul dacite: Typical microscopic photos with amphibole and plagioclase phenocrysts and antecrysts (left) and clinopyroxene xenocrysts surrounded by amphiboles (right). Photos with one nicol.

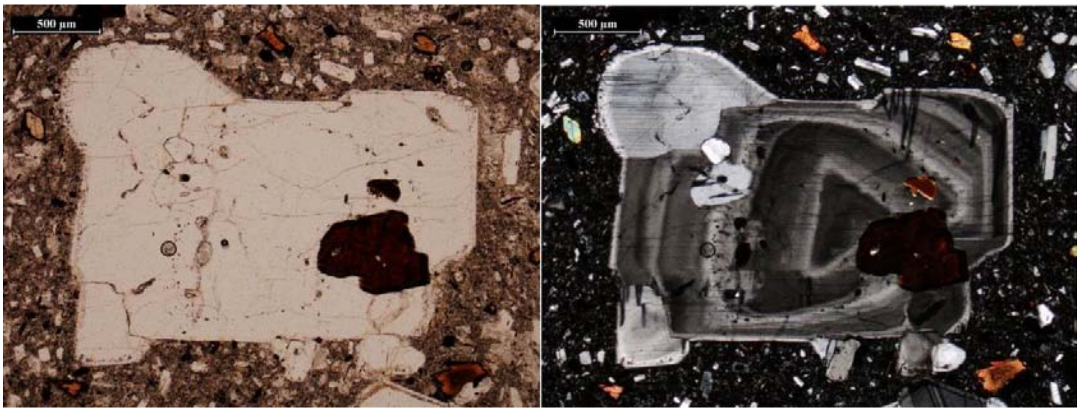


Figure II.218. – The Ciomadul dacite: Typical microscopic photos with large plagioclase antecryst including an amphibole Left with one nicol, right with crossed nicols.

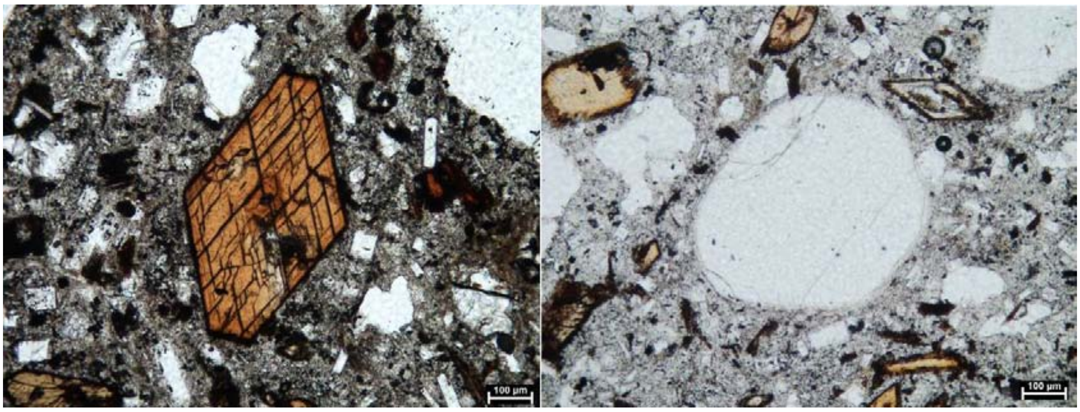


Figure II.219. – The Ciomadul dacite: Typical microscopic photos of the dacite from Nagy-Haram with large amphibole phenocryst (left) and a rounded quartz antecryst at right. Left with one nicol, right with crossed nicols.

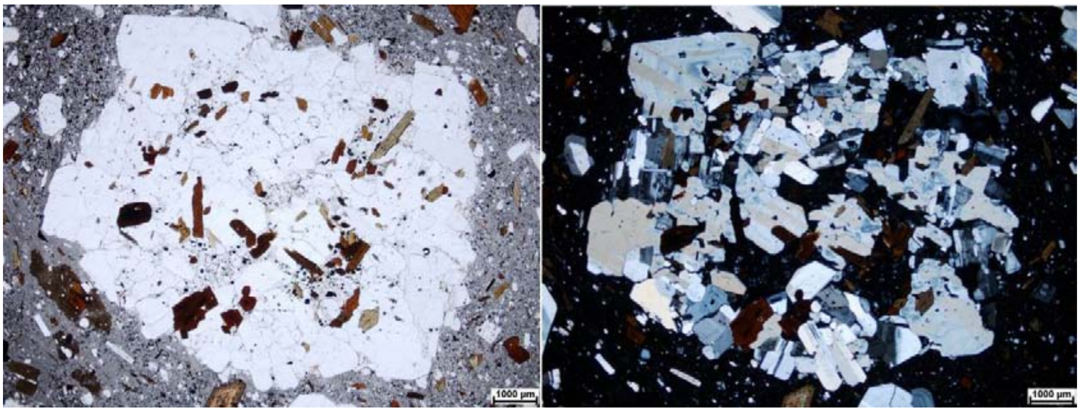


Figure II.220. – The Ciomadul dacite: microscopic photos of the dacite from Kövesponk with typical crystal clot. This dioritic-granodioritic crystal clot with plagioclase, amphibole, titanite, zircon and biotite could represent a pre-existingcrystal mush and remobilized. Left with one nicol, right with crossed nicols.

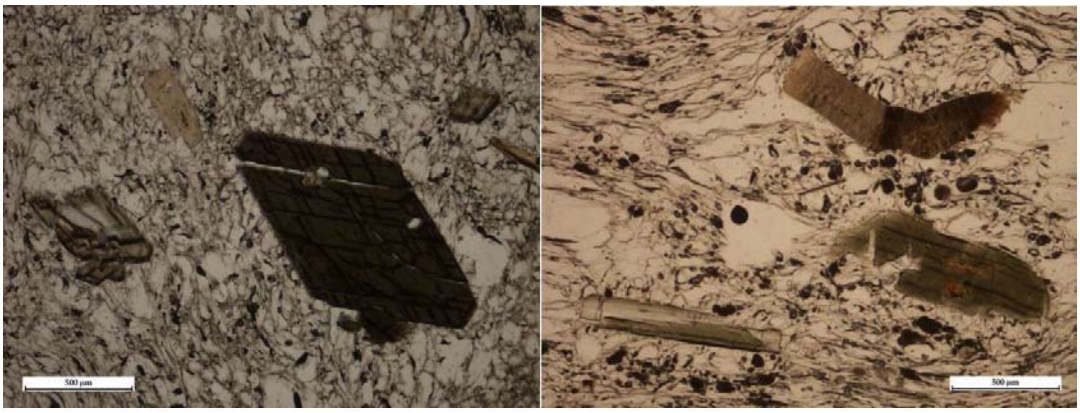


Figure II.221. – The Ciomadul dacite: microscopic photos of the dacitic pumice with amphibole and biotite phenocrysts from Tusnad. Photo with one nicol.

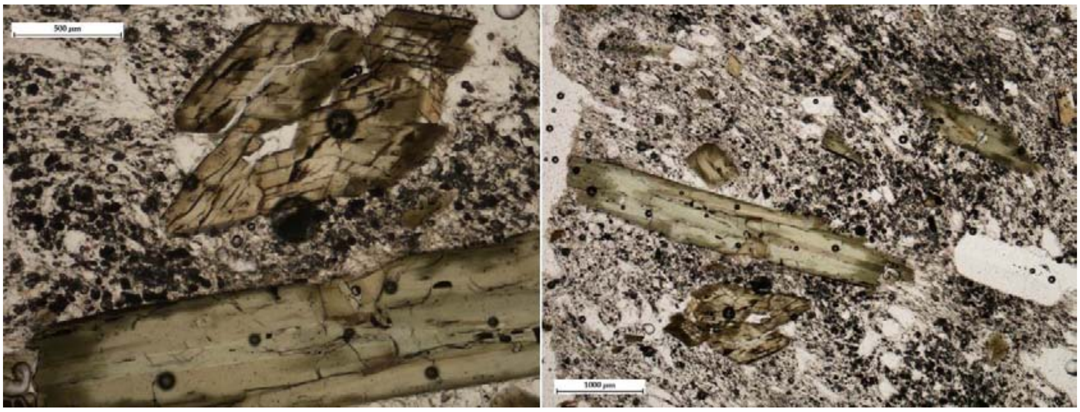
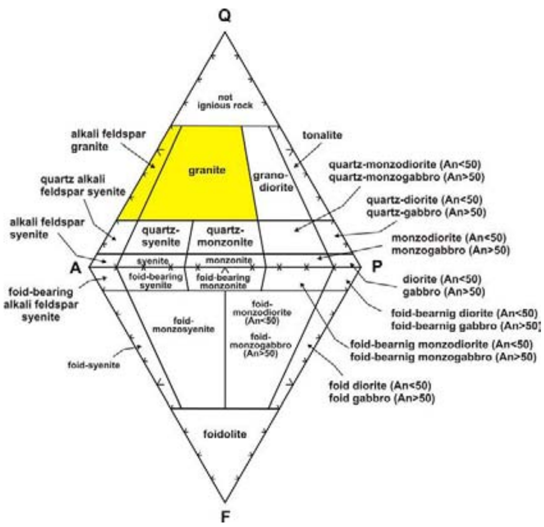


Figure II.222. – The Ciomadul dacite: microscopic photos of the dacitic pumice with amphibole phenocrysts from Bixad. Photo with one nicol.

GRANITE



Appearance: Light coloured, medium- to coarse-grained intrusive igneous rock containing more than 20% quartz and the amount of alkali feldspars (orthoclase) exceeds that of the plagioclase. The mafic minerals are usually biotite, but amphibole and pyroxene could also occur. Certain granite varieties muscovite, garnet and cordierite could be also found. Granites usually occur where thick continental crust developed, i.e. at subduction zones along active continental margin (e.g. Andes, Western USA) and at collision zones (e.g., Alps, Himalaya).

Mineral content:

Essential minerals: K-feldspar (sanidine) > Na-rich plagioclase, quartz, biotite, amphibole

Accessory minerals: titanite, apatite, magnetite, zircon, muscovite, pyroxene, andalusite, cordierite, garnet, turmalin, topas

Secondary minerals: sericite, chlorite, epidot

Rock types:

- monzogranite: within feldspars the alkali feldspar has an amount of 35-65%. This is the most common granite type, called formerly also adamellite (the Adamello granite is one of the most famous silicic igneous bodies at the Periadriatic line in the Alps)
- syenogranite: within feldspars the alkali feldspar has an amount of 65-90%.

