THE APATITE-BEARING VEINS OF NISIKKATCH LAKE SASKATCHEWAN

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ABSTRACT

Apatite-bearing veins are described from an area about 35 miles north-east of Uranium City, Saskatchewan. Pegmatite, feldspar, apatite, carbonate and amphibole zones are recognized, one or more of which may occur in an individual vein. The apatite zone is radioactive due to the presence of thorium minerals. Green and orange apatite, with yttrium earths predominating has $\omega = 1.635$, $\epsilon = 1.638$, S.G. = 3.18, to 3.24. Red and brown apatite, with cerium earths predominating, has $\omega = 1.640$, $\epsilon = 1.644$, S.G. = 3.24 to 3.28. Allanite, common in the apatite zone, is partially metamict and contains 12.03% rare earths at one locality. The feldspar is hyalophane.

Introduction

During the summer of 1953, a number of small apatite-rich veins were discovered near the Tazin River, east of Tazin Lake, Saskatchewan. These veins were particularly abundant in the region of Nisikkatch and Northwest Lakes, about 35 and 40 miles respectively, north-east of Uranium City. The writer had the opportunity to examine some of these occurrences in 1955 when employed by the Geological Survey of Canada.

Typical in this area are low gently rolling ridges which have been largely burnt free of primary growth. Rock exposures are plentiful and include a Precambrian assemblage of gneisses and concordant bands of amphibolite (in part metagabbro). Pegmatites and the apatite rocks occur in minor amounts. Some lamprophyres and graywackes were seen on the flanks of the area shown in Fig. 1. Except for the report of reconnaissance mapping by Alcock (1936), no account of the geology of this region is available.

The writer wishes to acknowledge assistance given him in the field by D. H. Loring and the many helpful suggestions of Dr. S. C. Robinson of the Geological Survey of Canada. Mr. J. P. Dolan, of Orchan Uranium Mines, kindly gave permission to publish this article and the analysis of allanite.

Geology of the Apatite Veins

The occurrences described in this report, stretch from the north of a lake, known locally as Lane Lake, to the south of Nisikkatch Lake

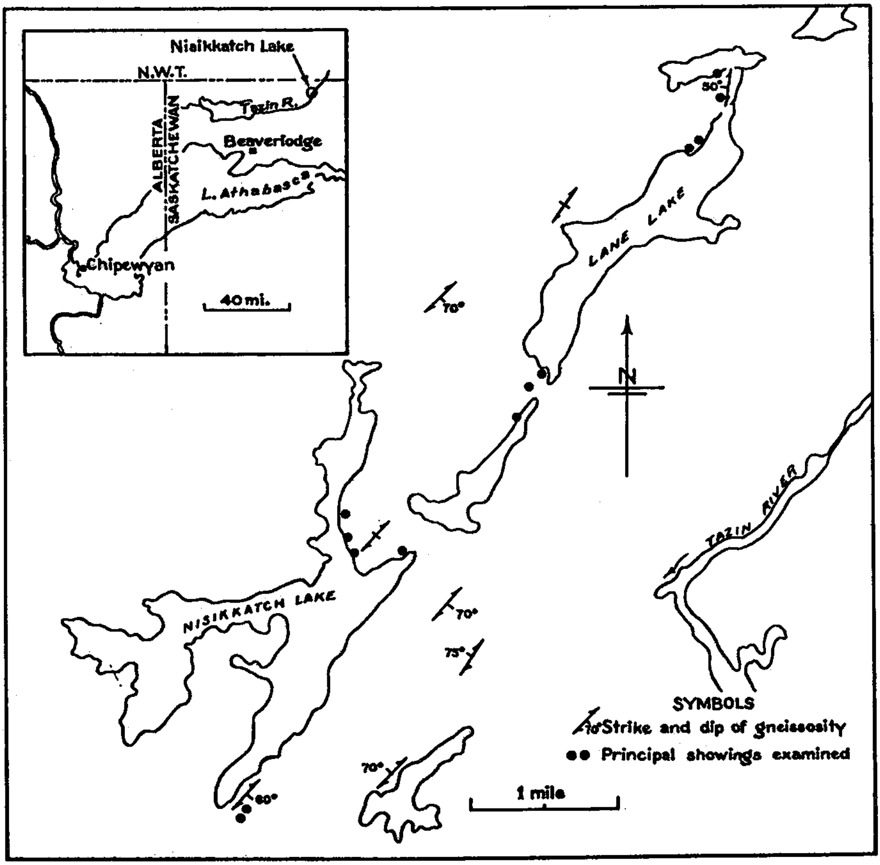

FIG. 1. Location of occurrences.

