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ROLE OF METASOMATISM IN THE LODE'S ENVIRONS OF GYÖNGYÖSOROSZI (MÁTRA MOUNTAINS)

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SUMMARY

The mineralogical-petrological investigation of the associated rocks of dead galleries connecting the veins was performed; the lodes lie in the mine of Gyöngyösoroszi in four levels (i. e. in heights of +250, +300, +350 and +400 metres above sea level). In the mine's gangways Lower Tortonian andesite and andesite tuff can be found. The andesite consists partly of orthoandesite (in the level +400 metres) and partly of hypomagmatic products of different texture with slight pyritization. Silicification, as well as clay mineralization in the faulted zones are common phenomena.

On the basis of derivatographic investigations in the clay-mineralized associated rock the following clay minerals, resp. their assemblage could be determined among the secondarily formed minerals of the four levels: illite-type, montmorillonite-illite, montmorillonite-kaolinite, montmorillonite-jarosite, kaolinite with calcite, kaolinite with jarosite and calcite. In addition to the clay minerals in most of the cases gypsum occurred in considerable quantity.

On the basis of the X-ray diffractometric investigations the following can be stated. Independently of the K_2O-content of the sample formation of sanidine and adularia, i. e. the replacement of plagioclases by potassium feldspars did not followed, the higher potassium content is connected to sericite-illite and not to the potash-feldspars. As a result of silicification quartz occurs in considerable quantity in the fresh rock, too. Out of the clay minerals illite-sericite, montmorillonite and kaolinite could be demonstrated, the definite zonal arrangement could not be observed. The description of jarosite from this mine has not been referred yet.

As a result of the investigation of the alkali content of different levels it is obvious that where the rock is fresh and no fault zone exists, in the neighbourhood of the lodes the high values concerning the K_2O were found between 10 and 25 metres. In the sites, however, where fault zone can be found the rock type is changing, the decomposition and clay mineralization are characteristic, the indication character of K_2O is lost. According to the investigations performed up to now there is a relation between the K_2O and sulphide-S and the optimal value of it may be given between the weight per cent of 2.5 and 4.5 of K_2O and this may indicate the exploitable ores.

INTRODUCTION

The geological structure and map of the mine and environs of Gyöngyösoroszi were demonstrated by NOSZKY sen. [1927] and later by G. PANTÓ [1950] concerning the closer area. According to his opinion in the environs of the outcrops there are mainly andesites, and three types of them can be distinguished: andesite with inclusions, older decomposed andesite agglomerate with interbedded lava bodies, and younger andesite agglomerate. He observed the different rock alterations only in the proximity of the mine and connected them to the ore formation. These alterations may be greenstone formation, blistered transformation, silicification and "kaolinitization".

The Miocene volcanic formations were divided into lower, middle and upper series by SZÁDECZKY-KARDOSS, E. *et al.* [1958]. The ore-bearing veins belong to the Lower Tortonian series and in their surroundings strong chloritic, silicic and clay mineral alterations can be observed.

VIDACS, A. [1961] distinguished two great volcanic phases. The first phase is that mentioned also by PANTÓ and which is the andesite series of inclusion. The presence of this sequence was proved by the bores of Gyöngyösoroszi No. 2. [1964] and of Mátraszentimre No. 2. [1966]. The product of the other phase is a relati vely fresh dark-grey pyroxene-andesite (cover-andesite).

The ore-bearing lodes lie in the Lower Tortonian series. The associated rocks became in several places clay mineralized, silicified and chloritized, the regular propilite, however, has not developed in the levels discovered up to now.

Regarding the lodes numerous data were published by NOSZKY sen. [1927] and ROZLOZSNIK, P. [1942], the introduction of the vein system known at that time was performed by VIDACS [1957, 1961, 1966]. Concerning the paragenesis further data were published by PAPP, F. [1933], SZTRÓKAY, K. [1938, 1939, 1952, 1962], KOCH, S. [1953, 1958, 1970], NEMECZ, E. [1953], KASZANIIZKY, F. [1958, 1961] and RÓZSA, É. [1961].

The movements generating the lodes took place in different times. At the formation of the oldest fault system veins of breccia-character had developed which were penetrated several times by productive lodes. The second tectonic phase produced the ore-bearing lodes being of NNW-SSE, resp. NNE-SSW and WNW-ESE strike direction. Among these lodes considerable difference of age cannot be determined. The third and fourth tectonic phase did not generate exploitable lodes, the last phase is characterized by amethyst.

Recently two groups of lodes are under mining in different levels and the investigations relate to their environs. The first is the Károly-lode, the second one the Aranybányaérc.

ASSOCIATED ROCKS OF THE ORE-BEARING LODES

In the area of the mine the investigations performed up to now concerned only the substance, structure and paragenesis of the lodes disregarding the associated rocks, their alterations and secondarily minerals. SZÁDECZKY-KARDOSS, E. *et al.* [1958] stated only the fact that the lodes lie in the middle andesite sequence and in this variegated rock series several types can be distinguished: chloro-andesite, propilite, hydroandesite, silicoandesite, carboandesite, blistered andesite, andesite with pseudoagglomerate. These varieties could originate hypomagmatically, by metamagmatic transformation or by a later endo- and exometamagmatic transformation of low temperature.

Since 1970 a series of investigations have started aiming the determination of the role of associated rocks. Such dead galleries were chosen which are connected to each other by two lodes and the distance between them is great enough for observing the alterations of the associated rocks. For this purpose the *Károly, Aranybányabérc* and *Péter-Pál* lodes were chosen. These are nearly parallel and of similar strike and are exposed on several levels. The position of the dead galleries as compared to the lodes mentioned above, the places of sampling as well as the number of the samples are shown in *Fig. 1.* The sketch exactly demonstrates that the Károly lode is nearly of vertical position while the Aranybányabérc lode together with the Péter-Pál lode is of eastern dip. In the +400 m (lower) and +300 m levels sampling was performed by every ten metres while in the levels of +250 and +350 metres it was done by every ten metres near the lodes and every 20 metres farther from them. Consequently, about 170 samples were collected and the petrological, mineralogical investigation and alkali-content determination of them were performed.

