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THE SCAPOLITE DEPOSIT OF BOLTON, MASSACHUSETTS

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The mineral deposit at Bolton, known by collectors and in mineralogic literature for nearly a century, is still worthy of a visit although fresh exposures of the rocks have not been made for many years. The locality is an abandoned limestone quarry situated a few hundred yards from the road between Stow and Lancaster, in the town of Bolton, about 25 miles west and slightly north of Cambridge. The present owner of the farm on which the quarry is located is S. B. Mentzger whose farm is on the roadside, about one mile east of the junction of the road from Hudson, the nearest railroad station, three miles southeast.

A general account of the geologic relations of the deposits may best be found in Emerson's Geology of Massachusetts, Bull. U. S. G. S. 597. It is one of a roughly linear series of small lenses of metamorphic limestone distributed over a distance of some 20 miles northeast from Bolton to Chelmsford. The limestone bodies are enclosed in a gneiss of unknown age; Emerson regards it as probably Carboniferous but Keith and LaForge are quoted by him as assigning it to a much older horizon, probably Cambrian.

The actual relations which may be observed at the larger, water-filled quarry are these:—the gneiss which forms the summit of the hill behind the quarry strikes NNE-SSW and dips steeply to the east; the limestone is conformable to the gneiss and beneath it. Between gneiss and limestone and exposed on the vertical wall of the quarry are several layers of varying mineral composition. Next to the gneiss is a layer of massive pink scapolite, lenseshaped, and reaching a thickness of 16 feet at one point. Next below this is a layer of diopside-actinolite rock grading downward into a zone of boltonite-rich limestone and through that into normal limestone. The limestone is magnesian, almost a dolomite in composition, generally gives a fetid odor on fracture, and is coarsely crystalline

in texture. There is an abundance of coarse granite pegmatite boulders in the immediate neighborhood of the quarry but the rock could not be discovered in place. In other pits to the SW, however, dike-like masses of quartz and scapolite which have been left standing in the excavation of the limestone give the impression of being igneous in nature and are interpreted as scapolite pegmatites. And it is believed that the formation of scapolite on the unusually large scale here exhibited is due to the action of pegmatite intrusions upon the materials of the gneiss-limestone contact zone.

The two minerals of most interest at this locality are scapolite and boltonite, a variety of forsterite. The best materials for the study of these minerals are now to be found in the collections of the Boston Society of Natural History which, by the acquisition of the Brigham collection, obtained what is undoubtedly the best series of Bolton specimens which has been preserved.

SCAPOLITE. The typical Bolton scapolite is massive but coarsely crystalline, in aggregates of columnar individuals which may be as much as two feet in length and six inches or more in diameter. On fracture and weathered surfaces these individuals are marked by their cleavage parallel to the prism. The color is pinkish-lilac shading to a lighter tone on the borders of the crystals. The freshest materials, and especially the centers of the larger crystals are clear and glassy. A polished block in the Harvard Mineralogical Museum with a surface of at least two feet is very decorative and suggests the possibility of using the material as an ornamental stone. Blocks of even larger dimensions, quite free from any admixture of other minerals, could be undoubtedly obtained, but it would be necessary to do the quarrying in winter when the deep quarry pool is frozen. The wall where the fresh scapolite is exposed is vertical and it is with utmost difficulty that at other times material can be broken from the ledge and saved from falling into the water below.

Scapolite also occurs in well formed rough crystals which are generally imbedded in quartz. These crystals which may reach a diameter of two inches and a length of four inches or more are generally simple prisms of the first order, rarely well terminated but sometimes showing the unit pyramid, with or without the basal pinacoid. Such crystals are generally opaque and white or grayish in color. The Brigham collection contained a great many

of these distinct crystals but they are no longer to be seen at the quarry. The old dumps, formerly rich in large blocks of massive scapolite, have been so long worked over by visiting mineralogists and have become so overgrown by shrubbery that it is now difficult to secure specimens of typical material from them.

The mineral early described from here under the name of nuttallite proved to be merely a variety of scapolite.

BOLTONITE. Under this name was early described a variety of forsterite which is abundant at Bolton. It is found in limestone in small scattered grains or making up a considerable part of the rock. It is smoky gray to colorless and the grains are mostly small but reach a size such that prismatic sections are two inches long by half an inch across. The analyses of boltonite to be found in Dana's System show it to be a lime-free forsterite with a low content of ferrous iron. It easily undergoes alteration to serpentine, the first change resulting in giving it a yellowish color not unlike that of the chondrodite with which it is associated. Its good cleavage (pinacoidal) furnishes a good means of recognition in the hand specimen.