(Fig. 1), a distance of about 6 miles. The strip of rocks containing the apatite veins is half a mile wide, and conforms to the regional strike.

Individually, the apatite-bearing rocks are irregular in shape with only a general concordant trend (Fig. 2*a*). Occasionally, they are distinctly cross-cutting (Fig. 2*b*) and sometimes the locus of small displacement. The showings are usually small and incompletely exposed. The widest is about 10 feet across, the longest was traced for about 100 feet.

Often the veins are well zoned (Figs. 2 and 3). The following zones are recognizable: carbonate (calcite-barite), pegmatite, feldspar (hyalophane) apatite, and amphibole zones. It is of interest that hyalophane is the principal mineral in the feldspar zone and occurs throughout the 6 mile length. Another remarkable fact is that all these occurrences are radioactive due to the presence of thorium minerals in the apatite zone.

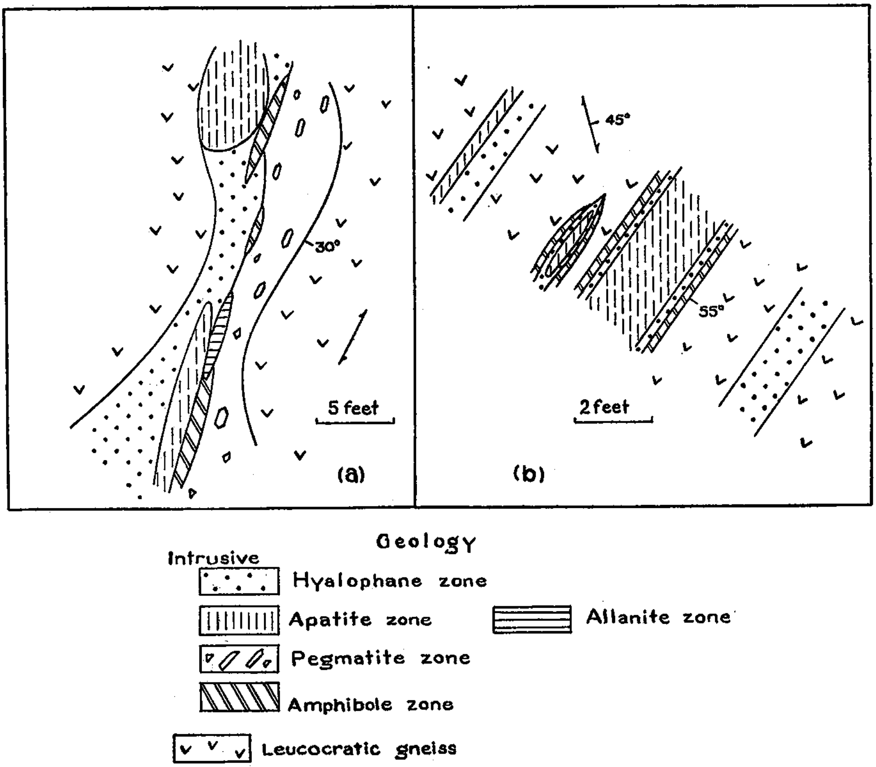

FIG. 2. Plans of typical apatite veins.

The Amphibole Zone

An Amphibole Zone is always found as the outside border of each vein. Both amphiboles and pyroxenes are coarse grained with some crystals up to 2 inches long. The amphiboles, with the optical properties of common hornblende, are either primary or a replacement of pyroxene. Pyroxenes are of rarer occurrence and in many veins are absent. Optical properties indicate that the mineral is salite containing 30 to 45% of the hedenbergite molecule. At a few localities, amphiboles and pyroxenes give way to coarse books of biotite.

Small quantities of other minerals are also present in this zone. Sphene is always present as large poorly defined crystals. Autoradiographs indicate that sphene at one occurrence is slightly radioactive. Allanite is erratically distributed. Chlorite, hematite and quartz are often seen as secondary minerals and small crystals of sulphides, magnetite and zircon are typical in certain localities.