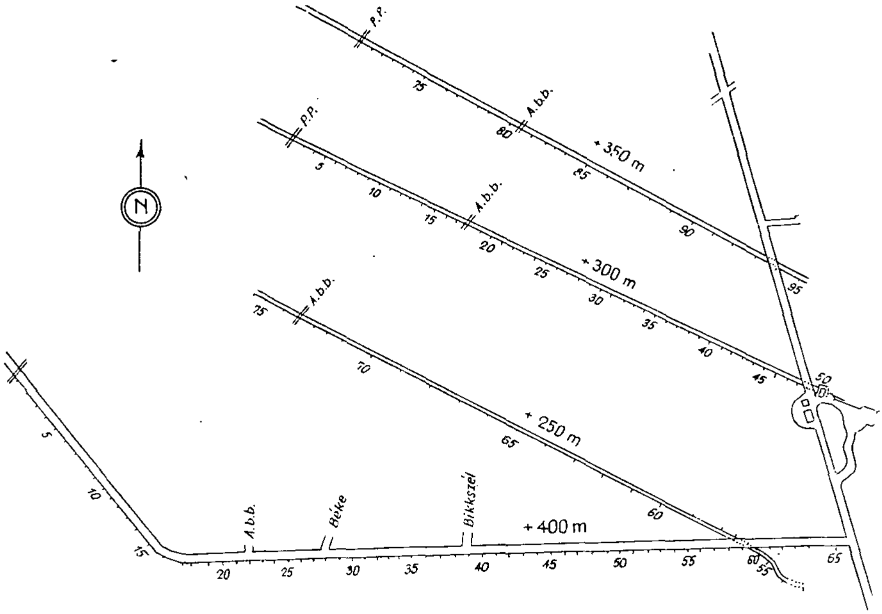


Fig. 1. Places of sampling in the dead galleries

The level of +250 metres

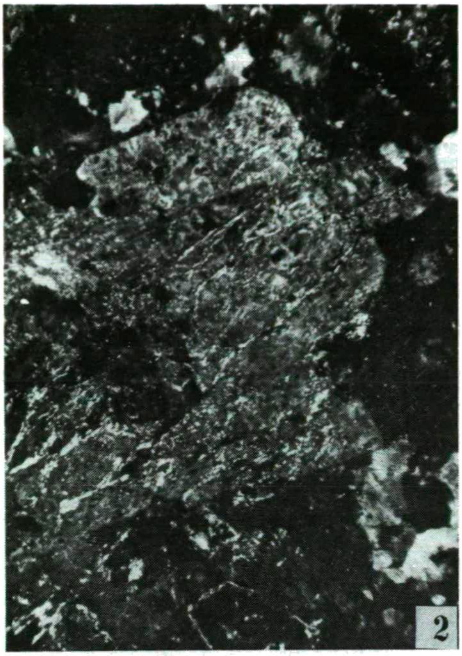
In the gallery of about 420 metres length the petrological formation of the rocks seems to be uniform. The compact rock of lighter-darker grey colour is mostly silicified, feldspar and chloritized pyroxene are characteristic. The slight pyrite impregnation seems to be common. More intensive clay mineralization occurs about 70 metres west of the Károly lode and in both sides of the Aranybányabérc lode.

On the basis of microscopic investigation only clay mineralization and silicic replacement indicates some variousness in the basic rocks. The original microlites can be rarely recognized, they are usually replaced by sericite and quartz of 0.01 to 0.02 mm measure, consequently only conclusions may be drawn to the original texture. Microscopic quartz veins frequently traverse the rock and the replacement of the basic substance is frequently observable.

The feldspar phenocrysts are well separated from the basic substance, their size may reach 2 millimetres and they are for the most part of columnar habit. Zonality cannot be observed, twin-formation is indistinct due to the chloritic and sericitic replacement. They are frequently dissected net-like by sericite *(Fig. 2)*. When in the rock's cave there are calcite crystals, the phenocrysts are also calcitized. The pyroxenes reaching 2 mm size are totally chloritized and always contain pyrite *(Fig. 3)*, their calcitization is less frequent.

Level of +300 metres

At the end of the gallery of Károly lode, i.e. in NW direction as well as in its environs the rock is compact, very hard and is of greenish-grey colour and of porphyric texture. The feldspars reaching the size of 3 millimetres are of whity-grey fatty colour, and often show idiomorphous cross section. Femic minerals cannot



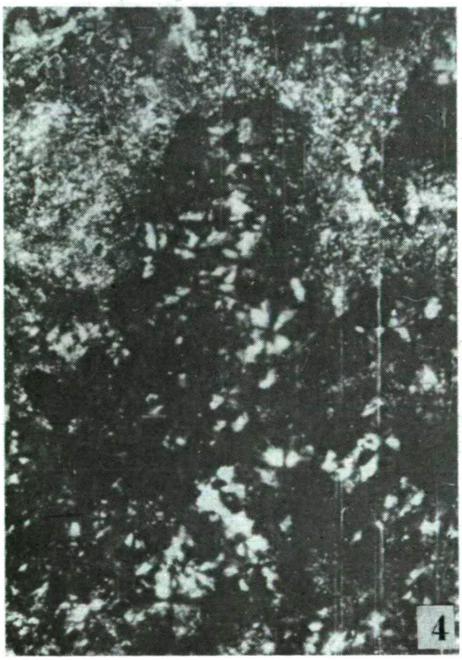


Fig. 2. Sericitized feldspar. +N X 80.
Fig. 3. Idiomorphic chloritized pyroxene cross section with pyrite. +N X 80.
Fig. 4. Chalcedonic replacement in the basic substance. +N X 80.
Fig. 5. Silicic, sericitic basic substance. +N X 80.

be observed microscopically. The rock is uniformly impregnated by pyrite, along the rips sometimes chloritic discoloration can be seen.

This type might be originally of pilotaxitic structure. The quantity of basic substance changes between 55 and 70 per cent, the phenocrysts are generally well separated. When no strong clay mineralization took place the thin pyrite veins can also be observed. Clay mineralization and silification may be of different degree, consequently the texture shows variegated picture. Silification is locally indicated by chalcedonous parts *(Fig. 4)* or by quartz-spots with sericitic parts *(Fig. 5)*.

Amongst the phenocrysts the feldspars prevail their quantity fluctuates between 20 and 25 per cent, except the fine-grained rocks (west of the Károly lode by 200 to 220 metres) where their quantity falls below 10 per cent. When the rock is of darker grey colour the feldspars are usually of zonal structure and the twin-formation is characteristic, these feldspars belong to the labradorite series *(Fig. 6)*. In these case only slight sericitization can be observed, sometimes calcitization occurs along the cleavage lines. The decomposed structure is more frequent and the sericitic pseudomorphism after the feldspars is also common due to the clay mineralization *(Fig. 7)*.

The femic minerals are represented by the rhombohedral and monoclinic pyroxenes. Be the feldspar any kind of form chlorite replaces the rhombohedral pyroxenes in every cases *(Fig. 8)* and the monoclinic ones are replaced by chlorite or calcite *(Fig. 9)*. It is frequent that in the chloritized pyroxene the quantity of pyrite is higher and its grain size if greater than in the rock itself, moreover, sometimes the substance of the rock does not contain pyrite and at the same time it is significant in pseudomorphs after pyroxenes. This pyrite is therefore of hypovolcanic character, it is simultaneous with chloritization and is older than that impregnating the rock.

In the dead gallery this rock type occurs within a distance of about 370 metres. Significant difference is shown only in the measure of decomposition and clay mineralization developed along the lithoclases. In this case the descendent solutions should also taken into consideration regarding the clay mineralization. The internal part of the single blocks are fresh and this is surrounded by a clay mineralized zone, and these often form pseudoagglomerate. The decomposing effect of the descendent solutions and the crumbling of pyrite are proved by the gypsum needles and crystal groups occurring in the yellowish-grey, yellowish-white clayey detritus.

In the fresh parts the pyrite veins are usually absent, they replaced by calcite veins of several centimetres size. Silification, sericitization and clay mineralization occur usually together which can be explained partly by the release of silicic acid in case of clay mineralization, partly the silicic acid content of the postmagmatic solutions resulting in the pyritization.

West of the Károly lode by about 50 metres there is a tuf intercalation which is locally of lapilli formation. In its western part grey-coloured breccia-like rock occurs in which angular white and grey nearly homogeneous detritus of about centimetre size was cemented. The white part are clay mineralized fragments, in general. The slight ore migration occurs rather in the cementing material. This breccia-like part indicates a fault line but its direction is indistinct due to the considerable clay mineralization. From the breccia-like part the rock is absolutely fades, it is a tuff powder with a few lapilli. In the smaller cavities of the rock sometimes idiomorphicu quartz of 2 to 3 mm occurs. The grain size of the tufaceous rock consisting mainly of quartz is about 0.05 mm. The cementing material is strongly sericitized. Its general textural sketch is shown in *Fig. 10*.