- alkáli granite: within feldspars the alkali feldspar has an amount of >90%. The mafic minerals are alkali pyroxenes (aegirinaugite, aegirine) and alkali amphibole
- graphic granite: quartz and orthoclase show oriented intergrowth. It forms from eutectic silicic melt.
- luxullianite (turmaline-granite): in this granite type turmaline occurs in significant amount
- greisen: a granite type showing metasomatic alteration. Typical minerals occurring in this granite are significant amount of quartz and less muscovite and/or Li-mica, topas. Feldspar, fluorite, turmaline, berill, rutile, cassiterite, apatite are found as accessory minerals. The feldspar and biotite in the original granite are replaced by quartz, Li-mica and caolinite.
- aplite: fine-grained granite with equigranular texture with orthoclase-microcline > Na-rich plagioclase and quartz. Mafic minerals are subordinate. It represent highly evolved silicic melt with eutectic (haplogranitic) composition.
- granophyre: It contains quartz and alkali feldspar in characteristic angular intergrowths. It is formed from eutectic melt.

The characteristic accessory minerals of peraluminiuous (S-type; the silicic magma is formed by melting of metasedimentary rocks) granites are Al-rich minerals, such as garnet, cordierite, andalusite and muscovite. In the metaluminuous (I-type; the silicic magma is formed by melting of metaigneous rocks) granites, amphibole and pyroxene represent the mafic minerals in addition to biotite. The peraluminous granites are characterized by the appearance of alkali mafic minerals such as alkali pyroxene and alkali amphibole. The feldspar content of the granite is also indicative on the origin of the silicic magma. If only one alkali feldpar type is found what often shows perthitic feature, it implies crystallization from relatively dry magma hipersolvus granites). Two different feldspar types (K-feldspar and Na-rich plagioclase) suggest that the crystallization could take place from water-saturated magma (subsolvus granites).

Figure II.223. – Granite with orthoclase megacryst (Erdősmecske).

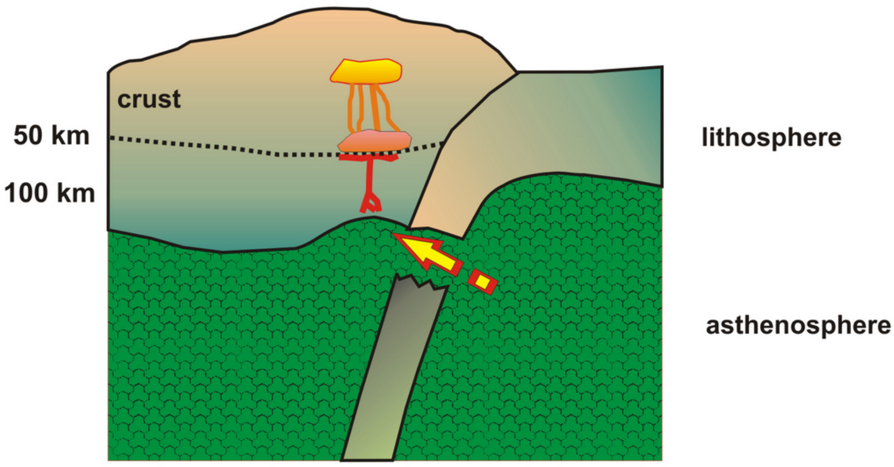


Figure II.224. – Formation of granitic magma in collision zones: beneath the collision front, shallow detachment of the oceanic crust could induce upwelling of hot asthenosphere. This could result in partial melting in the lower lithosphere followed by crustal melting due to the basaltic underplating beneath the thick crust. Intermittent uprise of crustal or hybrid melts build silicic magma reservoir in the crust and granites are formed by crystallization of this magma.

Figure II.225. – Medium-grained granite

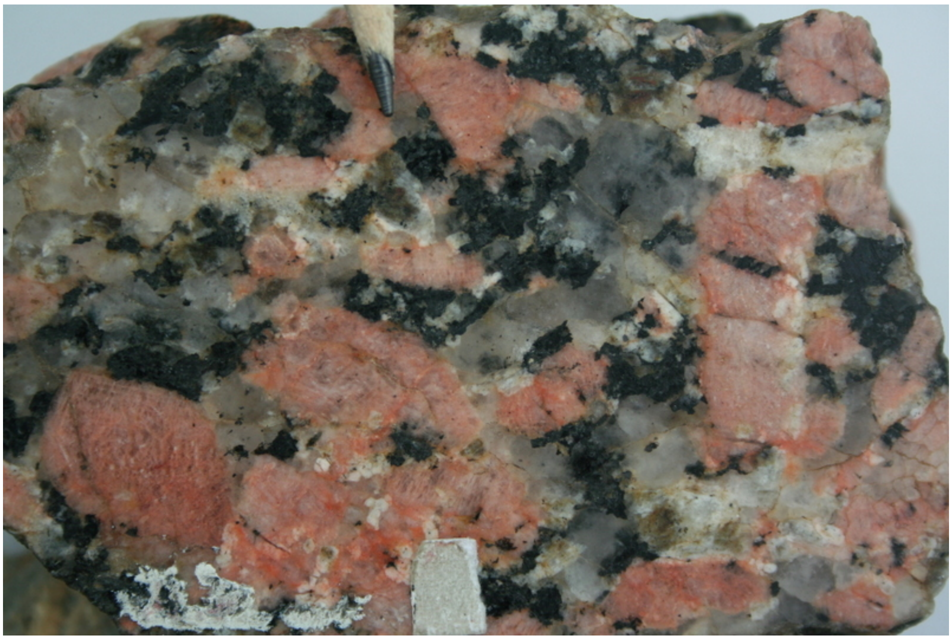


Figure II.226. – Coarse-grained granite (orthoclase, plagioclase, quartz and biotite)

Figure II.227. – Aplite vein in granite (Erdősmecske)

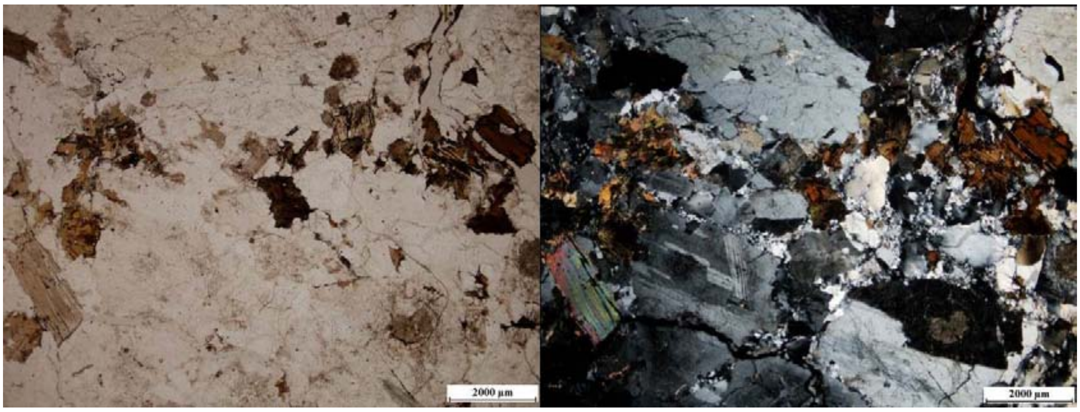


Figure II.228. – Typical microscopic picture of granite from Mórágy. Left with one nicol, right with crossed nicols.

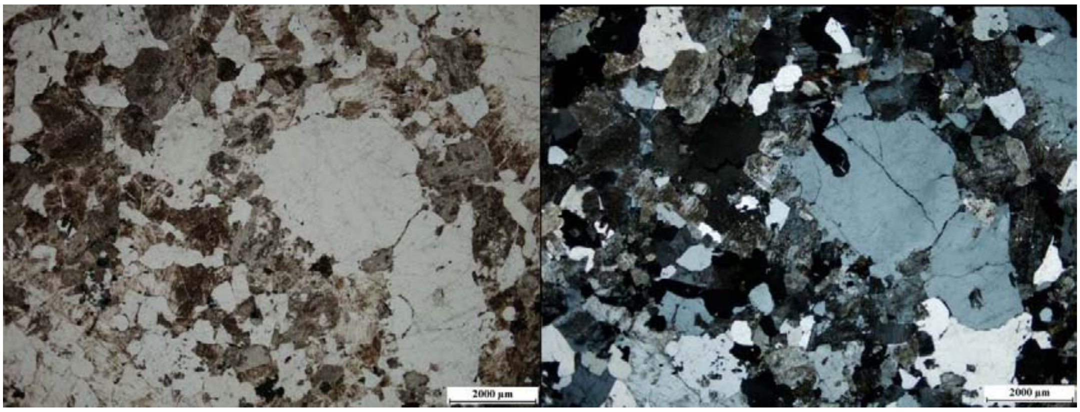


Figure II.229. – Typical microscopic picture of granite from Rigó hill (Velence Mts.). Left with one nicol, right with crossed nicols.

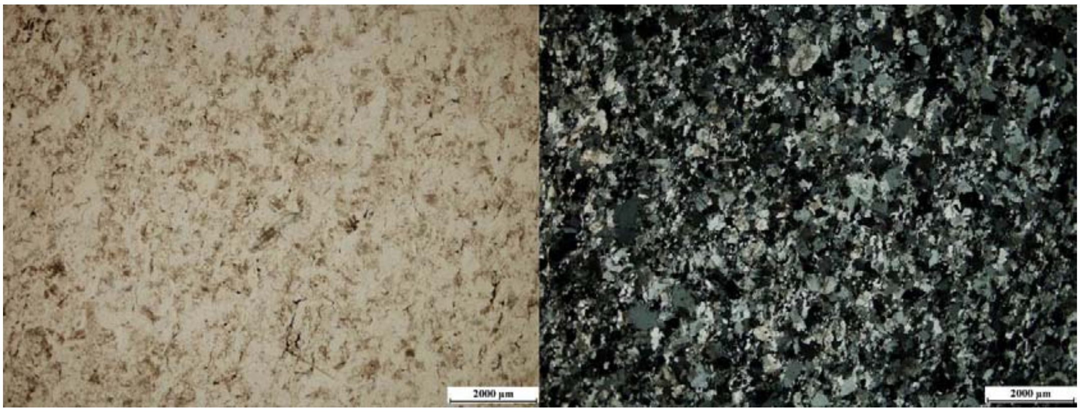


Figure II.230. – Typical microscopic picture of granite aplite from Erdősmecske. Left with one nicol, right with crossed nicols.