The Apatite Zone

Apatite is common in portions of every vein. The colour ranges from orange through red and brown although greens are not rare. The red and

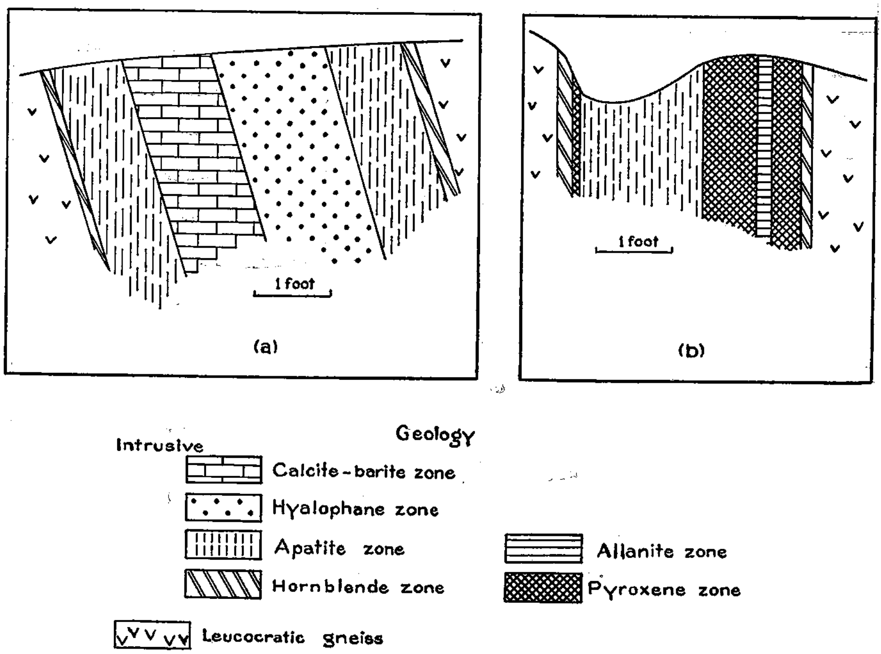

FIG. 3. Sections of typical apatite veins.

brown varieties are coloured by finely dispersed hematite. Spectrographic work by the Mines Branch and Geological Survey of Canada indicate that, of the contained rare earths, cerium earths predominate in the red and brown apatite and yttrium earths predominate in the orange and green apatite. A specimen of chocolate brown fragments showed 4.48% total rare earth oxides as Ce_2O_3 and 0.40% ThO_2 by chemical analysis. These elements are at least partly due to inclusions of monazite, uranothorite and allanite. The inclusions are often oriented. Fig. 5 shows the orientation of monazite in basal section. Prismatic sections show a finger print texture with a tendency for the inclusions to parallel the c axis. More commonly, there is a high index mineral oriented strictly parallel to the c axis (Fig. 6) which seems to enhance a prismatic cleavage.

The following constants were measured:

green and orange apatite $\omega = 1.635$, $\epsilon = 1.638 \pm 0.002$, S.G. = 3.18 to 3.24
dark red and brown apatite $\omega = 1.640$, $\epsilon = 1.644 \pm 0.002$, S.G. = 3.24 to 3.28