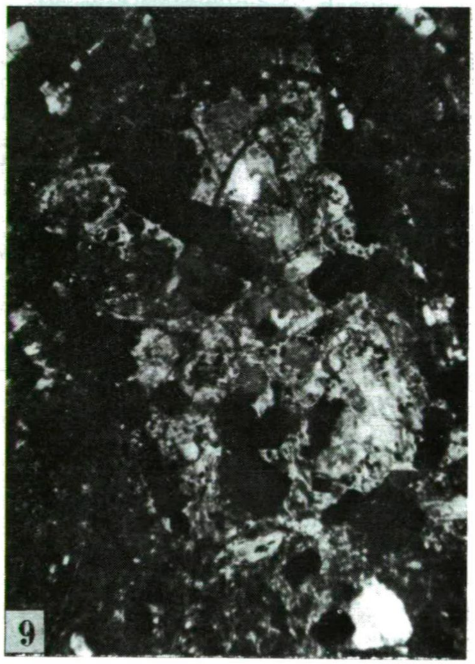



Fig. 6. Zonal feldspar. +N X 80.
Fig. 7. Sericite pseudomorph after feldspar. +N X 80.
Fig. 8. Chloritized pyroxene. // N. X 80.
Fig. 9. Calcitized augite with pyrite. +N X 80.

East of the andesite tuff greenish, compact andesite occurs up to the Károly lode. Feldspars of 2 to 3 mm and chloritic pyroxene of similar size represent the phenocrysts. The rock is impregnated by pyritic veins of a size less than one millimetre. In the cleavage faces the clay mineralization is of more significant role, beside the Károly lode the rock is faded.

Under microscope the original structure of the basic substance is unrecognizable due to partly the silification, partly the more considerable clay mineralization. The feldspars are usually replaced by secondarily formed sericite. Out of the femic constituents the rhombohedral pyroxenes were only chloritized and contain for the most part pyrite, the penetration twins are frequent. In case of monoclinic pyroxenes in addition to chloritization the calcitization can also be observed.

Level of +350 metres

It exposes the associated rock in a length of 415 metres northwest of the Károly lode. Southeast of the Péter-Pál lode light grey, locally whity grey rock strongly dissected by lithoclases can be found in a distance of about 50 metres. Along the cleavage faces the precipitation of pyrite is more intensive. In several places calcite veins of 1 to 3 cm size occur accompanied by pyrite bands. The decomposition, i.e. clay mineralization is more intensive along the lithoclases, locally yellowish-white, greyish-white pseudotuff developed. In the relatively fresh rock only the presence of feldspar phenocrysts may be supposed.

Southeastwards greenish-grey compact andesite occurs with calcite and chalcedony veins reaching 5 cm thickness. Out of the phenocrysts the fresh feldspars of 3 to 4 mm and chloritic pyroxene of 2 to 3 mm size are recognizable. The rock is impregnated by small quantity of pyrite. In smaller caves quartz crystals of centimetre size occur.

Southeast of the Péter-Pál lode between 100 and 160 metres the rock becomes pale but remains compact, the feldspar crystals are replaced by white clay mineralized spots, the basic substance is strongly silicified. The calcite veins are white-coloured and of coarse crystals. More intensive clay mineralization can be observed only besides the Aranybányabérc lode. This is superseded by greenish-grey compact andesite in which fresh tabular feldspars of 2 to 4 mm, and less chloritized columnar pyroxene of 2 to 3 mm occur. Along the fissures of the rock a more intensive clay mineralization took place followed first of all by the descendent solutions. Near the Károly lode there is a fine-grained, strongly silicified andesite, in this rock the clay mineralization is of less importance. In this type calcitic, pyritic and chalcedonic bands also occur.

The picture under the microscope exactly characterizes the transformation and alteration of the rocks which is represented by the varied appearance of the basic substance and by the state of the phenocrysts. The originally pilotaxitic texture remained only in the dark-coloured andesite, in case of more considerable silicification *(Fig. 11)* and sericitization *(Fig. 12)* the traces of the original texture appeared, as well. The local precipitation of calcite is limited more or less to the zones of calcite veins (associated rocks of the Péter-Pál and Aranybányabérc lodes). The large-scale replacement may generate pseudotuffic rocks.

Out of the phenocrysts the feldspars are always in greater quantity being of 1 mm size in the fine-grained rock and of 3 to 4 mm in general. When the measure of alteration is smaller, the zonal structure and twinning is fairly recognizable, in case of more intensive sericitization the crystal is reticulately dissected *(Fig. 13)* and when silification is of considerable size only the contours of the feldspars remain,

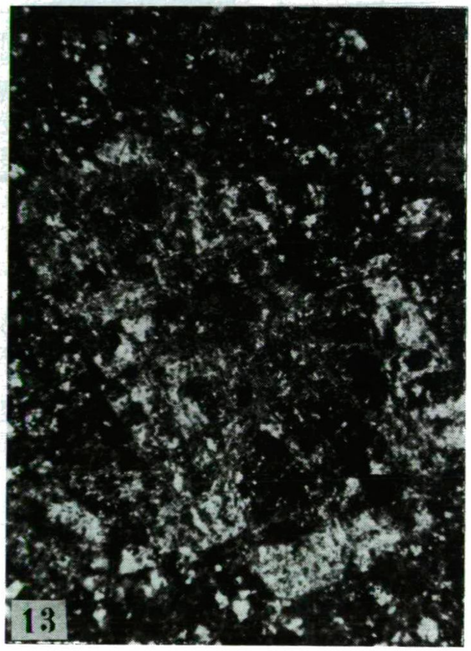


Fig. 10. Texture of andesite tuff. +N X 80.
Fig. 11. Silicified basic substance. +N X 80.
Fig. 12. Sericitic, silicic basic substance. +N X 80.
Fig. 13. Sericitized feldspar. +N X 80.

in general. The calcitic replacement of the feldspars is characteristic only in the carbonaceous zone.

Both the rhombohedral and the monoclinic pyroxenes can be traced, they may be max. 3 mm in size, their quantity falls behind 10 per cent. The rhombohedral pyroxenes are always pseudomorphs consisting of chlorite and usually are of reticulated dissection *(Fig. 14)*, in the netting the secondarily developed chlorite occurs. In addition to the chloritization the monoclinic pyroxenes often show calcitic replacement *(Fig. 15)*, in these cases the feldspars also endure smaller calcitic alterations.

In the neighbourhood of the Károly lode the biotite occurred only in one sample *(Fig. 16)* showing intense pleochroism and which is possibly the subsurface continuation of the superficial lava stream observed by PANTÓ, G. [1950].

Level of +400 metres (adit)

West of the adit between 550 and 670 metres there is a compact rock of darker greenish colour dissected by lithoclases. It contains phenocrysts of 1 to 3 mm size and is slightly pyritized. In several cases the relatively fresh parts are mottled by detritus of clay fraction and of limonitic colour, this part being of several centimetres.

Under microscope only the less silicified rocks show the originally pilotaxitic substance. The rock is sometimes traversed by quartz veins and in these cases the idiomorphic quartz is frequent *(Fig. 17)*. In the caves carbonates are of less importance. Out of the phenocrysts the feldspars belonging to the labradorite group may be of 2 to 2.5 mm in size, they are tabular, the smaller crystals are columnar habit. Zonality and the polysynthetic twinning are recognizable. Slight sericitization occurs rather along the cleavage lines. The pyroxene is always transformed. In these cases chloritization is negligible, serpentinization plays the predominant role (bastite; *Fig. 18*). In the relatively fresh rock only the hypersthene was transformed, the augite is nearly fresh and does not show alterations.

Eastwards this rock type is replaced by compact fine-grained rock of dirty-grey colour and along the fissures a thin decompositeod layer developed. On this detritus thin needles of gypsum and gypsum groups occur. Phenocrysts are unrecognizable still in the fresh parts of the rock. Under microscope it shows features according to which the rock might be a part of a thin lava stream which solidified originally also as a fine-grained rock. The major part of the basic substance is replaced by silica and sericite and in this substance the contours of sometimes idiomorphicu feldspars of just o.2 mm size can be observed. The femic constituents are represented by pyroxenes transformed intoc hlorite of 0.1 mm size.