<u>Locations in the Carpathian-Pannonian region</u>: Mórágy, Velence Mts., Zala basin and along the Balaton line, Veporids (Slovakia)

Velence Mts. (ca. 280-300 Ma; peraluminuous S-type biotite monzogranite)

Figure II.231. – Characteristic appearance of the granites in the Velence Mts. The Rigó hill quarry at Sukoró exposes granites, porphyritic granite and aplite as well as mafic xenoliths (photos: Szabolcs Harangi)

Figure II.232. – Characteristic appearance of the granites in the Velence Mts. The Rigó hill quarry at Sukoró exposes granites, porphyritic granite and aplite as well as mafic xenoliths (photos: Szabolcs Harangi)

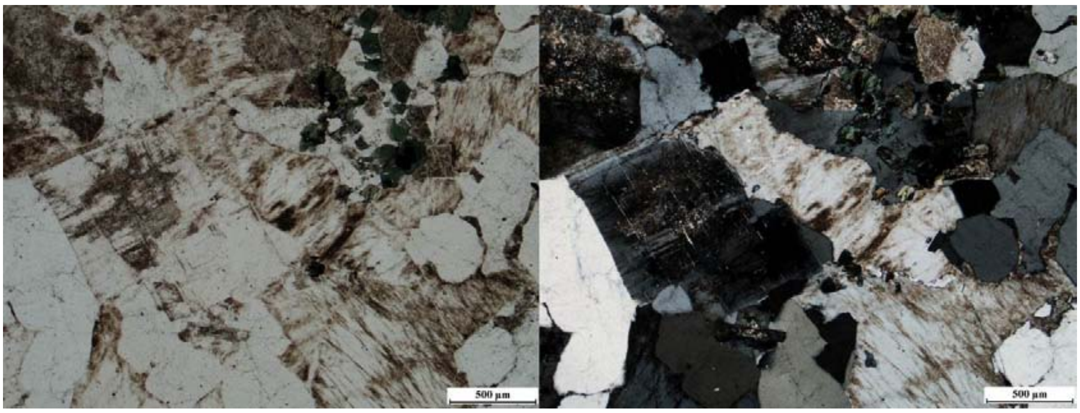


Figure II.233. – Typical microscopic picture of granite from Rigó hill (Velence Mts.). Left with one nicol, right with crossed nicols.

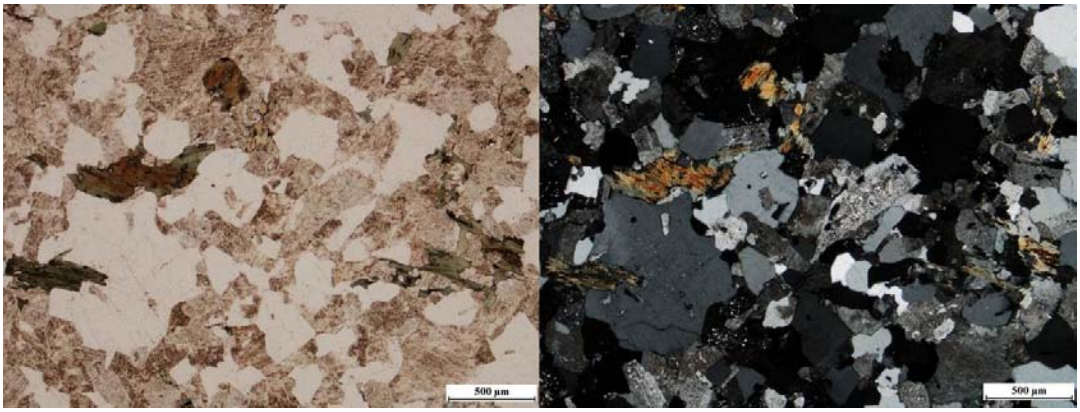


Figure II.234. – Typical microscopic picture of granite from Rigó hill (Velence Mts.). Left with one nicol, right with crossed nicols.

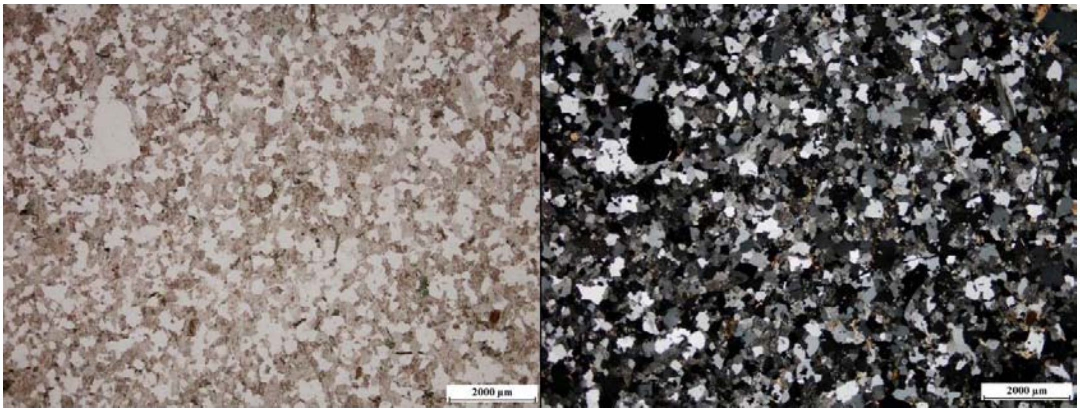


Figure II.235. – Typical microscopic picture of granite aplite from Rigó hill (Velence Mts.). Left with one nicol, right with crossed nicols.

Mecsek (ca.320-340 Ma; metaluminuous I-type microcline megacryst-bearing biotite monzogranite)

Figure II.236. – Typical appearance of the granite in Kismórágy. Note the dark mafic xenolith in the monzogranite and the coarse-grained, microcline-rich granite at right (Photo: Balázs Koroknai)

Figure II.237. –Typical appearance of the granite in Erdősmecske.

Figure II.238. – Aplite dyke and aplite vein in the granite of Erdősmecske.

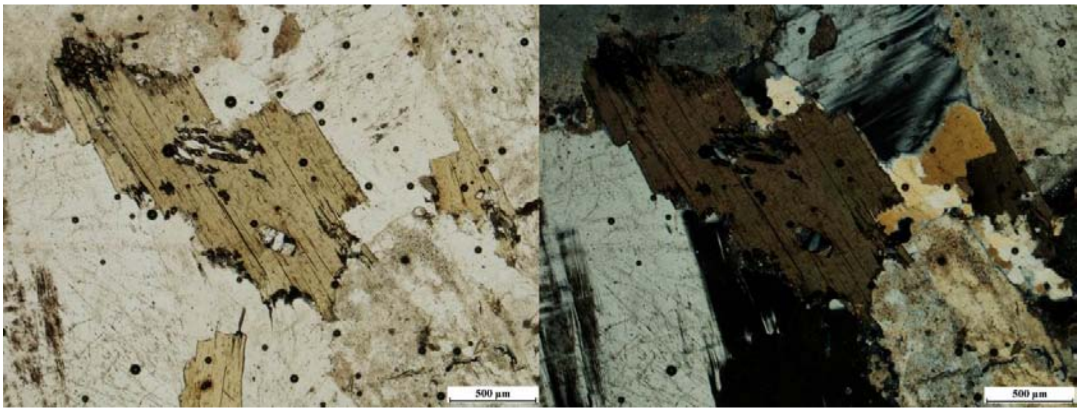


Figure II.239. – Typical microscopic picture of granite from Erdősmecske. Left with one nicol, right with crossed nicols.

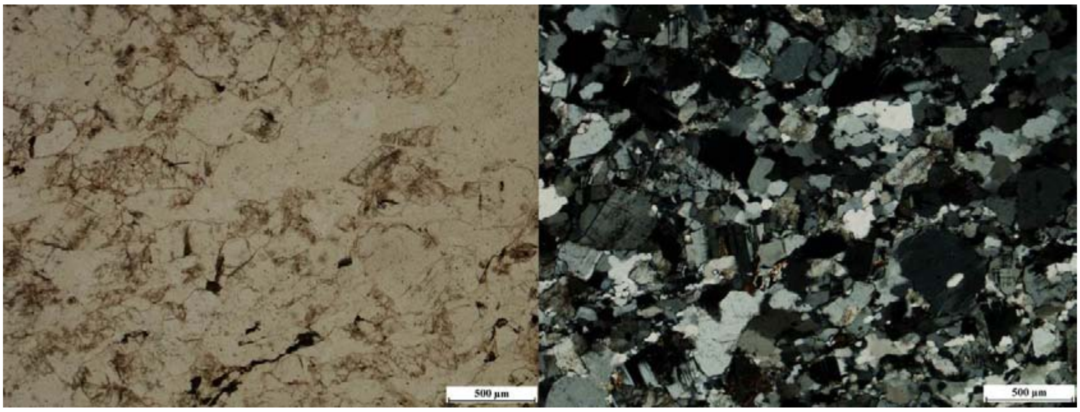


Figure II.240. – Typical microscopic picture of granite aplite from Erdősmecske. Left with one nicol, right with crossed nicols.

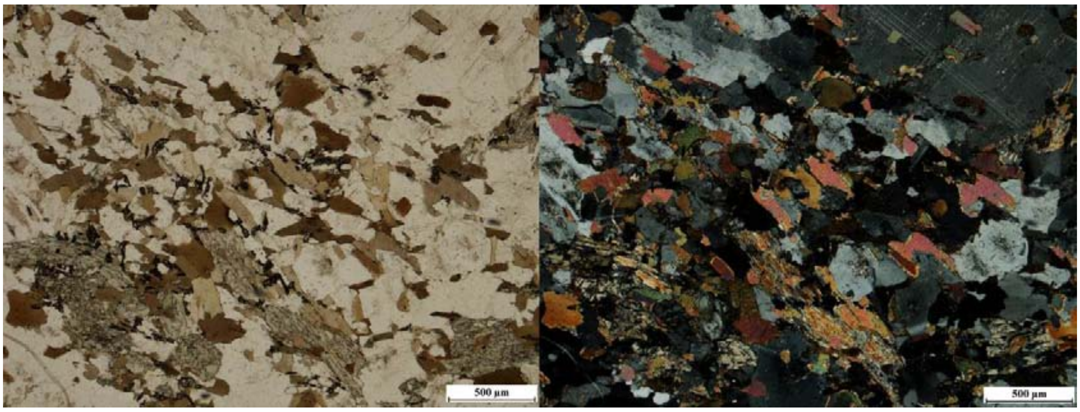


Figure II.241. – Mafic mineral accumulation interpreted previously as restites in the grantite of Erdősmecske. Left with one nicol, right with crossed nicols.