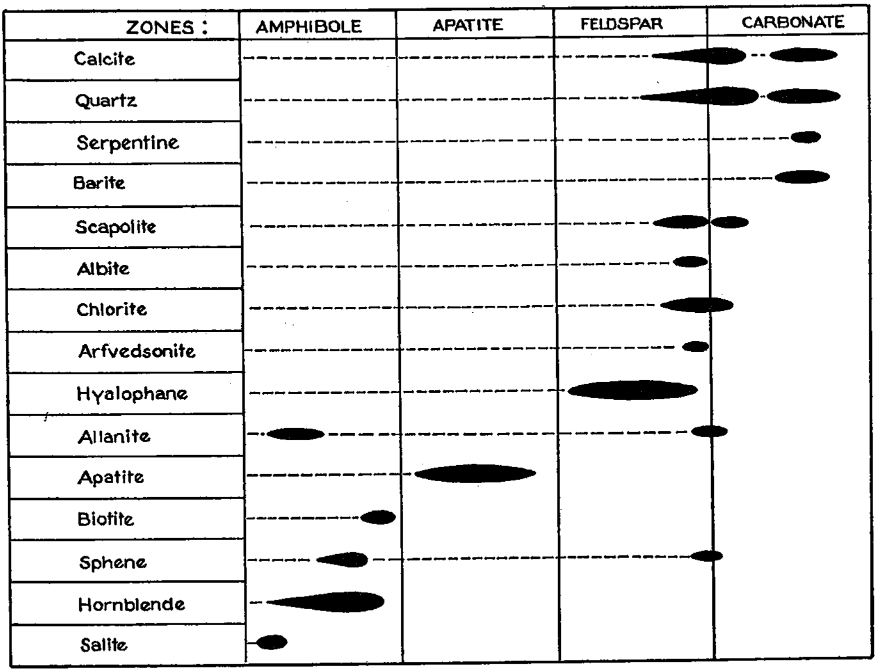

FIG. 4. Paragenesis of common minerals.

Allanite is abundant and often very coarse-grained. Radiating tabular crystals 4 inches long were observed at one locality in apatite, but usually the mineral is subhedral if not anhedral. Fine-grained allanite is frequently developed at the contact of apatite and hyalophane. Twinned allanite was observed in one thin section (Fig. 7). Frequently a colourless mineral of the epidote group rims allanite grains (Figs. 11 and 12). Specific properties vary widely. The mean indices of refraction of seven specimens vary from 1.688 to 1.710. The birefringence is not greater than 0.004. Some varieties are pleochroic. Specific gravities range from 3.42 (metamict) to 3.74 (non-metamict). A specimen of allanite from Lane Lake contains 12.03% total rare earths, principally Ce_2O_3 (analysis by the Mines Branch).

Monazite is present as microscopic, poorly formed crystals often enclosing non-metamict thorite (Fig. 8). The typical radiating fractures surround these minerals. Other common minerals in this zone are sphene, specularite and epidote.

