RECENT OBSERVATIONS DEALING WITH THE ZEOLITE MINERALS OF THE BASALT ROCKS IN THE HIGHLANDS OF LAKE BALATON

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Since 2 decades the author of the present paper has been examining the zeolite minerals of the basalt rocks of the Highlands of Lake Balaton. Many kinds of zeolite minerals were found, some of them are very rare minerals like for instance thaumasite.

During the summer of 1951 the investigations were continued. They were particularly successful in the recently exploited huge stone-quarry in the vicinity of *Uzsapuszta* which is, up to date, the most modernly equipped basalt stone-quarry. The quarry lies in the Tátika-Prágahegy-Szebike-Fertős Range on Mount Láz. In this area the basalt cover is fairly thin under it basalt breccia is deposited the surface of which takes a wavy course so that the interior of the basalt mine contains partly basalt and partly basalt breccia. In the basalt many vesicle cavities measuring only a few cm in diameter can be found the walls of which are covered with zeolite minerals.

The vesicle cavities and fissures, respectively, contain three different kinds of zeolite. Usually phillipsite is deposited on the wall of the cavities. Its crystals are rarely larger than 2—3 mm. Their shapes are simple showing pseudotetragonal twin character, apparently a combination of first class and second class bipyramids. These twin crystals develop rarely singly rather actually composing a crust through their dense deposition beside one another on the walls of the vesicles and fissures; or forming cluster aggregates.

Generally natrolite is deposited on the phillipsite. The latter usually shows a fine fibrous structure. The fibers are 2—3 mm long, but only 20—100 μ thick they are bounded by very simple combinations of shapes: prism (110) and the common flat pyramid (111). These fibers never occur singly but forms always fine radial-fibrous masses.

The single fibers are well developed crystals. Natrolite often occurs associated with scolecite. The latter zeolite, however, can only rarely be found in the form of well developed crystals. Generally it merely forms very fine fibers which are mostly interwoven with those of

natrolite. Usually the scolecite fibers occur at the origin of the natrolite ones, their terminal planes are missing and the two zeolites can only be distinguished by virtue of their optical constants. In the case of natrolite the longitudinal direction is Z, the extinction parallel, the refractions indices do not exceed 1,500, whereas in that of scolecite the longitudinal direction is X, the extinction on plane (010) 15—18° and the refraction indices exceed 1,500. The terminal planes of scolecite can only be detected in quite exceptional cases. Of the fibrous zeolite masses only the natrolites protrude unprotected, the scolecite fibers contained in the masses almost fall into decay towards the borders.

The sequence of formation of the three zeolite minerals is always distinct: first of all phillipsite forms quasi composing a crust on the wall of the vesicle cavity, the masses consisting of natrolite fibers are deposited on it, the formation of scolecite started simultaneously with that of natrolite, however, the development of the natrolite crystals lasted longer thus the unprotected end of the crystals could form automorphously.

The formation of the three zeolite minerals did not always occur simultaneously. In some of the caves phillipsite is not present in which case natrolite is usually deposited directly on the wall of the cavities mostly associated with scolecite.

In some places the paragenesis varies to a greater extent, this is due to a co-occurence of calcite which only rarely forms well developed crystals generally appearing only in granular masses. Thus on the wall of one cavity granular calcite is directly deposited and on it natrolite with a small amount of scolecite, however, the latter zeolites also grow sometimes directly on the wall of the cavity. In other cavities phillipsite is deposited directly on the wall of the cavity and calcite and natrolite are deposited on it. In other cases calcite and phillipsite are deposited beside each other directly on the wall of the cavity and fine radial fibrous natrolite associated with some scolecite is deposited on the two minerals.

In a few cavities thick natrolite prisms are deposited on phillipsite, these prisms contained tiny globules which are composed of some kind of gel substance the crystallization of which was due to its radial fibrous structure; the longitudinal direction of the fibers is Z.

There are vesicle cavities which are partly quite compact and filled up with a white substance. This compact white substance contains the following components: compact phillipsite and natrolite, fine apatite and well developed automorphous brown augite crystals floating unprotected in the compact substance. This mass formed after the lava had become rigid and originated at the same time as the other zeolite minerals.

The series of the minerals cavities is completed by the fine, pretty, aragonite which usually occurs unassociated in the cavities.

The basalt also contains bulblike granular quartz inclusions originating from the breaked through sandstone.

The two basalt mines of Mount Tóti (Káptalantóti) furnished zeolites in great quantities. These mines are situated on the northern side of the mountain top, but at present they are not exploited. The basalt of these mines contains many vesicle cavities which are mainly lined with phillipsite. The crystals are the common twins, pseudotetragonal columns combined

with pseudopyramids, the twin crystals are 1—2 mm in size. Natrolite is rare and does not occur in well developed crystals. Scolecite is similarly a rare mineral occasionally associated with phillipsite. Apparently the two zeolites formed simultaneously as both are deposited directly on the wall of the vesicle, however, sometimes they are also deposited on each other. The solecite is probably also present, but so insufficiently developed that its identity could not certainly be determined.