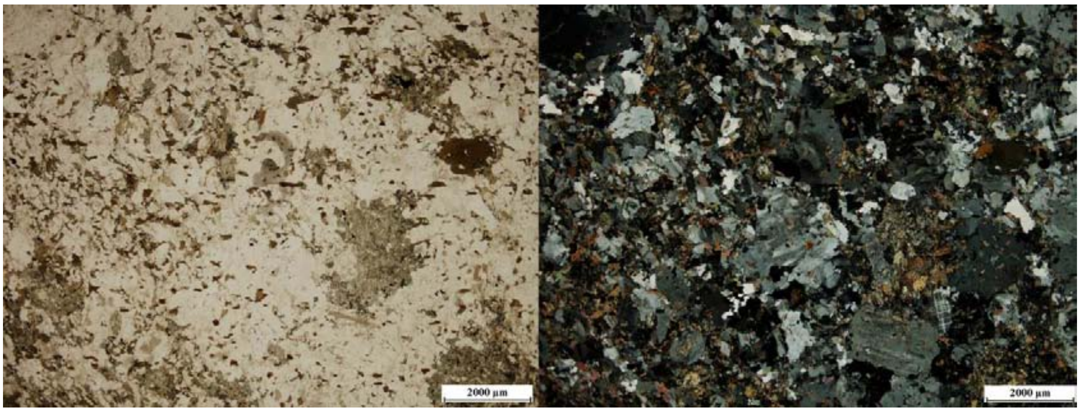


Figure II.242. – Mafic mineral accumulation interpreted previously as restites in the grantite of Erdősmecske. Left with one nicol, right with crossed nicols.

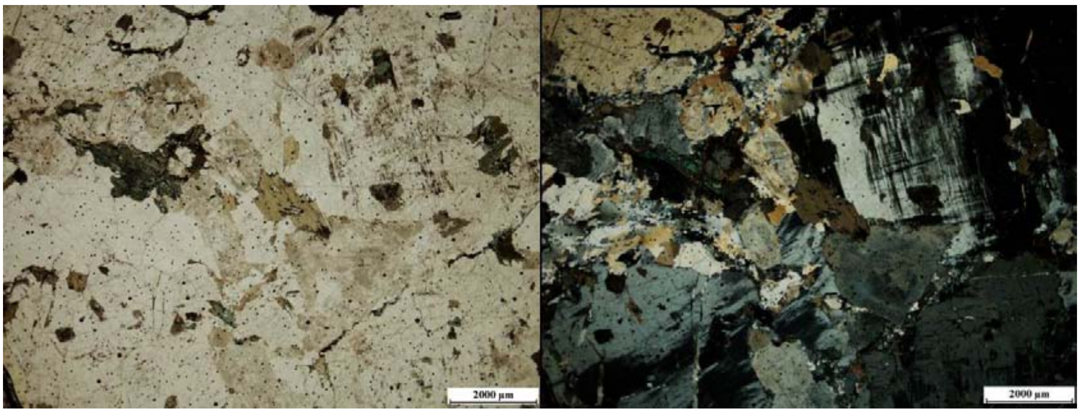


Figure II.243. – Typical microscopic picture of granite from Mórágy. Left with one nicol, right with crossed nicols.

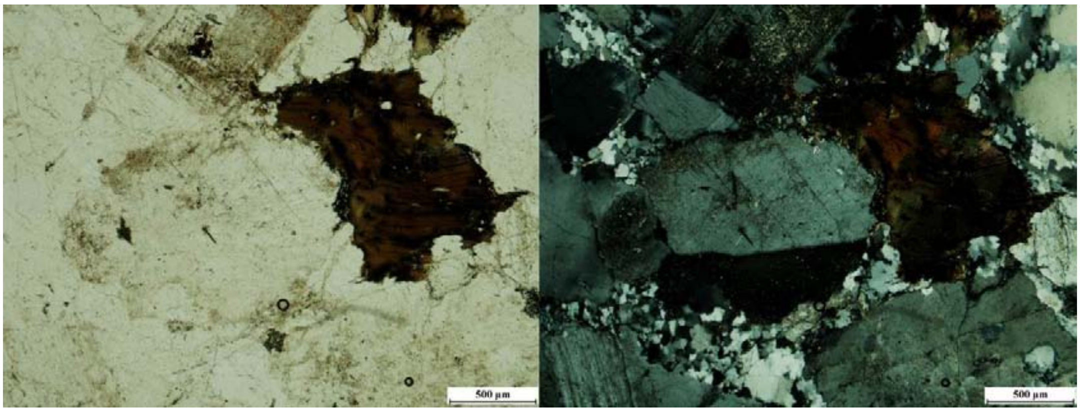


Figure II.244. – Typical microscopic picture of granite from Kismórágy. Left with one nicol, right with crossed nicols.

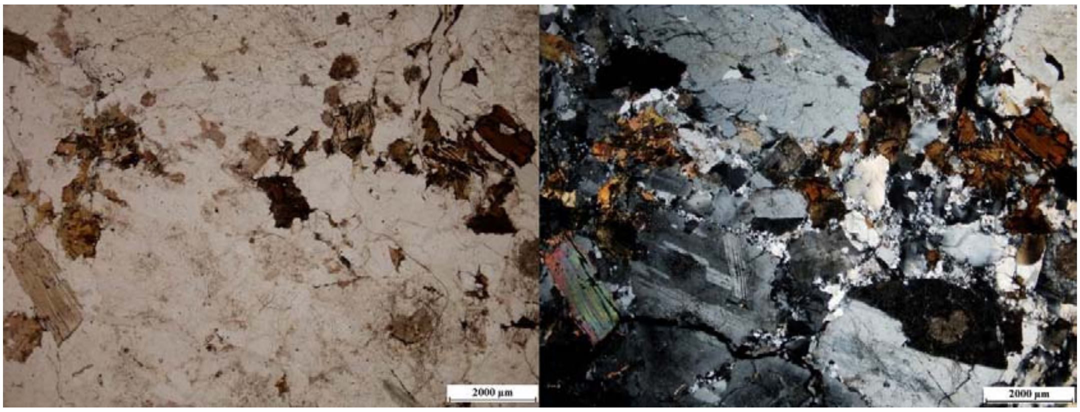


Figure II.245. – Typical microscopic picture of granite from Kismórágy. Left with one nicol, right with crossed nicols.

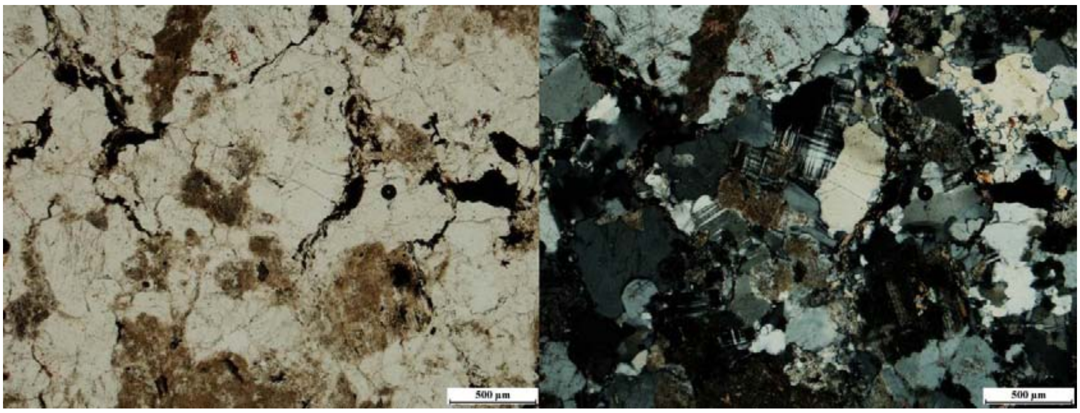


Figure II.245. – Typical microscopic picture of granite aplite from Kismórágy. Left with one nicol, right with crossed nicols.

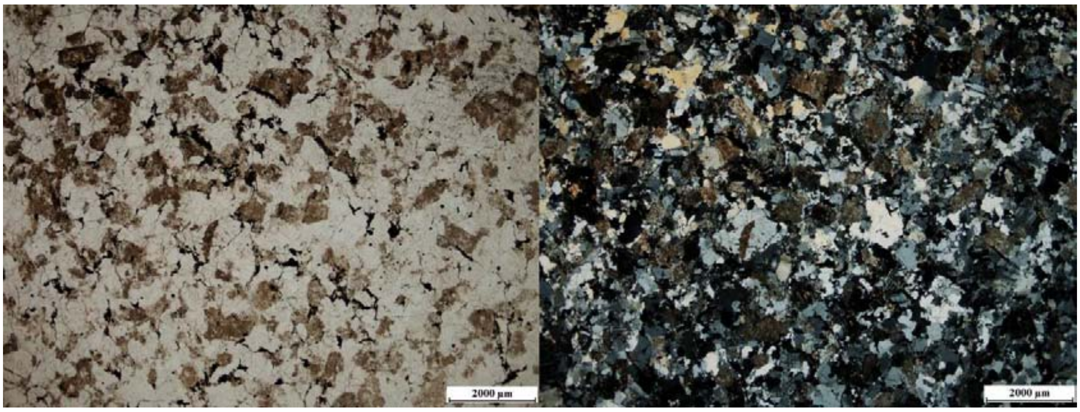
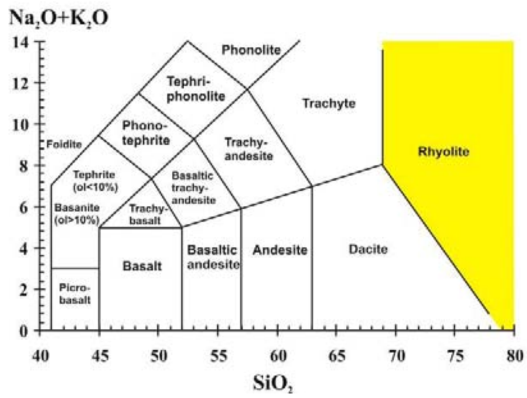


Figure II.246. – Typical microscopic picture of granite aplite from Kismórágy. Left with one nicol, right with crossed nicols.