Feldspar (Hyalophane) Zone

This zone is characterized by hyalophane with minor untwinned

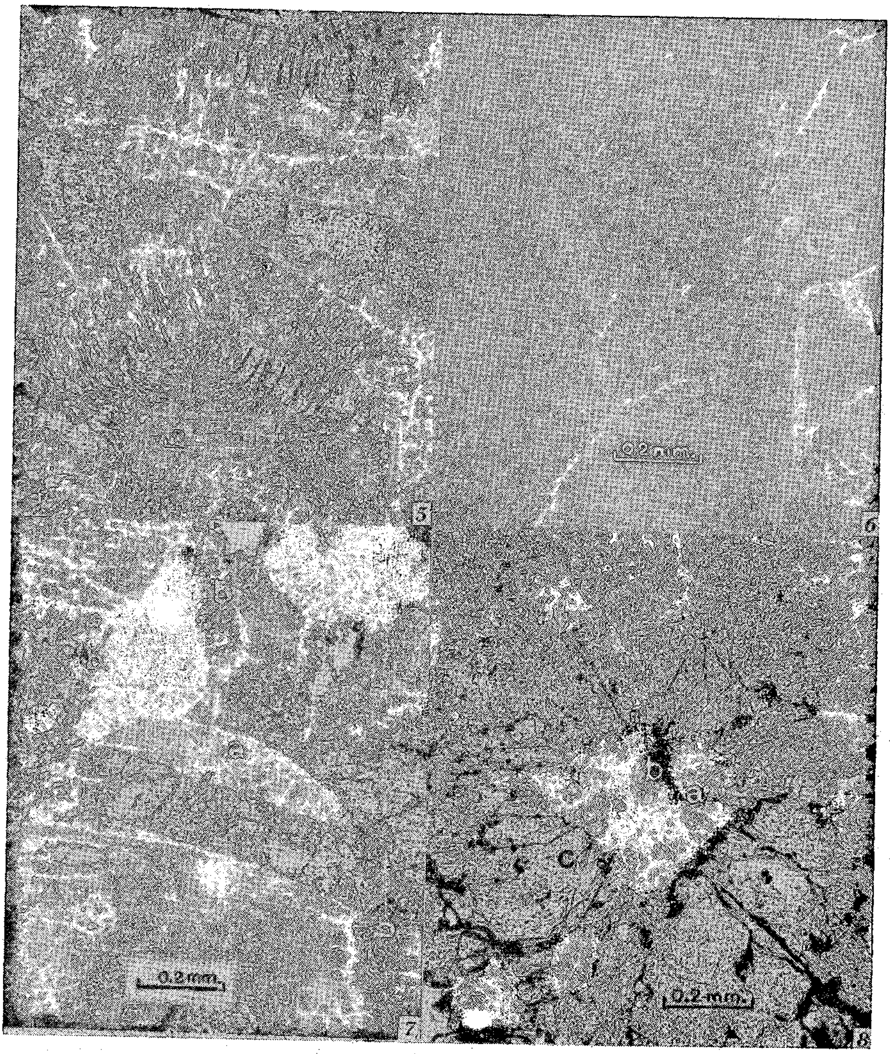

FIG. 5. Basal sections of apatite showing inclusions. Ordinary light.

FIG. 6. Prismatic section of apatite showing inclusions parallel to the *c* axis. Ordinary light.

FIG. 7. Twinned crystal of allanite (a) and hornblende (b) in untwinned allanite. Crossed nicols.

FIG. 8. Monazite (a) enclosing thorite (b) in apatite (c) Ordinary light.

microcline and albite. The hyalophane is light grey and may be very coarse. Optical properties of a typical specimen are:

$\alpha = 1.540 \pm 0.002$
$\beta = 1.543$
$\gamma = 1.546$

$2V = 80°$ (4 axis stage)
S.G. = 2.77 (Berman microbalance)