In the gallery in a distance of about 110 metres eastwards dark-grey colored, locally greenish shaded compact rock occurs. It is abundant in phenocrysts. At the Aranybányabérc lode the rock is fresh and shows no alterations, the pyrite occurs sometimes in nodes.

Under microscope the prevailing basic substance (54.3 per cent) is of pilotaxitic texture and slightly impregnated by pyrite. The plagioclases belonging to the labradorite series (32 per cent) may be of 2.5 mm size. The greater ones are usually tabular, the smaller ones are of columnar habit. The zonality and twinning are frequent in both cases. All the transitions from the microlite to the phenocrysts can be observed. Out of the pyroxenes the augite is frequent (10.1 per cent). It is usually fresh, sometimes twinning is recognizable. The columnar crystals of hyper-

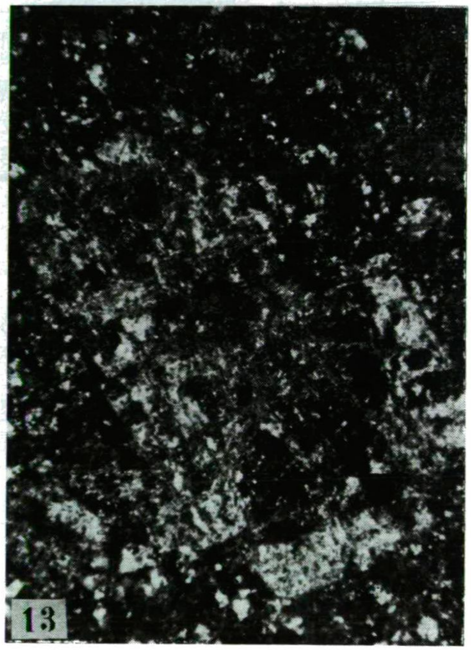


Fig. 10. Texture of andesite tuff. +N X 80.
Fig. 11. Silicified basic substance. +N X 80.
Fig. 12. Sericitic, silicic basic substance. +N X 80.
Fig. 13. Sericitized feldspar. +N X 80.

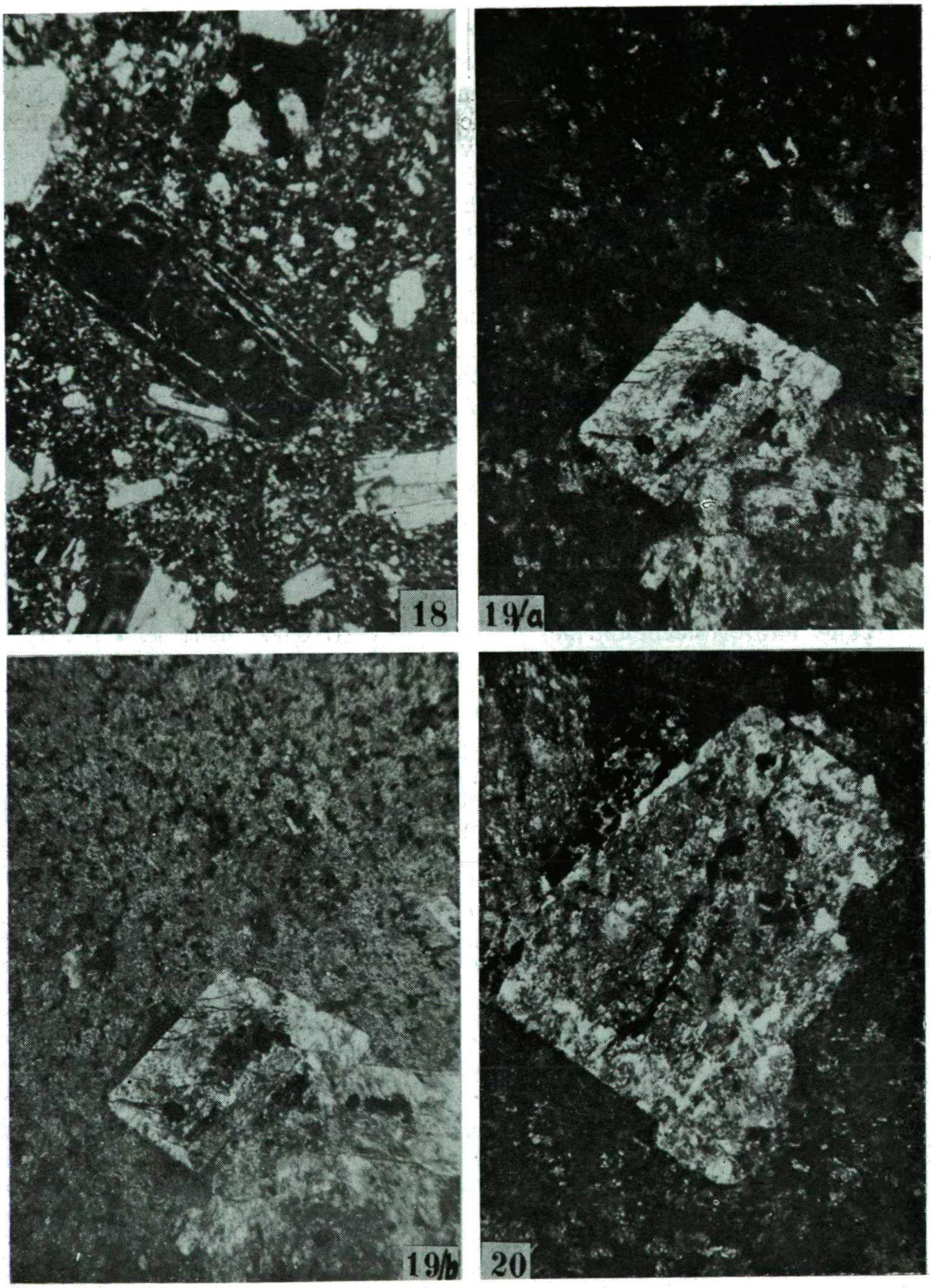


Fig. 18. Zonal feldspar and serpentinized hypersthene. +N X 80.
Fig. 19. Sericitized feldspar in silicic-sericitic basic substance. *a)* +N X 80. *b)* //N X80 .
Fig. 20. Sericitic "zonal" feldspar. +N X 80.

sthene (3.6 per cent) transformed totally into seladonite. In certain samples the quantity of the phenocrysts may increase and sometimes chloritic parts occur.

West of the Károly lode within a distance of about 400 metres uniform greenish-grey coloured, compact rock occurs. The variety is given only by the fact that decomposition along the lithoclases, thin veins and fissures is in a more progressed state. In these cases the rock is traversed by yellowish-grey veins the material of which is clay mineralized detritus coloured by limonite containing often gypsum, moreover locally gypsous clay occurs. The fresh part of the rock is of splintery fraction and it is locally silicified. In the western side of the Károly lode where a smaller fault zone developed the clay mineralization is characteristic. In the relatively fresh rock only the feldspar phenocrysts may be supposed.

Under microscope the substance is sericitic, and silicic but often mottled. This derives from the fact that the orientation of the microlithes and silicic parts is nearly the same, further the pyrite grains, resp. the secondary minerals developed from them are of reticular occurrence which can be excellently seen under parallelled nicols *(Figs. 19a* and *19b)*. The sericitization of feldspars is common, the greater tabular crystals may be of 2.5 mm size, frequently only a smaller part of them remain intact but the zonal structure can be traced in these cases as well *(Fig. 20)*. The calcitic replacement is negligible. The pyroxenes grown up to 1 millimetres were fully serpentinized but are of less importance. They frequently contain pyrite inclusions. Chloritization is subordinate.