It is associated commonly with diopside and actinolite, more rarely with chondrodite, apatite and titanite. Scapolite is rarely found with it.

OTHER MINERALS. A number of other minerals are found in the Bolton locality but none is of special note. The observations which follow are drawn from a paper prepared by A. W. Pinger who studied the collections at the Boston Society of Natural History as well as those at Harvard and visited the locality more than once.

FELDSPARS. The feldspar at Bolton is chiefly microcline, found in the pegmatites in association with scapolite, and phlogopite mica. Andesine has been described by Emerson as occurring in limestone with pyroxene. The scarcity of feldspar in the pegmatites is probably to be explained by the abundance of scapolite which has seemingly taken its place.

PYROXENE. The only pyroxene is diopside which is abundant in the limestone in company with actinolite, apatite and titanite. It is commonly granular but may form large individuals with platy basal parting. In cavities filled with later calcite it forms small crystals of ordinary diopside habit, together with later

fibrous actinolite. These are pale green or greenish white in color and sometimes transparent.

Much of the platy diopside in collections was found under the label petalite.

Actinolite is the only amphibole determined. It forms dark to light green needles filling the limestone rock or radiating into calcite-filled cavities together with diopside. It seems to have formed after diopside but not as an alteration of it.

Zircon was determined as microscopic inclusions in gray scapolite.

Allanite was seen in numerous specimens as grains surrounded by a strained zone caused by increase of volume on alteration. All material examined under the microscope was isotropic with an index of 1.68 in the freshest grains. It was found in scapolite rock, in limestone and in the minerals characteristic of the latter.

Garnet in reddish crystals in scapolite rock was sparingly observed; probably essonite.

Chondrodite in vivid yellow grains was seen not uncommonly in the boltonite rock.

Mica, both dark and light brown in color, is sparingly present and is thought to be phlogopite. The lighter varieties are disseminated in the limestone; the darker ones in granular masses along the contact of the pyroxene and scapolite rock layers.

Serpentine and talc form alteration products after forsterite, chondrodite and diopside. They are not abundant and exhibit no noteworthy characters.

Titanite in brownish crystals is widely and fairly abundantly distributed throughout the deposit, chiefly however in the pyroxene zone. The crystals reach a diameter of one inch and have the usual flat lense shape; small crystals are quite complex but most of them have been shattered by pressure and show pronounced pressure twinning. In cavities containing diopside crystals cleancut crystals of titanite are sometimes present. These cavities are marked by having a filling of granular calcite, removal of which with dilute acid reveals the crystalline lining of the walls.

Petalite has long been recorded as occurring at Bolton and Dana gives an analysis of this mineral from there. Many specimens labelled petalite were examined in both collections studied but none of them proved to be correctly identified. They included platy diopside, microcline, scapolite, and especially a fine grained

form of partially altered massive scapolite mixed with calcite. It seems probable that the petalite originally found here was from an erratic similar to the spodumene boulder found in Sterling, Massachusetts.

Graphite and magnetite both occur sparingly in thin veins in the gneiss, and in altered scapolite rock.

Spinel in small blue-gray octahedrons occurs in the limestone in the usual close association with chondrodite.

Rutile, doubtfully identified as rod-like inclusions in gray scapolite, and quartz, abundant in massive form in the pegmatite, complete the list of oxide minerals recognized.

Sulphides sparingly present in minute grains in the limestone include arsenopyrite, chalcopyrite, pyrite, and pyrrhotite. The first three were identified by crystal form under the binoculars as well as by other tests.

Apatite of a pale green color is common throughout the deposit in crystals ranging in size from microscopic needles to prisms three inches in length. It was seen in massive scapolite, in boltonite rock, and in druses with titanite and diopside. It appears always to have formed at an early stage of crystallization. Some gray crystals contain the rod-like inclusions thought to be rutile also seen in scapolite.

Fluorite, yttrocerite and cerium ochre are names of minerals reported from Bolton but not identified in the collection studied.

THE FORMATION OF KAOLIN AT MODERATE DEPTHS[1]

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In an intelligent discussion of the formation of kaolin it is necessary to consider the minerals from which kaolin may be formed, the reagents that will change these minerals to kaolin, the source of these reagents, and the minerals that will be formed simultaneously with the kaolin.

In the present paper the writer will attempt to indicate the type of minerals from which kaolin may be formed with an outline of the probable reactions and a summary of the results of some of the reactions. In addition attention will be drawn to two kaolin

[1] Read at the meeting of the Mineralogical Society of America, Ann Arbor, Michigan, Dec. 29, 1922.