

compound is  $\text{CO}_2$  (up to 97%), followed by CO (up to 18%). Hydrogen and nitrogen are also present. Water is usually scarce. Hydrocarbons and traces of HCl are sometimes detected. Thermal analysis shows that release of the fluids often occurs in several distinct steps, at definite temperatures.

From the above results, and from experimental data published by other authors, it appears that the Oka apatites crystallized in the presence of fluid phases, at moderate temperatures. Variations in the shape of the fluid inclusions may reflect changes in the temperature of crystallization. Studied in conjunction with synthetic systems, apatite may thus become valuable as a geologic thermometer in the study of carbonatites.

## PHOSPHATE-SULFATE MINERALIZATION AT THE WHITE MOUNTAIN ANDALUSITE DEPOSIT, MONO COUNTY, CALIFORNIA

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The White Mountain andalusite deposit is on a steep west-facing slope of the White Mountains, Mono County, California.

Andalusite occurs in a massive, north-south trending, dike-like body which is exposed along its strike for 2,500 feet and is 850 feet in width. A smaller body of andalusite occurs south of the main body at a lower elevation, and is believed to be a downward displaced segment of the main body.

The main andalusite body is bounded by both north- and east-trending faults. Due to intense hydrothermal alteration the amount of fault displacement and the relative ages of the different rock types are difficult to decipher. The main andalusite body is bordered on the east by quartz monzonite porphyry, on the west by hydrothermally altered sericite schist and metavolcanic rocks; and is overlain in part by a weakly foliated quartzite.

The main andalusite body consists of irregular, massive, milky quartz and andalusite, zones of quartz-topaz rock, and irregular zones consisting of phosphate and sulfate minerals and quartz. Diaspore, pyrophyllite, and rutile are predominant in hydrothermally altered areas adjacent to the andalusite-bearing rock.

The andalusite deposits suggest several phases of development, which include: pegmatitic, pneumatolytic, and finally hydrothermal alteration. In the pegmatitic stage of mineralization silica and alumina were introduced early, followed by fluorine and boron. This stage was followed by the introduction of phosphates and sulfates. Finally, minerals of complex composition and hydrothermally altered minerals developed within and adjacent to the main andalusite body.

## ORE MINERAL RELATIONS IN THE CUYUNA SULFIDE DEPOSIT, MINNESOTA

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The Cuyuna sulfide deposit is located in south-central Aitkin County in an outlying area of the Cuyuna Iron Range, Minnesota.

The ore minerals of the deposit have been studied systematically by polished section methods. The principal ore minerals are pyrrhotite and pyrite, whereas magnetite and marcasite are subordinate. In addition, sphalerite, chalcopyrite, arsenopyrite, ilmenite, hematite, and goethite are present in minor quantities.

Four generations of pyrite have been recorded, namely, pyrite I, which is sedimentary or diagenetic; pyrite II, which is metamorphic; pyrite III formed directly

from pyrrhotite through oxidation; and pyrite IV evolved from pyrrhotite in a reaction involving marcasite I as an intermediate product.

Magnetite may also be divided into magnetite I, a metamorphic variety; magnetite II, a by-product of pyrrhotite oxidation; and magnetite III, an oxidation product of some supergene sulfides.

There are two generations of marcasite: marcasite I, originating through the pyrrhotite reaction mentioned above and occurring as concretions or veinlets of amorphous to crypto-crystalline nature, and marcasite II, which is found as crystalline aggregates on edges of pyrite III or pyrite IV but not on pyrite I and pyrite II. The second generation is apparently pseudomorphic after pyrite, which, to the author's knowledge, has neither been produced in the laboratory nor reported previously in ores.

The genetic and textural relations displayed by the ore minerals indicate that an iron formation originally containing sedimentary sulfide-carbonate mineral assemblages was profoundly modified through subsequent metamorphic and supergene events.

### MINERAL LINEATION AND "TECTONIC TRANSPORT" IN COLDBROOK ROCKS, BEAVER HARBOUR, NEW BRUNSWICK

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Low-grade metamorphic rocks of the Precambrian(?) Coldbrook Group contains a steep plunging lineation which has regional significance in the Beaver Harbour area.

The lineation is synkinematic with the first and main deformation of the metavolcanic sequence. It is expressed by prismatic actinolite in the basic rocks. Interlayered quartz-feldspathic rocks show blastoporphyritic feldspars with trails of recrystallized minerals in the same orientation as the *c*-axes of the actinolites. Plunges of mesoscopic folds are either parallel to the lineation or have shallower attitudes in the plane of schistosity.

The combined fabric of actinolite, quartz, and mica has orthorhombic symmetry.

The ambiguity regarding the tectonic significance of lineations can be solved for the area studied by a combination of kinematic and dynamic inferences based independently on the observed microscopic fabric of the rock. A kinematic interpretation of the different subfabrics applying Flinn's L-S system allows conclusions about the possible orientation of the principal strain axes. It is established that the lineation is parallel to the longest axis (*Z*) of a triaxial deformation ellipsoid. The intermediate axis (*Y*) has also undergone elongation. The lineation is therefore the maximum extension direction but not a single transport direction.

The fabric is also compared with mineral orientations expected from recent thermodynamic models of mineral crystallization under non-hydrostatic stress. The strain ellipsoid derived by kinematic inferences can be related to stress axes using Kamb's theory.

### SECTOR ZONING IN STAUROLITE, KWOIEK AREA, BRITISH COLUMBIA

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Electron microprobe analyses of a staurolite crystal from the Kwoiek area, British Columbia, a contact metamorphose terrain associated with the Coast Range Batholith, showed that it contains three distinct compositional sectors. Each staurolite sector consists of those parts of the crystal that grew in the [001], [010], or [110] directions. Analyses for the five elements Fe, Mg, Si, Al, and Ti were performed at 10 micron intervals in two crystallographic directions across each of six successive thin sections perpendicular to the *c*-axis of the staurolite crystal.