RHYOLITE



Appearance: Light coloured or red, often banded (the banding is related to the difference in volatile, i.e. vesicles and crystallites in the glassy groundmass), aphyric-glassy (obsidian-like) or variously porphyritic volcanic rock, the volcanic equivalent of granite. It contains more than 20% quartz and the amount of alkali feldspars (orthoclase) exceeds that of the plagioclase. The mafic minerals are usually biotite. Rhyolite occurs mostly at areas where thick crust developed, i.e. mostly along subduction zones (active continental margins; e.g. Andes), but can be found also in extensional regions such as in Taupo, New Zealand. In Large Magmatic Provinces they are associating with flood basalts. Rhyolites are the dominant volcanic products along the Snake River Plain – Yellowstone area, where they represent large volume caldera-forming volcanic products. The so-called supervolcanic eruptions are fed either dacitic or rhyolitic magmas. Rhyolites occur also in Iceland, where the Hekla produced violent explosive eruption of rhyolitic magma many times. Here, the rhyolitic magma is formed by melting of basaltic crustal material.

Mineral content:

Essential minerals: K-feldspar (sanidine) > Na-rich plagioclase, quartz, biotite

Accessory minerals: zircon, apatite, magnetite, ilmenite, pyroxene, amphibole

Secondary minerals: sericite, chlorite, epidot

Rock types:

- obsidian: rhyolitic glass with 1-2% water content, it is usually black, or rarely red, having cuspate fracture.
- perlite: rhyolitic glass with 3-5% water content, expansion due to the hydration causes characteristic cuspate fractures finally leading to a globular appearance

- pumice: highly vesicular glassy rhyolite (‘solidified magma foam’) originating mostly during explosive volcanic eruptions, but this can be formed also in rhyolitic lavas
- pantellerite: peralkaline variety of rhyolite. The type locality of this rock is in the island of Pantelleria in the Sicily-strait. Here, the phenocrysts are anorthoclase and sanidine. Quartz is quite rare, although the groundmass is high-silica glass. The mafic minerals are alkali pyroxene (aegirine), alkali amphibole (arfvedsonite, ferrorichterite) and aenigmatite.
- comendite: alkali rhyolite, which has lower FeO and higher Al_2O_3 than the pantellerite. It has a slight blueish colour as a result of the arfvedsonites and riebeckites

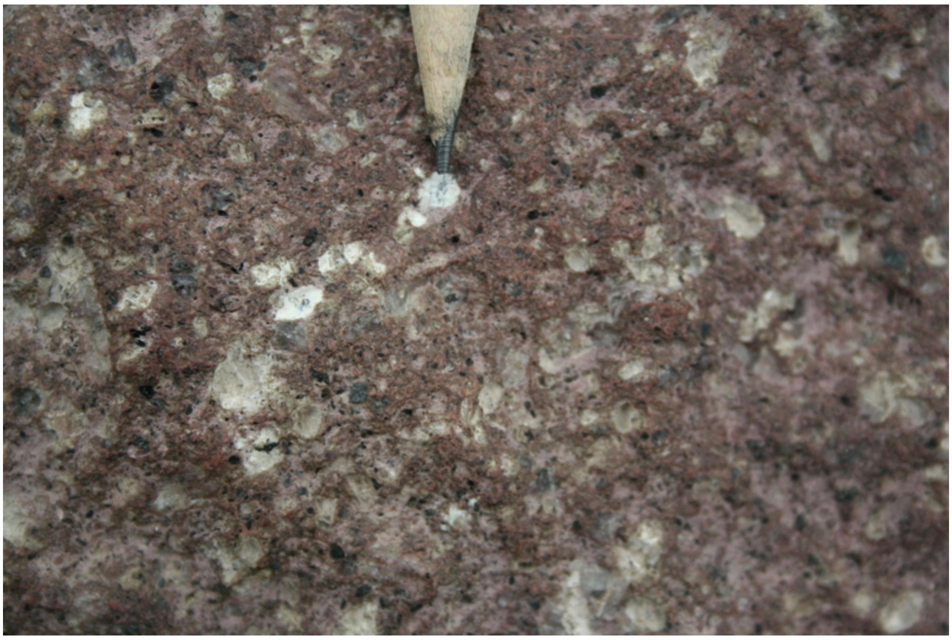


Figure II.247. – Rhyolite lava rock.

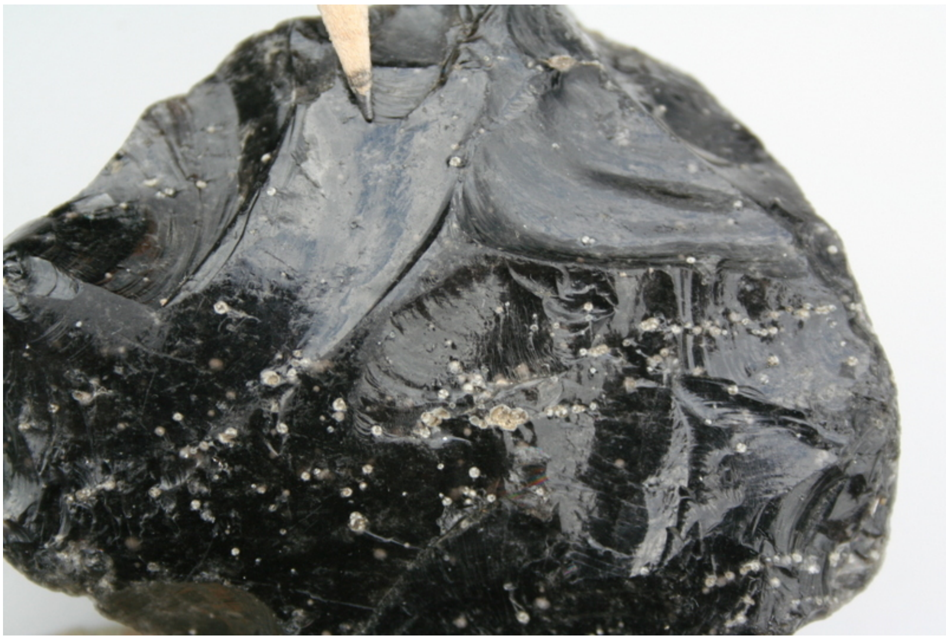


Figure II.248 – Rhyolitic obsidian

Figure II.249. – Rhyolitic perlite.

Figure II.250. – Perlite with obsidian clasts (Pálháza, Tokaj Mts)

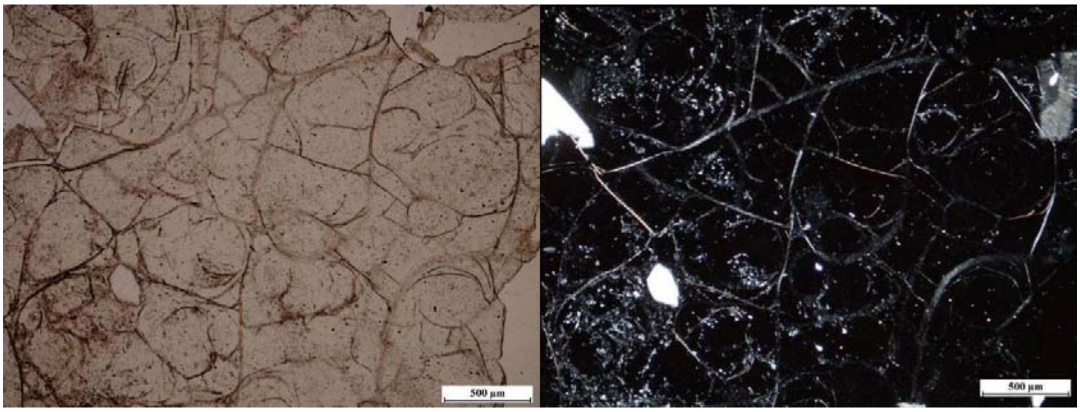


Figure II.251. – Typical microscopic picture of rhyolitic perlite from Tállya, Tokaj Mts. Left with one nicol, right with crossed nicols.

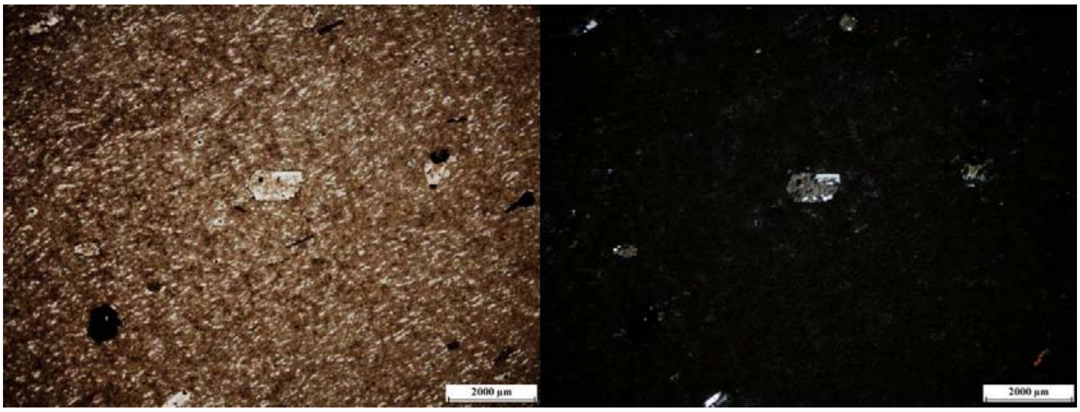


Figure II.252. – Typical microscopic picture of rhyolite from Stara Kremnica. Left with one nicol, right with crossed nicols.