Taking into consideration the results of the petrological investigations it can be stated that several lava streams should be taken into account in this mine, moreover tuff intercalation also occurs. The position of the single rock types are demonstrated in a profile of N—S direction *(Fig. 21)*. In the level of +250 metres the solidified rock of a relatively uniform lava stream is of hypomagmatic character, the variousness is indicated only by the measure of alteration. Above this level (+300 metres) the andesite tuff may be a thinner intercalation, it rapidly wedges and it is absent in the over- resp. underlying strata. Above this layer a relatively thicker hypomagmatic mass occurs with varied clay mineralization and this shows transition towards the higher levels in a thin zone into microandesite with minimal phenocrysts. The overlying andesite is of ortho-character with fresh zonal feldspars and augites, the sericitization is subordinate. As contrasted to the chloritic character of the lower levels this feature is absent or subordinate.

DERIVATOGRAPHIC AND *X*-RAY DIFFRACTOMETRIC INVESTIGATION OF THE CLAY MINERALIZED ROCKS

The clay mineralization of the associated rocks is a common phenomenon due to the metasomatic effect of the hydrothermal solutions. NEMECZ, E. [1967] mentioned numerous factors in case of formation of the clay minerals which have different role in clay mineralization. Since in the investigated area the temperature and pressure seem to be equalized, as well as the alteration observed in the associated rocks relates to the relative standard value of the pH, the most important factors of clay mineralization the mineralogical composition and texture of the associated rocks as well as the concentration of the hydrothermal solutions may be regarded. It has also to be taken into consideration that in these depths the vadose descendent solutions play also an important role and in this case certain salt concentration should also taken into account since the mining of Gyöngyös-

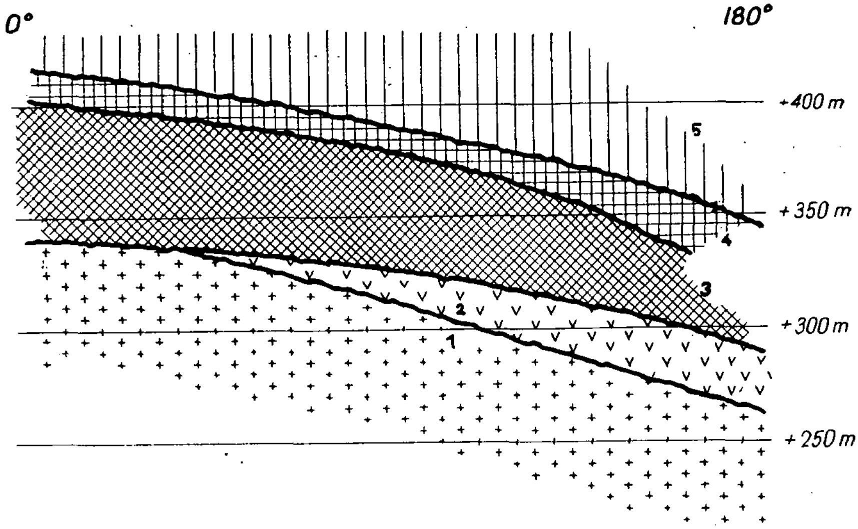


Fig. 21. Position of the lava streams in the galleries of the mine.

oroszi still belongs to the zone of active water exchange determined by CHOUKHROW [1965].

Taking into account these facts numerous derivatograms were performed from the clay mineralized rocks of the four levels. Definite types can only be separated only in a few cases. In most cases certain clay mineral occurs in addition to the prevailing clay mineral. Gypsum occurred nearly in every cases. This fact relates

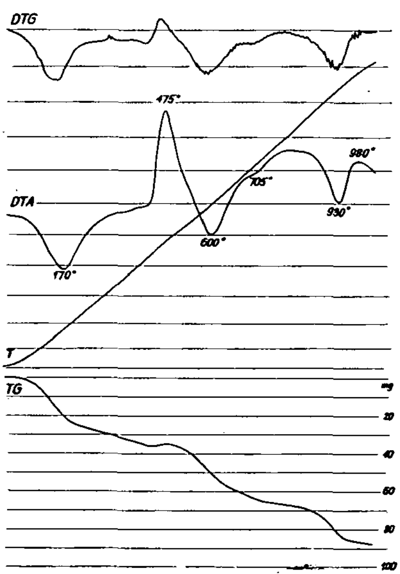


Fig. 22. Derivatogram of the clay mineralized illite-type rock.

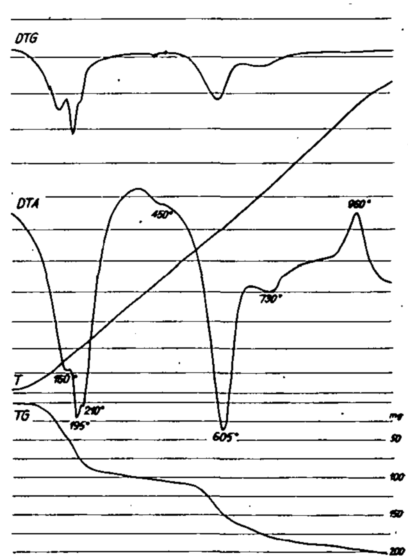


Fig. 23. Derivatogram of the clay mineralized montmorillonite-illite type rock.

to the phenomenon that clay mineralization is the result of not a single genetic process but in the course of formation the effects of both the ascendent and the descendent solutions played an important role.

On the basis of the derivatograms the following types were distinguished: illite-type *(Fig. 22)*, montmorillonite-illite-type *(Fig. 23)*, kaolinite-montmorillonite-type *(Fig. 24)*, kaolinitic type with calcite *(Fig. 25)*, kaolinitic type with jarosite and calcite *(Fig. 26)* and montmorillonitic type with jarosite *(Fig. 27)*.

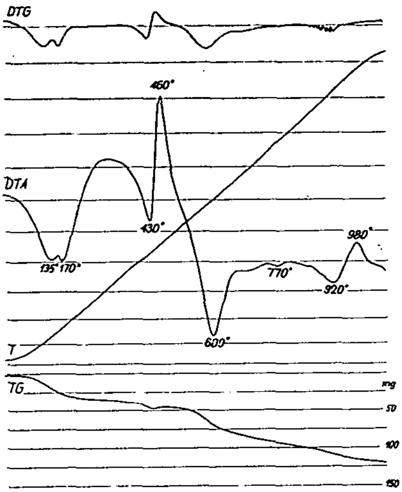


Fig. 24. Derivatogram of the clay mineralized kaolinite-montmorillonite type rock

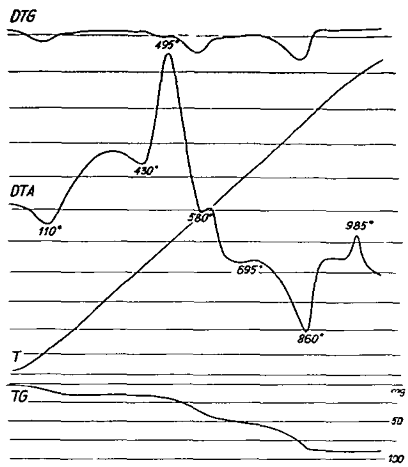


Fig. 25. Derivatogram of the clay mineralized kaolinite type rock with calcite.