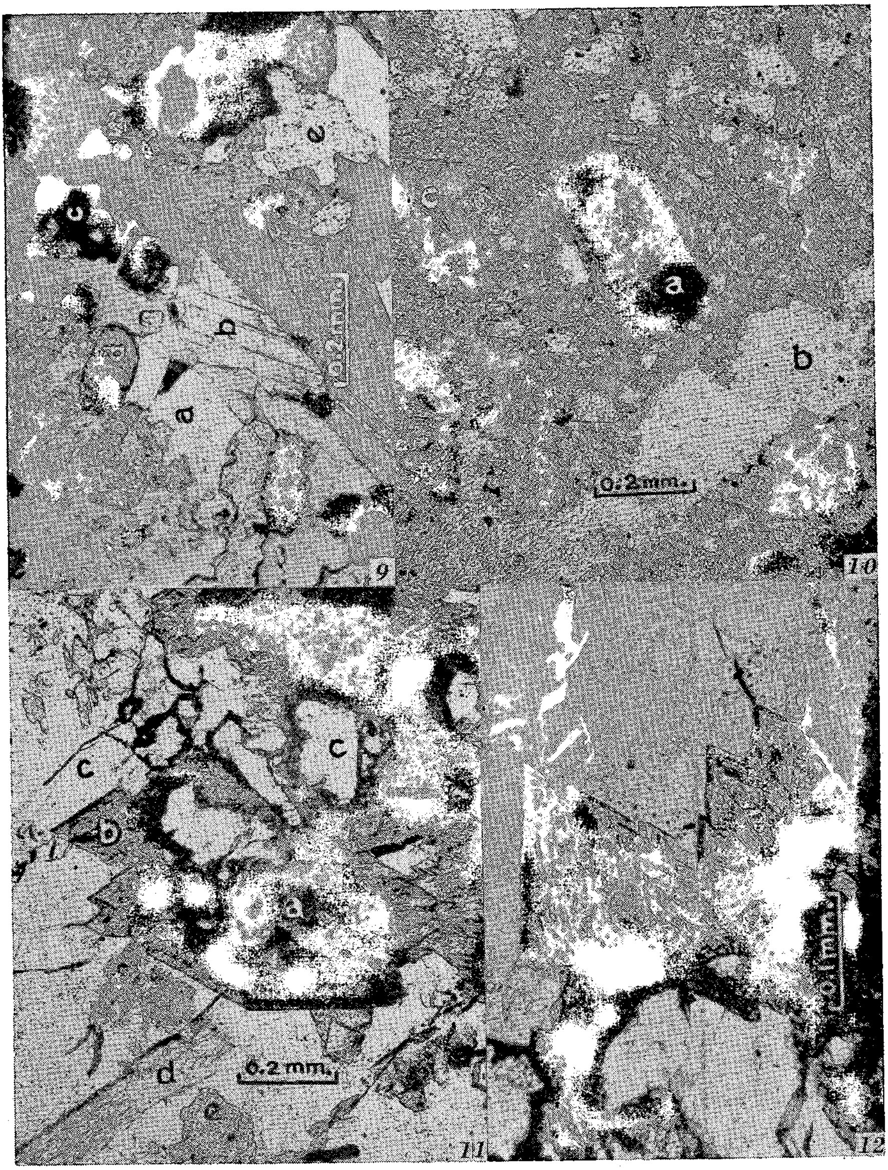

FIG. 9. Carbonate rock showing quartz (a), calcite (b), chlorite (c), apatite (d) and barite (e), Crossed nicols.

FIG. 10. Skeleton of an allanite crystal (a) in carbonate (b) and chlorite (c) Ordinary light.

FIG. 11. Allanite (a) rimmed by clinozoisite (b) in a rock composed of quartz (c) calcite (d) barite (e) and chlorite (f) Ordinary light.

FIG. 12. Enlarged portion of Figure 11 showing zoning of clinozoisite. Ordinary light.

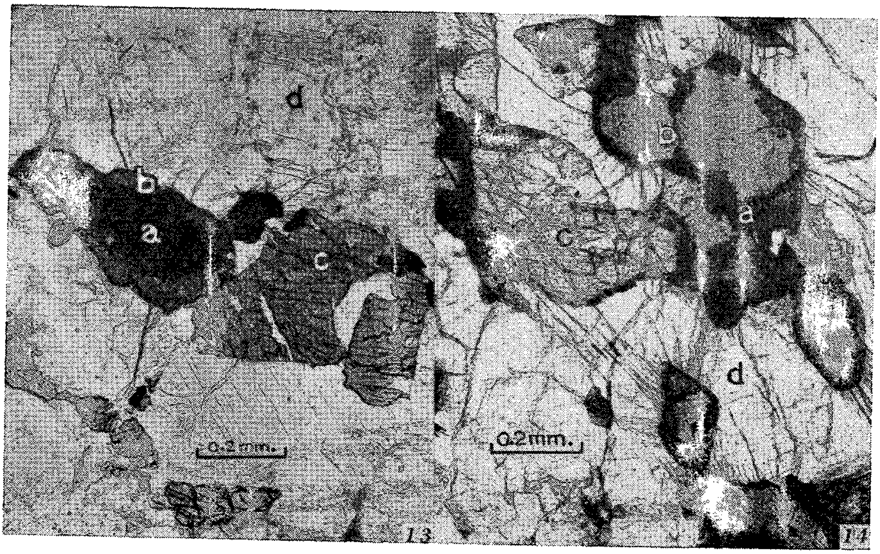

FIG. 13. Iron oxide (a) surrounded by sphene (b) in a rock composed mostly of salite (c) and microcline (d) Ordinary light.

FIG. 14. Pleochroic allanite (a) surrounding non-pleochroic allanite (b) Other minerals are pyroxene (c) and hyalophane (d) Ordinary light.

These properties indicate a composition of Or_{75} Cn_{25} from the data given in Winchell (1951). The presence of barium was confirmed by the optical spectrograph. Other barium minerals are of much rarer occurrence, only harmotome was recognized.

A number of minerals usually regarded as of metamorphic occurrence were observed in this zone. The most notable is scapolite which occurs in cleavable green masses or yellow crystals developed near the contact with the feldpsar zone. Optical constants indicate that the mineral has the composition of a mizzonite ($Me_{65}Ma_{35}$) quite different from the red crystals found within the amphibole zone (mizzonite: $Me_{50}Ma_{50}$) and the yellow crystals in the pegmatite zone (dipyre: $Me_{35}Ma_{65}$). Tremolite, anthophyllite, garnet and epidote were also observed. Very coarse chlorite (n = 1.610 and virtually isotropic) was noted at one locality.

In two veins, a late amphibole, thought to be arfvedsonite, is found in hyalophane. Its optical properties are:

Pleochroism:	X dark greenish blue	Absorption:	$X > Y > Z$
	Y green		$2V$: large
	Z green		$X \wedge c = 31°$

A modal analysis, of one slide, indicates a content of 33.4% (by volume) of this mineral.