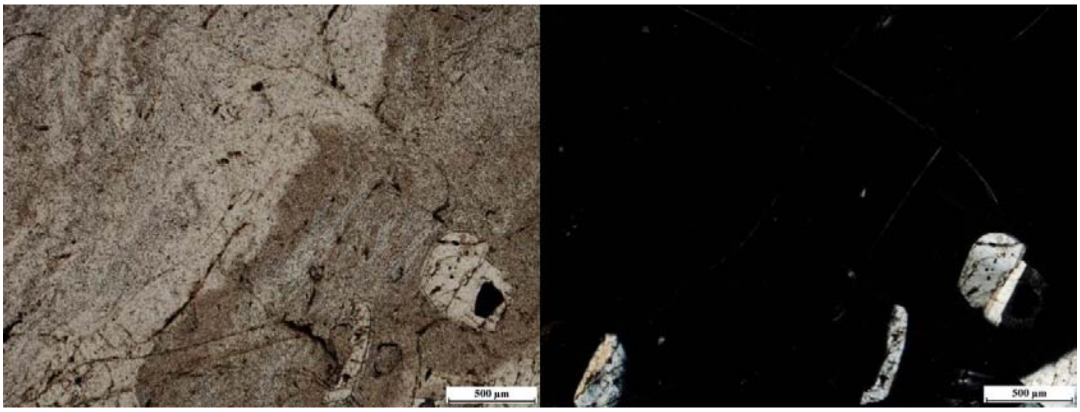


Figure II.252. – Typical microscopic picture of perlitic rhyolite from Stara Kremnica. Left with one nicol, right with crossed nicols.

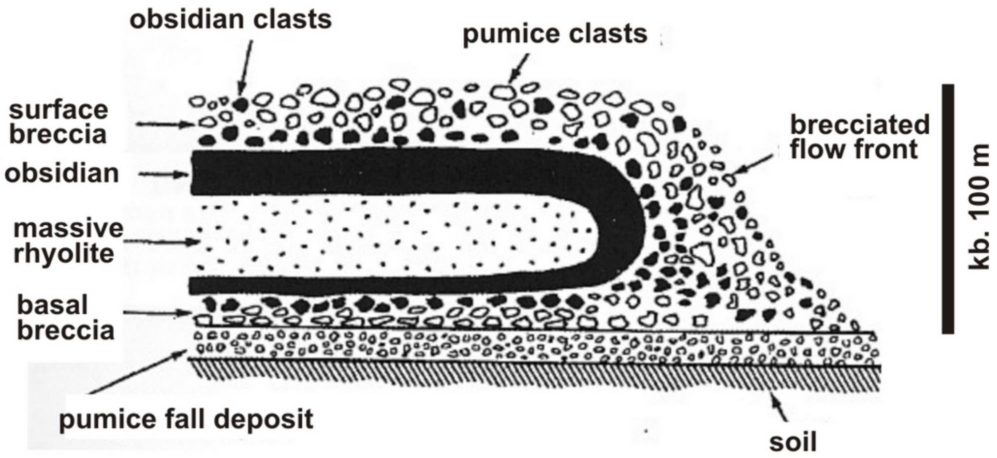


Figure II.253. – Theoretical structure of a rhyolitic lava flow

Figure II.254. – Rhyolitic obsidian lava flow at Newberry, Oregon, USA. It is 1300 old, 1.8 km long and 20 m thick at the flow front. (photo: Willie Scott, USGS)

Figure II.255. – Rhyodacitic lava dome at Novarupta, Alaska, USA formed after the cataclysmic Katmei-Novarupta eruption in 1912. It is 75 m thick and its diameter is 275 m (Fotó: Lilly Clairborne)

Figure II.256. – A closer view of the Novarupta rhyodacitic lava dome. It consists of large fractured blocks (Fotó: Lilly Clairborne)

Locations in the Carpathian-Pannonian region: Mecsek (Permian), Staivnica-Kremnica area (Central Slovakian Volcanic complex: e.g., Stara Kremnica, Skalka, Hlinik, Szabó cliff), Mátra (Gyöngyössolymos), Tokaj Mts. (e.g., Pálháza, Cser-hegy, Tállya), Vihorlát (Barabás-Kaszonyi-hill), Calimani (Dragoiasa)

Miocene rhyolitic lava rocks

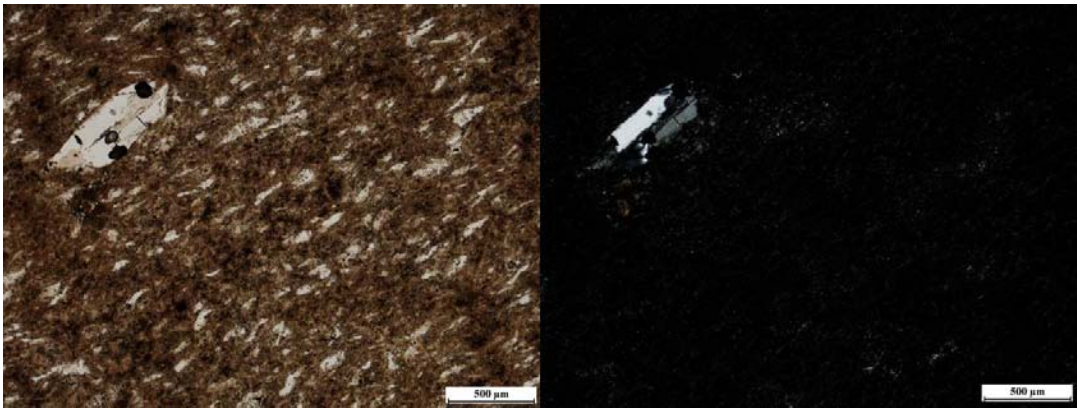


Figure II.257. – Typical microscopic picture of rhyolite from Stara Kremnica. Left with one nicol, right with crossed nicols.

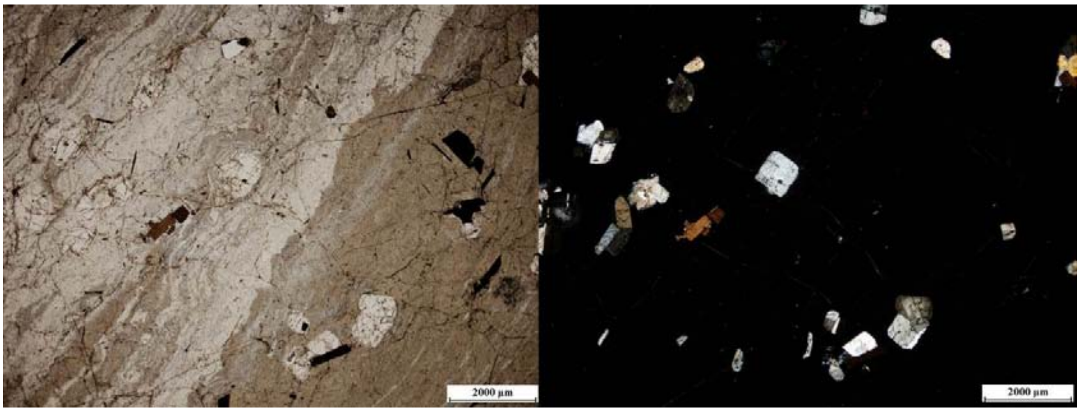


Figure II.258. – Typical microscopic picture of banded rhyolite from Stara Kremnica. Left with one nicol, right with crossed nicols.

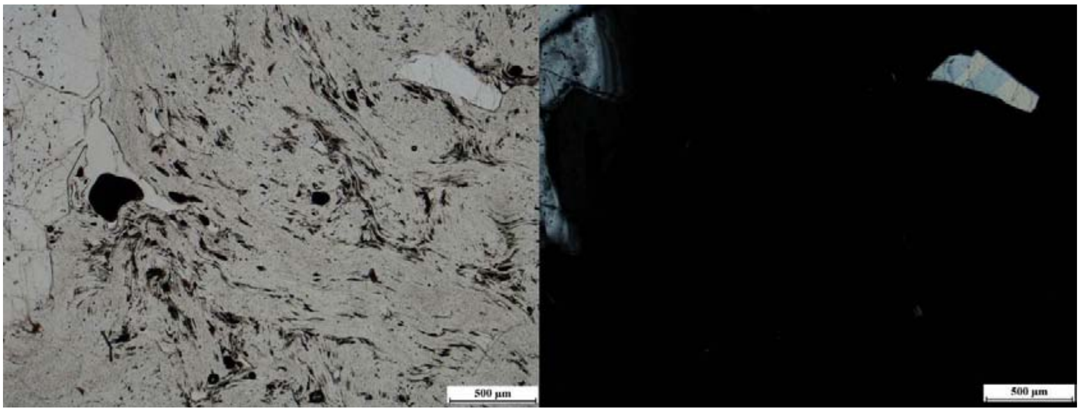


Figure II.259. – Typical microscopic picture of rhyolitic obsidian from Pálháza (Tokaj Mts.). Left with one nicol, right with crossed nicols.

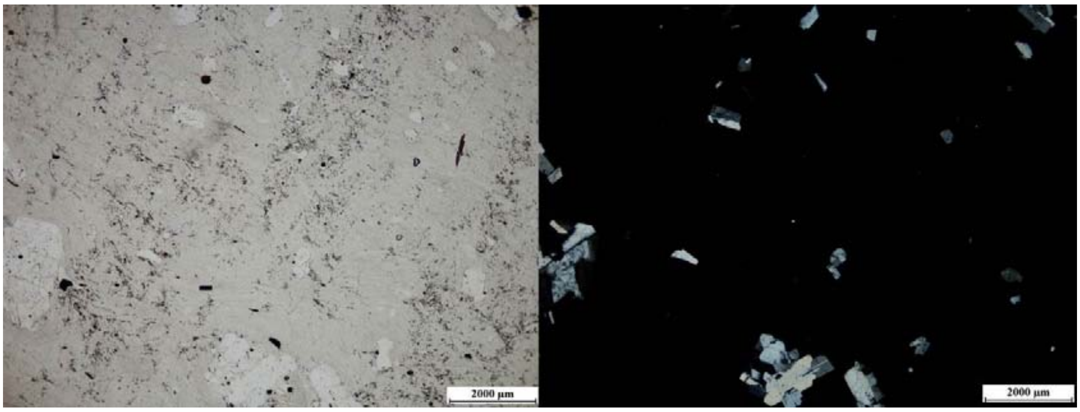


Figure II.260. – Typical microscopic picture of rhyolitic obsidian from Pálháza (Tokaj Mts.). Left with one nicol, right with crossed nicols.