The identification of *jarosite* is a new result since it has been unknown in the area of mining till now. According to KULP and ADLER [1950] in case of the members of the alunite-jarosite series there are two significant endothermal peaks. At the first one all the structural waters are released connected to the decomposition of the lattice, in the second endothermal reaction the SO_4 radicle connected to the aluminium or ferric-iron is released. Since the connection to the ferric-iron is weaker than to the aluminium, thus the temperature of the endothermal reactions will be lower than in case of alunite. In our case the endothermal reaction occurring at 440 °C is considerable and the connected loss of weight is 2.5 per cent measured in the TG curve, while at 790 °C the loss of weight is 3.6 per cent. Taking into consideration the values of the chemical analysis this corresponds to about 20 to 25 per cent jarosite.

Out of the decomposed and clay mineralized rocks of the different levels 40 samples were investigated by diffractograms. In general, the following can be stated.

Independently of the K_2O content of the sample no sanidine and adularia formation, i.e. the replacement of plagioclases by potash feldspars could be determined, this, however, has been expected on the basis of the microscopic investigations. The higher K_2O content is therefore connected not to the potash feldspars but to the clay minerals or to jarosite. Either the fresh or the decomposed rocks were investigated quartz occurred with highest intensity. This shows the considerable silification of the rocks and the more important role of silicic acid of secondary appearance in case of claymineralization of the rocks. Nearly all the surfaces being decomposed or clay mineralized the gypsum interwoven with the detritus has appeared. The clear crystals of frequently 2 to 3 mm size as well as the crystal groups formed on the effect of the descendent solutions in the oxidation zone; these are youngest and are forming recently, too.

The most frequent mineral of the clay minerals is the illite (sericite). In this case first of all the $d\sim 10.0$ value could be taken into account, since the other lines of high intensity coincide or nearly coincide with the lines of other minerals. The case of montmorillonite was similar to this. In this case only the $d\sim 14{,}0$ values could taken into account where the values $d\sim 7.0$ were absent together with the $d\sim 3.54$ values, so the chlorite could be excluded. The montmorillonite frequently occurred together with jarosite which indicates the same formation conditions. In addition to illite the kaolinite plays less important role. Only in the neighbourhood of the Aranybányabérc lode occurred usually post-originated clay mineral or it appeared accompanying other secondary minerals. Here the fire-clay type (kaolinite-*d*) occurred.

Chlorite occurred only in the samples which showed clay mineralization of less measure. Though the chlorite remains stable in the oxidation zone due to its

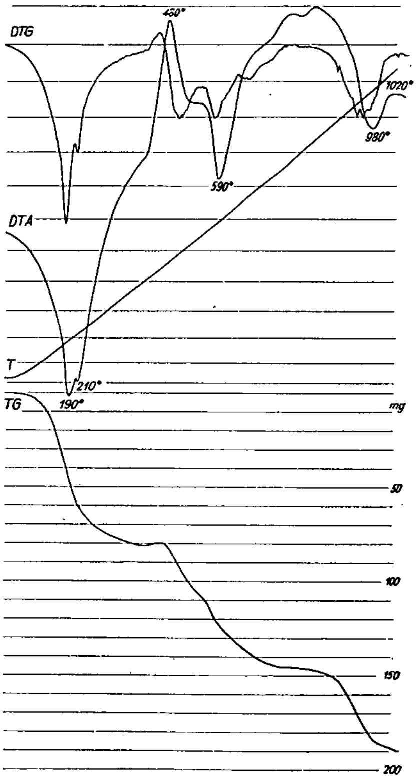


Fig. 26. Derivatogram of the kaolinite-type with jarosite and calcite.

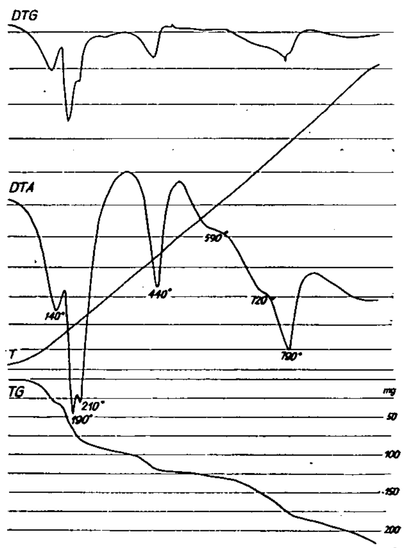


Fig. 27.
Montmorillonite-type with jarosite

high water content, it was absolutely absent in these clay mineralized zones and this is in correspondence with the former investigations.

Out of the secondarily developed minerals the determination of jarosite was done first in this area which could be identified in the diffractograms. The $d \sim 5.9$; 5.7; 5.09; 3.10; 3.07; 1.93 values unambiguously determined the mineral all the more so the d-values of the secondary minerals of this assemblage did not disturb these peaks. The place of occurrence is connected not always to the closeness of lodes, but it formed in the oxidation zone where the descending waters were of more considerable effect. It occurs usually together with certain kind of clay minerals, sometimes it is accompanied by gypsum. The regularity observed by MARTIN VIVALDI, J. *et al* [1971] in the gold mines of Rodilquilar could not be demonstrated in this area.

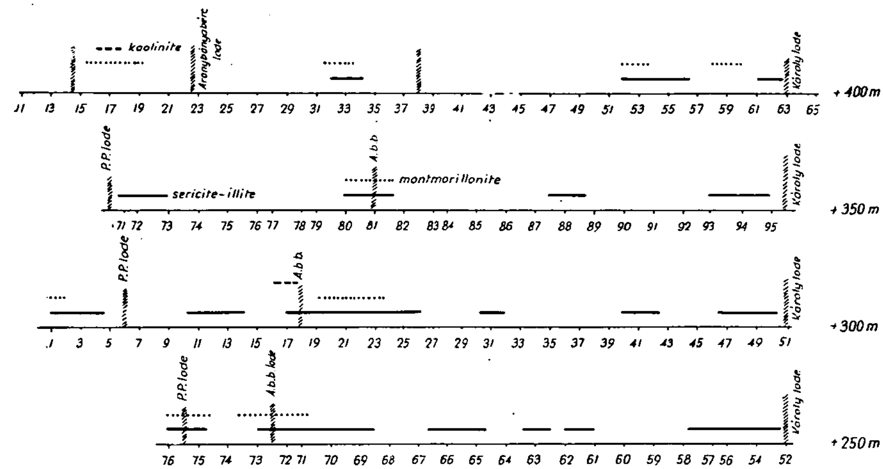


Fig. 28. Zonal arrangement of clay minerals

According to several observations in the course of hydrothermal metasomatism some zonal structure develops in the formation of the clay minerals, to a certain extent. In Hungarian relations this phenomenon has been investigated in details by NEMECZ, E. [1967] and SZÉKY-FUX, V. [1970]. NEMECZ related to the clay mineralized zone of the Mátraszentimre lode, as well.

On these bases the clay minerals occuring in the single levels' samples were demonstrated in a sketch profile *(Fig. 28)*. On this basis the general occurrence of illite can be unambiguously stated. Along the lodes, in general excellently crystallized illite structures were developed. Due to the replacement of plagioclases the Si/Al ratio is also displaced and, since the major part of Al_2O_3 will be bound the solution becomes richer in silicic acid. But a definite kaolinitic or montmorillonitic zone could not be separated. Near the Károly lode of greater importance only in the +400 metres level developed a montmorillonitic zone, the kaolinite was absent near the lode. In case of the Aranybányabérc lode of less significance there is an overlap among illite, montmorillonite and kaolinite. The overlap may be explained partly by the possibility of the transformation of these clay minerals into one another (illite-kaolinite, illite-montmorillonite), partly by the secondary development on the effect of descendent solutions. The statement of NEMECZ [1967] regarding the conditions of the Tokaj Mountains is probably valid for the area of the Gyöngyösoroszi mine, i.e. considerable ore formation cannot develop together with kaolinite, because the high potash-content of the ascending solutions results in such a high pH-value, which is favourable for ore formation but hinders the formation of kaolinite. Consequently, the occurrence of kaolinite and montmorillonite cannot be assigned to the zonal arrangement but it was originated by other genetic processes, i.e. in this case the descending solutions provide the possibility of the formation of these clay minerals.