Another fibrous zeolite also occurs associated with the well developed phillipsite the longitudinal direction of which is X it has a weak birefringence, its identity could not be established.

The phillipsite is covered in some places with small granular calcite. The observations on Mount Tóti are rendered more difficult owing to the fact that the basalt mines are not under exploitation and the collections can only be made from the old fragments.

Hitherto the occurences of *Mount Tik* in the vicinity of Taljándörögd were unknown. Unfortunately there are no good exploitations in this area and in the cavities of the scattered rolling masses, so far, merely fairly well developed twin crystals of phillipsite could be detected.

Recently on *Mount Szentgyörgy* situated to the south of Tapolca a single amygdaloidal basalt was found the vesicles of which contained very minute chabasite crystals. The aragonite consisting of columnar aggregates occurs more frequently.

In previous papers different zeolite and other mineral formations occuring in the basalt cavities and fissures of *Zalahaláp* were described. Most of them could be also observed in the course of these more recent investigations. The natrolite globules 1—1.5 cm in diameter showing a radial fibrous structure should particularly be mentioned they terminate in well developed automorphous prisms the ends of which proceed into mezolite the boundary can be well distinguished as the mezolite so to say forms a cap at the end of the natrolite needle. Their optical character can be well determined: the inclination of Y to the perpendicular axis is 2°—5° thus the extinction is nearly parallel, the refaction slightly exceeds 1,500, the birefringence is extremely weak.

In some of the cavities peculiar phillipsite masses showing a lattice structure occur on which half-globules of natrolite with a radial fibrous structure are deposited.

In the fissures and veins finely developed plagioclas tablets associated with automorphous brown augite crystals, olivine granules a fine network of apatite needles and ilmenite tablets can be found. The feldspar tablets are often interwoven with apatite needles. Round the quartz inclusions brown, or green, automorphous augite wreats occur. In the cavities lined with calcite automorphous green augite samples can also be observed. In some places the calcite forms sharply boundered rhombohedrons $(01\bar{1}2)$ 2—3 mm in size. A characteristic feature of the mineral formations of *Zalahaláp* is that they are often coated with a thin layer of some kind of whitish-greyish gellike substance.

In the course of the recent investigations no zeolite minerals could be found in the basalt breccia mine of *Szigliget*, but clumps composed of olivine granules, and in the fissures, quartz inclusions and lime incrus-

tations, were frequent. The basalt mine of *Gulács* furnished some new findings. In the so-called firtreemine the sharp angular fragments of basalt are cemented with calc spar. This cementation is probably very recent.

On the phillipsite, cluster aggregations can be found, the clusters are composed of very fine natrolite fibers and their surface is covered with calcite. The natrolite on the other hand, either fills up the deposited veins or is situated in radial fibrous groups on the crystalline calcite mass. The calcite occurs in yellow masses and also as independent crystals. The yellowish calcite deposited on phillipsite forms long, pointed, almost columnar crystals the terminal shape is furnished by the $(02\bar{2}1)$ planes of rhombohedron.

Analcime occurs deposited on phillipsite a single crystal of which is composed of a distinct well developed hexahedron-octahedron combination.

About 10 years ago a basalt mine was opened up on the north-eastern side of *Mount Hajagos* in the vicinity of Diszel. At the present the mine is not exploited. In this mine no zeolite mineral could be found. In the old mine on the south-western side of Hajagos which is still exploited some new interesting observations could be made.

Some of the cavities are lined with fine aragonite, i. e. the aragonite composes globules showing a radial fibrous structure. On several of the radially situated aragonite prisms calcite rhombohedrons are deposited. Numerous vesicles are lined with phillipsite crystals, the latter are frequently characteristic complex twins consisting of 12 individuums.

The sharp calcite rhombohedrons are 2—3 mm in size and have an index of $(02\bar{2}1)$ they are very sharp and can be frequently found deposited on phillipsite. In other cases the phillipsite is deposited on the calcite.

The basalt from Diszel contains many quartz inclusions; the inclusions are generally surrounded by green and brown automorphous augites. The mine of *Sarvaly-puszta* in the vicinity of Sümeg furnished zeolites hitherto unknown in the area of the Highlands of Lake Balaton.

One of the vesicle cavities is filled up with fairly well developed small thomsonite crystals: its birefringence is weak, extinction parallel, optically it is positive, the refraction index exceeds 1,500 and the crystals are short and columnar. Dirty-greyish globules containing calcite are deposited on the thomsonite. Another small vesicle cavity contains insufficiently developed zeolites which are probably also thomsonites, however, owing to them decomposing easily they cannot be exactly determined.

Similarly the small globules showing a radial fibrous structure having a weak birefringence and a slightly green colour, the longitudinal direction of the fibers being Z are also difficult to determine. Some of the cavities are lined with a thin phillipsite crust on which $(10\bar{1}1)$ rhombohedrons of calcite are deposited. Sometimes fine aragonite needles are crystallized on the calcite. In the basalt of Sarvaly olivine clumps are frequent.