Miocene rhyolitic pyroclastic rocks

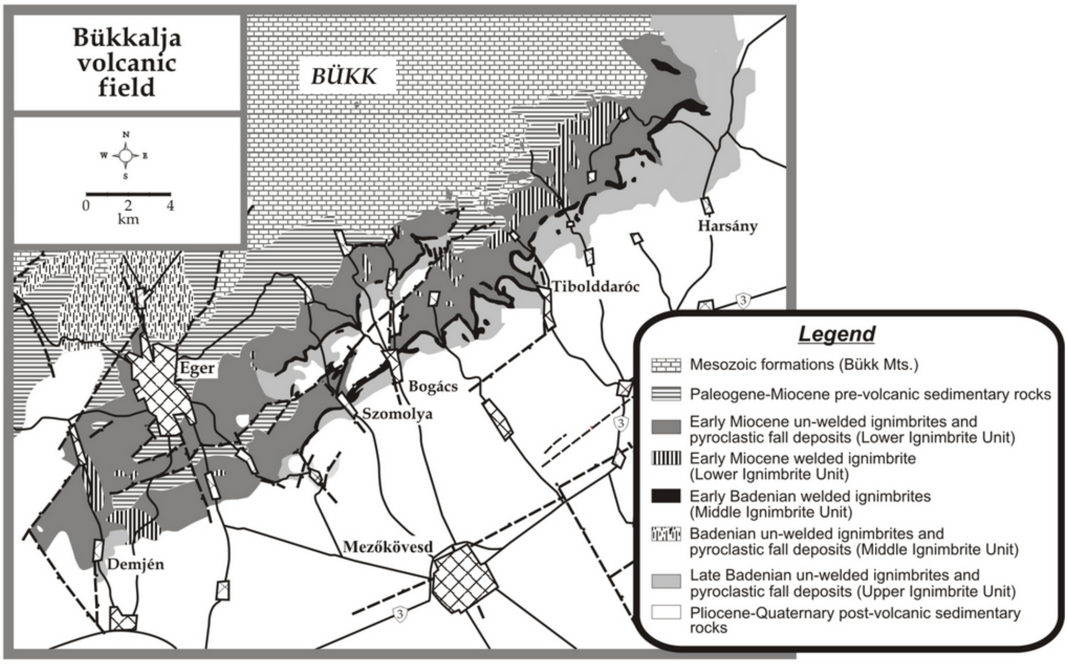


Figure II.261. – The Miocene rhyolitic ignimbrites in the Bükk foreland.

Figure II.262. – Non-welded ignimbrite in the Bükk foreland (Szomolya; photo: Szabolcs Harangi).

Figure II.263. – Welded, fiamme-bearing ignimbrite in the Bükk foreland (Tibolddaróc, Bükkalja; photo: Szabolcs Harangi).

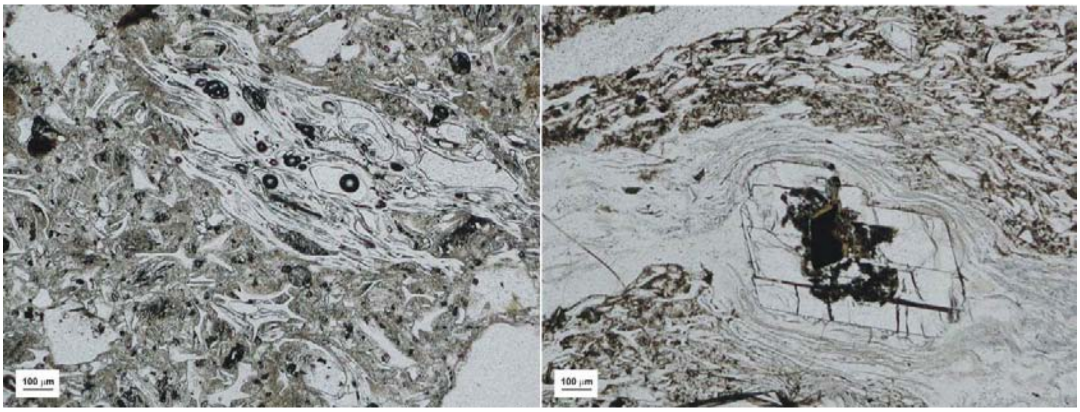


Figure II.264. – Characteristic microscopic picture of non-welded ignimbrite (left; Mocsolyástelep) and welded, fiamme-bearing ignimbrite (Pünkösdhegy, Demjén). Photos with one nicol.

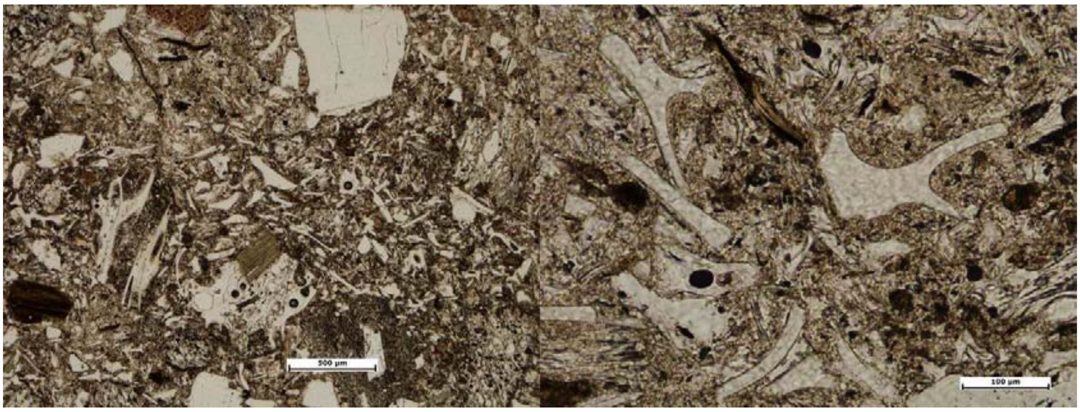


Figure II.265. – Characteristic microscopic picture of non-welded ignimbrite from Tar. Note the cuspate shaped glass shards. Photos with one nicol.

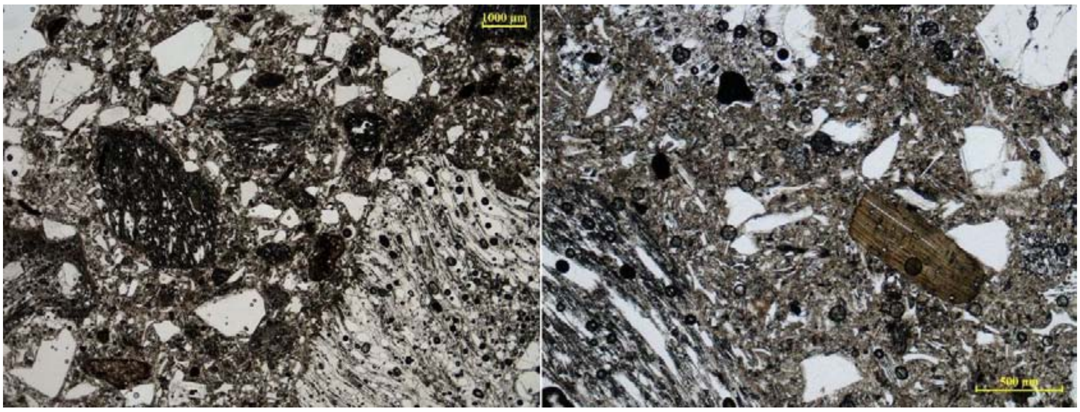


Figure II.265. – Characteristic microscopic picture of non-welded ignimbrite with pumice clasts from the borehole of Nyékládháza-1, depth of 185 m. Photos with one nicol.

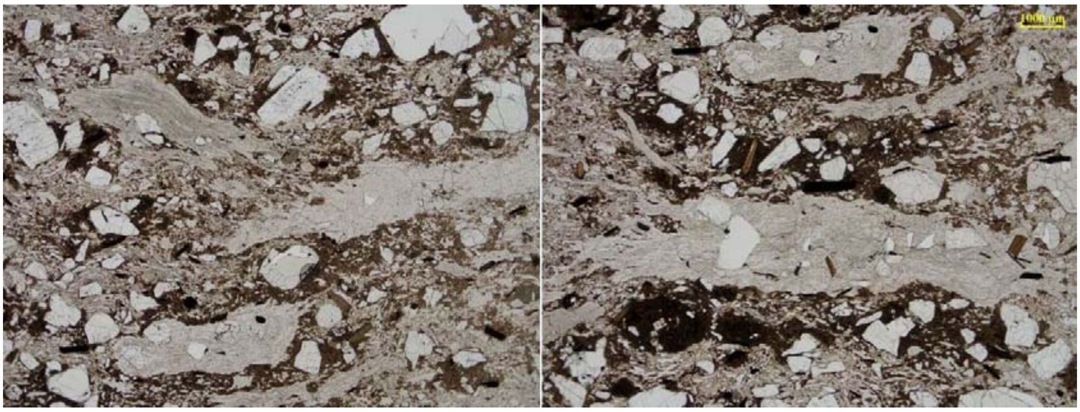


Figure II.266. – Characteristic microscopic picture of welded fiamme-bearing ignimbrite from the borehole of Nyékládháza-1, depth of 223 m. Photos with one nicol.

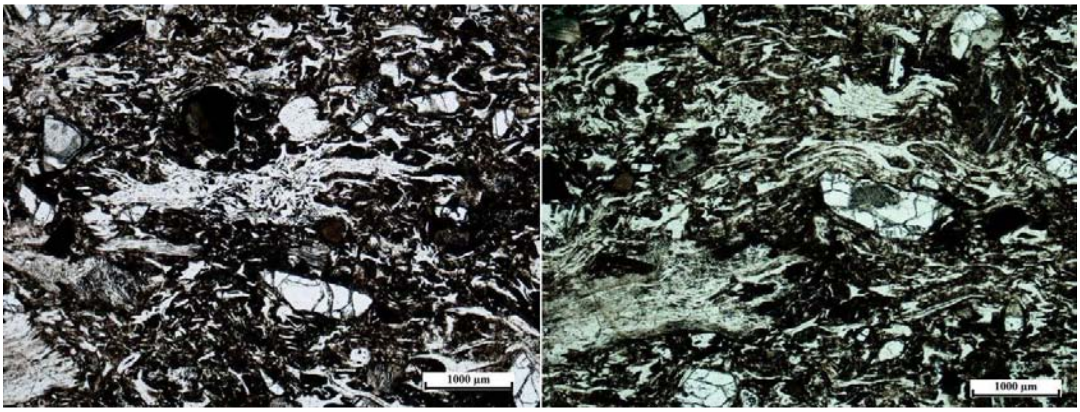


Figure II.267. – Characteristic microscopic picture of welded fiamme-bearing ignimbrite from the Tarizsa valley. Photos with one nicol.