ALKALI CONTENT OF THE ASSOCIATED ROCKS IN THE DEAD GALLERIES OF THE FOUR LEVELS

In the mine's area the environs of the lodes show alkali contents and alkali ratios being dissimilar to those common in the orthoandesites. Some literature data relate to the fact that in the environs of lodes there is a potash anomaly and connection can be supposed between the ore formation and potash metasomatism.

In the environs of Borskovo (Yugoslavia) where lead and zinc are mined Kněževič, V. and Djordevič, P. [1968] observed that near the ore body the potash-content shows positive anomaly and reaches the maximum about between 25 and 30 metres. In the porphyric-keratophyric rock sanidine or orthoclase of sanidine character developed as a result of metasomatism. In this area the potash content, being high only in the environs of the ore bodies, can be regarded positive indicator.

Széky-Fux, V. [1970] searched the connection of K_2O between the associated rock and ore formation in the area of Telkibánya (Hungary).

Investigating the mineral paragenesis of the gold mine of Rodalquilar (Spain) Martin Vivaldi, J. *et al.* [1971] found also potash anomaly along the lodes. On the basis of the mineralogical composition three zones were distinguished. The first one extended from the vein up to 30 to 35 metres, the second zone was found up to 60 metres while the third zone represented the original rock. The quantity of illite (sericite) increased only in the close neighbourhood of the vein, that of the kaolinite gradually increased from the second zone towards the lode and reached about 20 per cent along the vein. From the innermost zone the vermiculite and chlorite could not be determined, but the quantity of the alunite-jarosite series gradually increased towards the vein.

Since in the close neighbourhood of Gyöngyösoroszi considerable potassium enrichment can be observed together with sanidine formation in the area of Mátraszentistván, and similar phenomena occurred in the western neighbourhood of the mine it would be practicable to make investigations on the basis of which the fact could be stated that higher potassium content occurs near to the lodes and when this followed some kind of regularities could be demonstrated in case of increase or decrease of concentration in the dead galleries between the two lodes. The further question is that when there is a potassium enrichment the form of appearance will be sanidinization, adularia formation of sericitization. It is probable, too, that whether is there any regularity or connection between the change of potassium content and ore formation. The samples investigated were the same used in the mineralogical-petrological investigations, and place of sampling is shown in *Fig. 1*. The results are as follows.

The change of alkali content of the lowermost level (+250 m) is shown in *Fig. 29*. There is considerable difference in the potassium content from that of about 4 per cent of the hypomagmatically developed andesite, near the lodes the

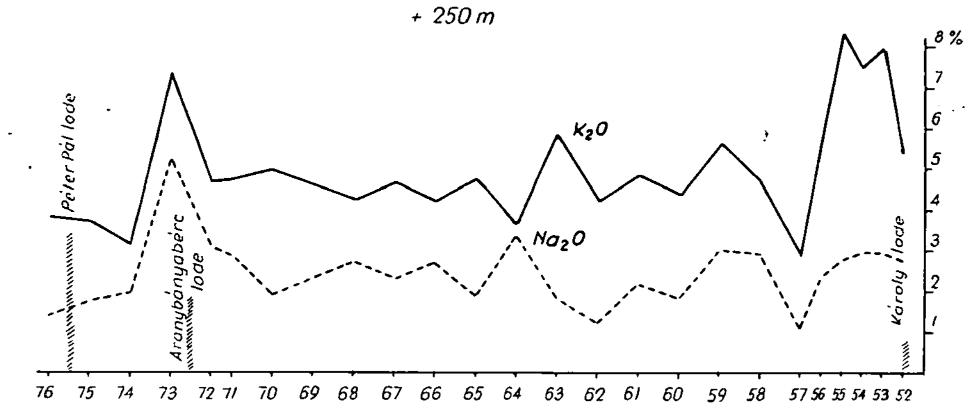


Fig. 29. Change of alkali content of the level +250 m.

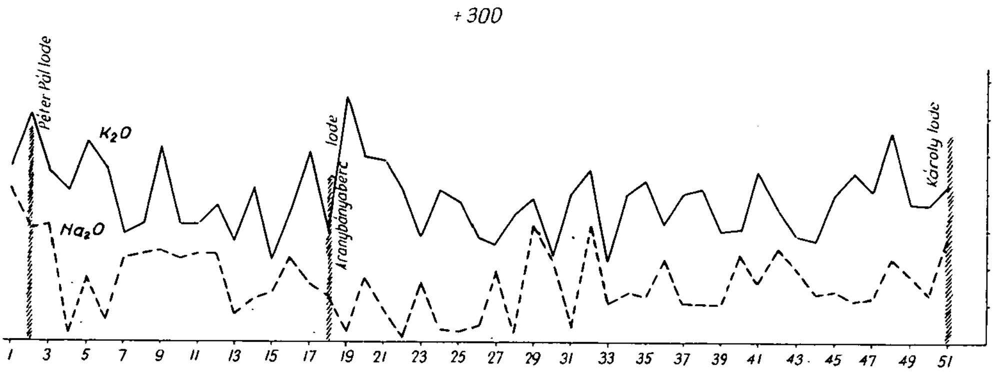


Fig. 30. Change of alkali content of the level +300 m.

K_2O content surpasses 8 per cent. Since the potash feldspar is absent in the mineralogical components, the considerably increased potash content is connected for the most part to illite and sericite. The level consists of uniform rock, decomposition is of less importance so the metasomatic effect of the hydrothermal solutions is demonstrated most pregnantly in these lodes. The change of Na_2O though with smaller values was nearly parallel with that of the K_2O.

In the level of +300 metres *(Fig. 30)* the petrological formations are more variegated, several lava streams and tuff levels can be distinguished and locally brecciated zone of lithoclases developed. This results in first of all that along the lodes the K_2O content is less characteristic but it surpasses 6 per cent. The quantitative change of the Na_2O content is similar to that of the underlying level, higher values occur in the fault zone.

In the level of +350 metres *(Fig. 31)* the petrological picture is changed. The andesite tuff is absent, clay mineralization is of less significance, silification is, however, increased and locally thin calcite veins also occur, i.e. the fluctuation of the K_2O content is less. The higher K_2O value is connected to the illite and sericite. The higher value between the Károly and Aranybányabérc lodes indicates a more intensive clay mineralization. In this level the quantity of Na_2O sometimes surpasses that of the K_2O. In these cases the rock has been more fresh and clay mineralization was of less importance.

In the level of +400 metres *(Fig. 32)* where the silicified rock is orthoandesite the values of K_2O and Na_2O are nearly the same. In the Aranybányabérc lode, however, the K_2O value is high, i.e. the metasomatic effect of the hydrothermal solutions has prevailed. Between the Béke and Károly lodes in a distance of about 400 metres a rock originating from a relatively uniform hypomagma is exposed in the different stages of decomposition (effect of the descendent solutions) and metasomatic replacement and this results in the whimsical change of the values.

On the basis of the alkali content investigations it has become obvious that in case of fresh, faultless rocks free from clay mineralization and oxidized parts and where the rock type shows negligible changes, the values of K_2O are extremely high near the lodes (10 to 25 m), this anomaly, therefore, indicates the closeness of the lodes, in any other cases it has no indication character.

CONNECTION BETWEEN ORE FORMATION AND THE IGNEOUS ROCK

The igneous rock receiving the ores, the regional extension of the ore formation as well as the connection between the igneous rocks within the Carpathian Tertiary volcanic formations were formerly investigated.