The "Pegmatite" Zone

This type of rock is restricted to the area north-east of Nisikkatch Lake and its significance in the zonal sequence is not understood. The zone is characterized by a porphyroblastic texture. Coarse grains of braided perthite with intergranular albitic plagioclase comprise the porphyroblasts. These porphyroblasts display strain shadows and show some semblance of elongation parallel to the length of the vein. Rarely long yellow scapolite crystals are encountered. The finer material consists of microcline, quartz, hornblende and a little allanite and apatite.

The Carbonate (Calcite–Barite) Zone

This zone is developed only in the most northerly occurrence, although some other veins are rich in carbonates. At first glance, this rock appears to be a crystalline limestone. The most important minerals are subhedral calcite and quartz (Fig. 9). These minerals attain a maximum diameter of 2 mm. The average of 3 modal analyses of this rock is:

Calcite	45.6%
Quartz	32.5
Barite	9.6
Apatite	5.9
Chlorite	4.4
Allanite } Other epidote minerals }	2.0
Total	100.0

Barite appears as tiny red, or more rarely green grains in hand specimen. Apatite is found as green crystals containing microscopic inclusions parallel to the prism axis.

Allanite is sometimes replaced by carbonate and quartz. A skeleton crystal of allanite, now completely replaced by calcite and hematite, is shown in Fig. 10. Replacement of allanite by quartz is seen in Figs. 11 and 12. Note the rim of clinozoisite around allanite. Quartz-carbonate veinlets with grains of barite cut the feldspar zone. Similar veinlets are found in a number of other occurrences. At one section of the carbonate zone, fibres of witherite an inch long enclose trapezohedrons of a green mineral giving an x-ray powder pattern somewhat similar to serpentine. The latter mineral may be pseudomorphic after analcite which was found in calcite veinlets at another locality.

Gypsum, pyrite, specularite, siderite, zircon and sphene, occur as minor minerals in the carbonate zone.

Other Occurrences Probably Related to the Apatite Veins

Several bodies of rock north of Nisikkatch Lake contain microcline and pyroxene. An average modal analysis from two thin sections gives the following composition:

Microcline	74.5%
Salite	12.7
Quartz	5.2
Scapolite	4.0
Albite	2.0
Remainder	1.6
Total	100.0

A photomicrograph of this rock is shown in Fig. 13. Sphene commonly surrounds grains of iron oxides.

An outcrop of an unusual gneiss occurs near the south end of Nisikkatch Lake. A photomicrograph is shown in Fig. 14. It is notable that the feldspar is hyalophane and that allanite is an essential constituent. A modal analysis, gives the following composition:

Hyalophane	40.3%
Salite	26.5
Allanite	23.8
Hornblende	5.9
Sphene	2.5
Remainder	1.0
Total	100.0

Host Rocks

By far the most common wallrock is a fine-grained leucocratic gneiss. Modal analyses show that this rock is composed of about 70% microcline, 25% quartz and 3 to 5% mafic constituents. The primary mafic mineral is usually augite, hornblende, or more rarely, clinohypersthene. Wallrock alteration is not apparent near the veins. Biotite and hornblende-rich rocks and sometimes amphibolites, are less frequently encountered.

Keeping in mind the relationship between gabbro and the apatite lodes of southern Norway (Beyschlag *et al.* 1914) particular attention was paid to the altered norite sills east of Nisikkatch Lake. No definite evidence of a genetic connection could be found.

Paragenesis and Origin

A generalized scheme of paragenesis is shown in Fig. 4. The sequence of deposition is complex and may involve several generations of the same mineral. Thus calcite veins are of two definite ages: the early ones carrying quartz and scapolite, the later ones quartz, serpentine and barite. There are two generations of amphibole. The early amphibole is common hornblende whereas the later amphibole is considered to be a sodic variety.

The apatite veins are thought to be part intrusive and part hydrothermal. Sometimes the veins exhibit dilatent structures but the carbonates often occur as veinlets of typical hydrothermal structure. There is no direct evidence of assimilation of limestone as no limestone outcrops have been located in the district. Neither is there evidence of a gradation from normal pegmatites.

The available evidence seems to indicate that the source magma was rich in lime, barium, potassium, rare earths and volatiles. The initial stages of igneous activity were those of intrusion followed by hydrothermal emplacement of carbonate and quartz.

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