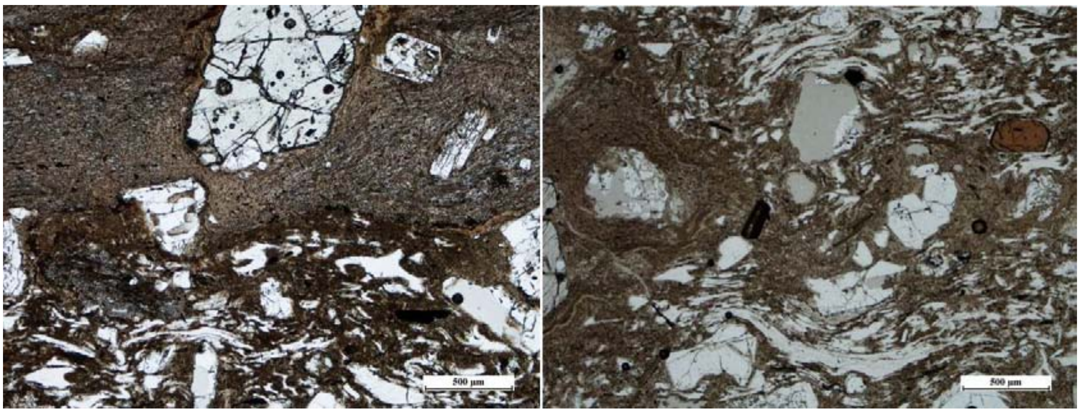
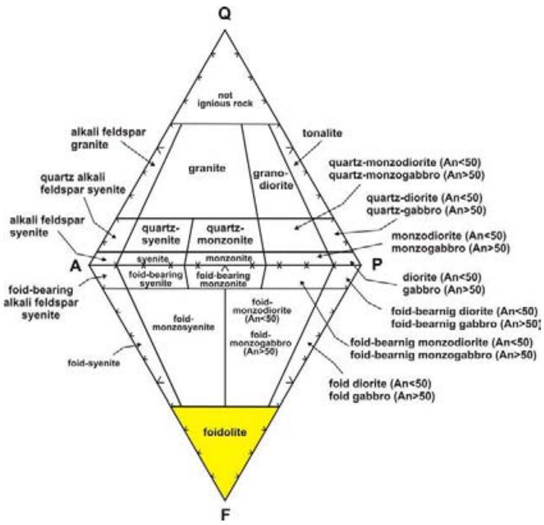


Figure II.268. – Characteristic microscopic picture of welded fiamme-bearing ignimbrite from Bogács. Photos with one nicol.

II.5. Alkali Si-undersaturated igneous rocks (Foidolites)

IJOLITE



Appearance: Dark coloured, fine- or medium-grained alkali, Si-undersaturated intrusive igneous rocks. It contains approximately equal amount of clinopyroxene (Ti-rich agugite, aegirinaugite, aegirine) and nepheline. In addition, olivine, phlogopite and further feldpathoids could also occur. It can be found often accompanying with carbonatites mostly in continental rift zones and ocean islands. It is the intrusive equivalent of nephelinite at least based on chemical composition.

Mineral content:

Essential minerals: clinopyroxene (Ti-augite, aegirinaugite, aegirine), nefeline

Accessory minerals: olivine, flogopite, leucite, zircon, apatite, magnetite and/or ilmenite, carbonate minerals, garnet (melanite)

Secondary minerals: sericite, epidote, chlorite

Rock types:

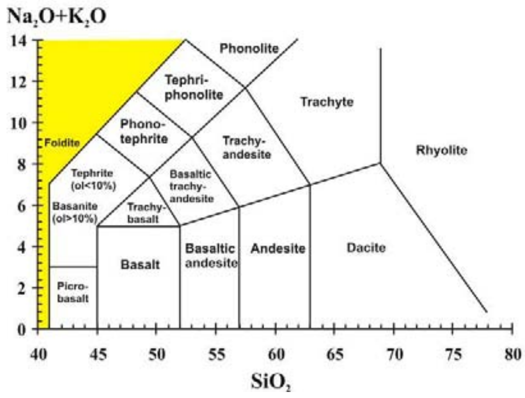
- jacopirangite: pyroxene-rich variety of ijolite

Figure II.269. – Ijolite with carbonatites (Fuerteventura, Canary islands; photo: Szabolcs Harangi).

Figure II.270. – Ijolite with carbonatites (Fuerteventura, Canary islands; photo: Szabolcs Harangi).

Locations in the Carpathian-Pannonian region: not known

NEPHELINITE, LEUCITITE, MELILITITE



Appearance: Dark coloured, usually aphyric volcanic rock. It contains abundant feldspathoids (nephelinie or leucite), in addition to olivine, clinopyroxene and phlogopite phenocrysts. The feldspathoids could occur also as phenocrysts. Feldspars are lacking or are in minor amount. They are typical of continental rift zones and could occur also in oceanic islands.

Mineral content:

Essential minerals: olivine, clinopyroxene, feldpathoids (nepheline, leucite, melilite)

Accessory minerals: zircon, apatite, magnetite and/or ilmenite, analcime, carbonate minerals, perovskite, sodalite

Secondary minerals: analcime, sericite, chlorite

Locations in the Carpathian-Pannonian region: Stradner Kogel (Stájer-medence; nephelinite); Bár (olivine-leucitite)

Figure II.271. – Olivine-leucitite (Bár).

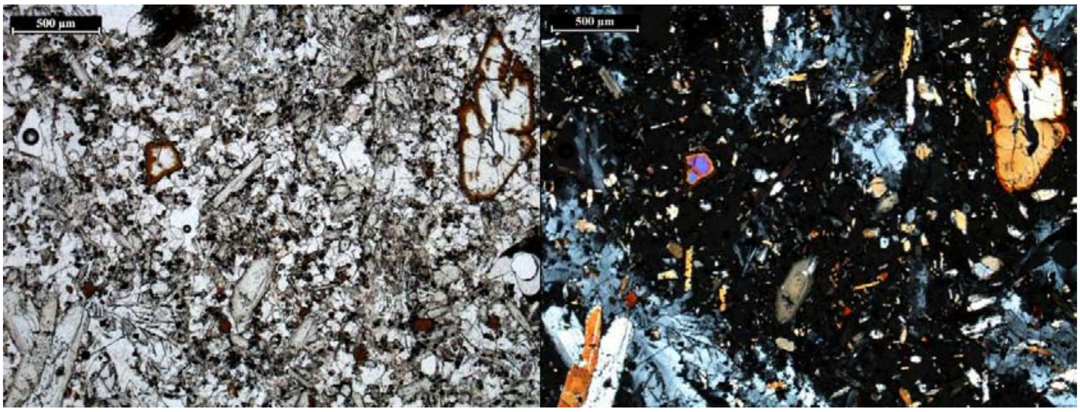


Figure II.272. – Characteristic microscopic picture of olivine-leucitite from Bár. Left with one nicol, right with crossed nicols.

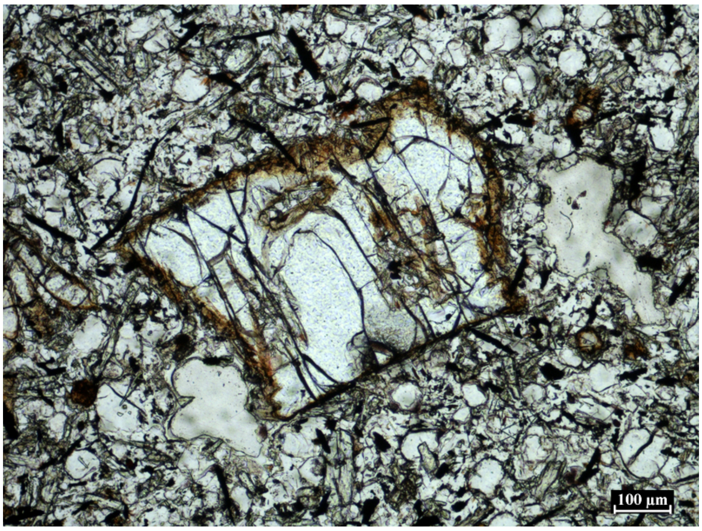


Figure II.273. – Characteristic microscopic picture of olivine-leucitite from Bár. Note the iddingsitized olivine phenocryst and the leucites in the groundmass. Photo with one nicol.

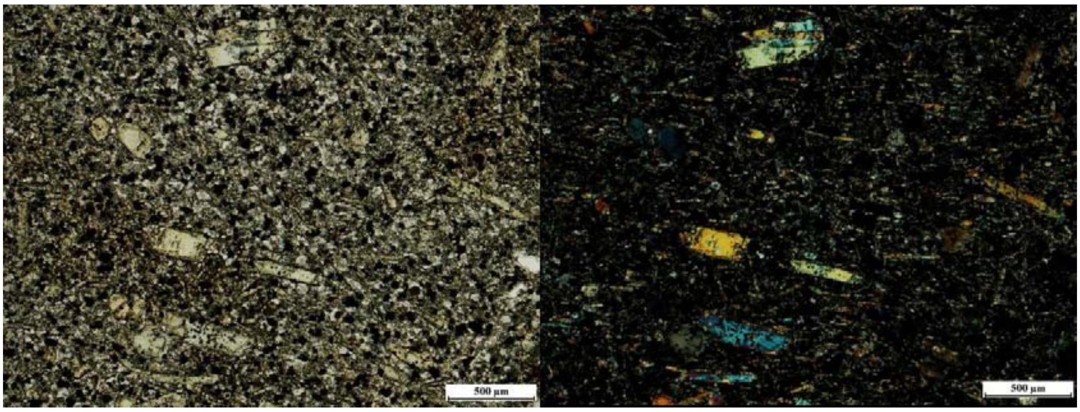


Figure II.274. – Characteristic microscopic picture of nephelinite from Stradner Kogel (Styrian basin). Left with one nicol, right with crossed nicols.

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