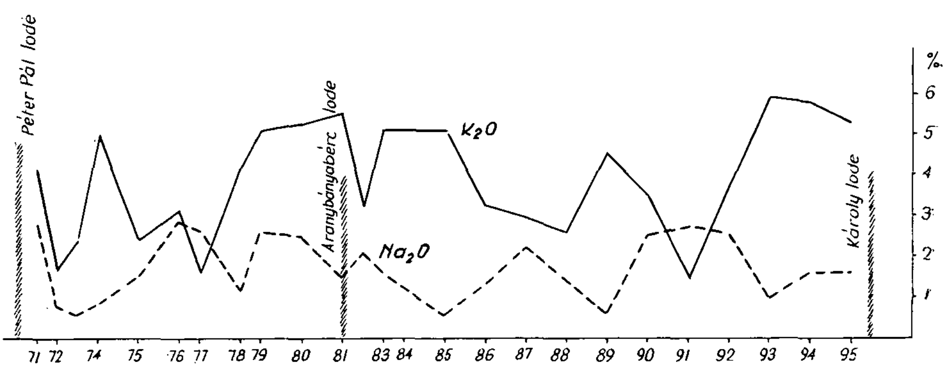


Fig. 31. Change of alkali content of the level +350 m.

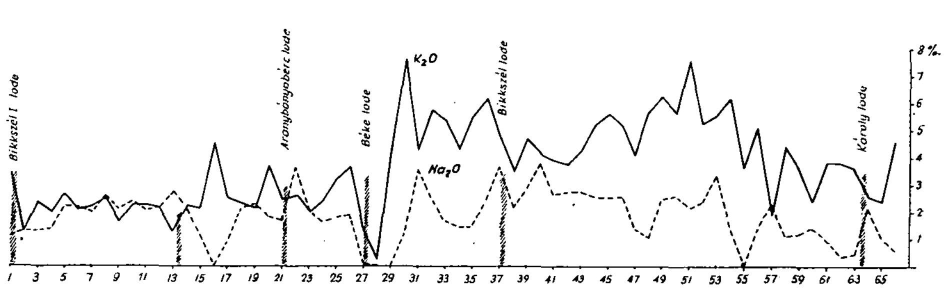


Fig. 32. Change of alkali content of the level +400 m.

SZÁDECZKY-KARDOSS, E. [1941] related to the fact that connection can be established between the ore distribution and crystallization degree of the igneous rock. According to the ratio of volume percentages of the rock-glass and crystalline substance the volcanites can be assigned to seven groups on the basis of the crystallization degree. On this basis the volcanites of the Mátra Mountains belong to the fifth group. The crystallization degree, of course, is only one of the numerous factors, therefore it cannot determine the necessary appearance of ore formation alone.

VENDEL, M. [1947, 1951] investigated the connections between the Cretaceous and Tertiary volcanic cycles. According to him there is a connection between the silicic acid content (SiO_2) and the intensity of ore formation. This is more obvious when demonstrating the intensity of ore formation in function of the NIGGLI's *si* or the weight percentual SiO_2 values.

According to PETRASCHEK, W. [1964] in the Carpatho-Balkanian ore province the lodes are connected to the Alpine metamorphism in space, time and substance. The common features of the Alpine-Mediterranean ore province are the uniform age as well as the Alpine magmatism within the whole mountain range, but the bed-forms are different.

PANTÓ, G. and MORVAI, G. [1967] in their metallogenetic grouping connect the ore formation of the Mátra Mountains to the Late Alpine phase, similarly to the ore formation of the Börzsöny Mountains and Telkibánya.

KOCH, S. and PANTÓ, G. [1970] introduce the characteristic parageneses and ore formations connected to the single Alpine tectonophases, among others the area of Gyöngyösoroszi, too.

According to SZÉKY-FUX, V. [1970] the most significant factor of the favourable appearance of the ore formation is the petrogenetic development of the rock. In her investigations at Telkibánya she searched the connection between the change of K_2O content and the intensity of ore formation.

GRASSELLY, GY. [1969]* raised the question that when the connection between the potash-metasomatism and the intensity of ore formation should be investigated the intensity of ore formation seems to be more suitable to indicate with the sulphide-S content, and in this way the connection mentioned above could be expressed by two parameters being measured by the same exactness.

For this purpose the samples which were investigated for alkalies have been investigated for their sulphide-S and sulphate content, too. Results together with the K_2O values are shows in *Fig. 33*. Between the potash-oxide and sulphide-S there is such a connection according to which the curves follow each other. In cases when the sulphur content shows higher values the pyrite formation on the cleavage faces and lithoclases is more intensive. From the similar character of the obtained values the conclusion can be drawn that in the associated rocks the migration of the potassium and sulphur containing solutions may have been the result of simultaneous of nearly simultaneous processes. The high potash-ion content ensured the migration of sulphides in solution and their precipitation under the suitable conditions. The sulphate content derives from the gypsum originated on the effect of the descendent solutions. These values are extremely high in case of fault zones and more intensive decomposition.

When demonstrating the weight per cent of the sulphide-S content in the weight per cent of the K_2O content *(Fig. 34)* and leaving the pyritic parts out of con-

* Personal communication.

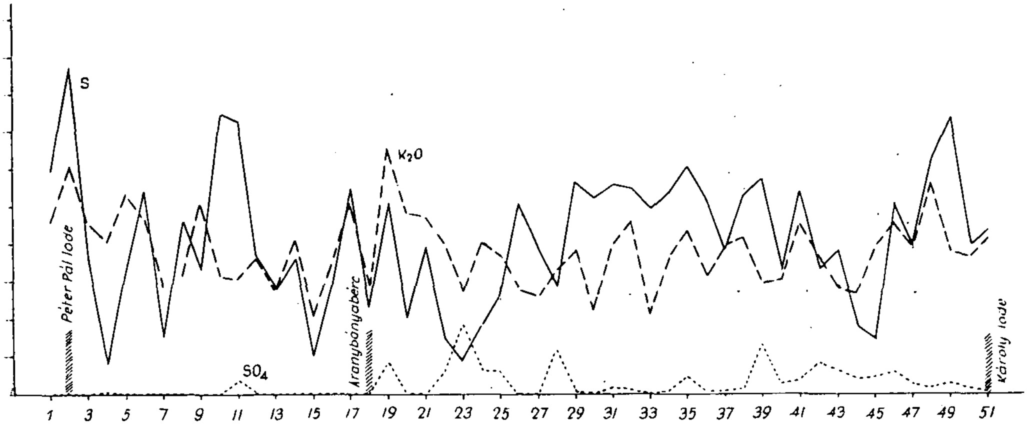


Fig. 33. Connection between sulphide-S, sulphate and K_2O

sideration, an optimal K_2O content can be determined necessary for ore formation which may be between 2.5 and 4.5 per cent. Recently this data concern only the single gallery of a single mine thus it cannot be of conclusive strength but the possibilities will be investigated in other occurrences, as well.

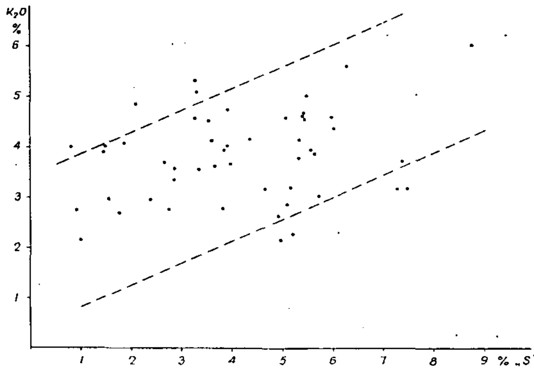


Fig. 34. Change of the ratio of K_2O and sulphide-S.

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