analyses promise to provide better understanding of the structural modifications of plagioclase feldspars, if not of their quantitative phase relations.

This report of the Feldspar Symposium at Copenhagen is recommended to mineralogists and petrologists as a review of the current state of knowledge of the feldpsars, and as a selected bibliography of more complete accounts of the studies. The Instituto "Lucas Mallada" deserves thanks for making the papers available under one cover.

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PROCEEDINGS OF THE SEVENTH ANNUAL MEETING OF THE MINERALOGICAL ASSOCIATION OF CANADA

The seventh annual meeting of the Mineralogical Association of Canada was held on April 24–25, 1962 at the Chateau Laurier Hotel, Ottawa, Ontario, in conjunction with the annual meetings of the Canadian Institute of Mining and Metallurgy and the Geological Association of Canada.

The general business meeting of the Association was held on April 25 and was chaired by the President, R. M. Thompson; L. G. Berry, Editor, reported that the special issue on Sudbury ores (Volume 7, part 1) would be ready for distribution in May, that the regular issue for 1962 had gone to press, and that a special issue for 1962 was being prepared. Separate copies of the Sudbury issue bound in hard covers would be available for sale to non-members and as extra copies. The publication of two regular issues of The Canadian Mineralogist annually was under consideration.

H. R. Steacy, Treasurer, pointed out that the Association's fiscal year now corresponds to the calendar year and that the balance on hand, on December 31, 1961, was $1865.99.

S. Kaiman, Secretary, reported that 235 ballots were cast in the election of officers. The officers elected to serve in 1962 are:

President	R. M. Thompson	
Vice President	D. H. Gorman	
Secretary	S. Kaiman	
Treasurer	H. R. Steacy	
Committee Members	E. H. G. Cornford	E. H. Nickel
	J. P. Girault	J. A. Gower
	S. A. Forman	G. Perrault

Reports were also heard from E. H. Nickel, chairman of both the Programme Committee and the Membership Committee. The Association now has more than 600 members drawn from over 30 countries.

The annual banquet of the Association on April 25 took the form of a luncheon meeting and was held at the Cathay House Restaurant. The guest speaker was Dr. V. B. Meen of the Royal Ontario Museum and the subject of his talk was "Impressions of some mineral collections in the countries of eastern Europe".

The technical sessions were held on April 24 and April 25. The following are abstracts of the papers presented at the technical sessions.

SPHALERITE-PYRRHOTITE RELATIONSHIPS AT QUEMONT MINE

Finley A. Campbell
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X-ray diffraction techniques were used to analyse 38 sphalerite samples for FeS and 27 pyrrhotite samples for Fe. The samples were selected from throughout the massive sulphides of the Quemont ore zones. The data indicate the average temperature of formation of the sphalerite was 539° C with a standard deviation of ±72° C. The average temperature of formation of the pyrrhotite was 323° C with a standard deviation of ±47° C. This discrepency is explained on the basis of the ore having formed from a sulphide melt with an original sphalerite-pyrrhotite equilibrium at around 540° C, then subsequently the pyrrhotite phase has undergone readjustment in the solid state to form a more iron-rich pyrrhotite plus pyrite. This readjustment was completed at around 325° C.

SULPHOSALTS FROM ALICE ARM, BRITISH COLUMBIA

A. D. Drummond,[1] J. Trotter,[2] and R. M. Thompson[2]

What may be a new Pb-Bi-Cu-Ag-S mineral from a mineral deposit at Alice Arm, British Columbia, is described. The chemical composition is $7PbS.3Bi_2S_3.(Cu,Ag)_2S$. It is monoclinic with space group $C2$, Cm or $C2/m$. Cell dimensions are $a = 37.5$, $b = 4.07$, $c = 41.6$ all ±0.1 Å, $\beta = 96.8°$. The mineral occurs in a number of quartz veins cutting altered quartz diorite and granodiorite as very fine needles and small compact masses. The specific gravity is 7.02±0.1. It is associated with galena, sphalerite pyrite, molybdenite, tetrahedrite, cosalite, aikinite, and an unknown Pb-Bi-Cu sulphosalt. Indexed *x*-ray powder data are given.

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[1] University of California, Berkeley. [2] University of British Columbia.

A STUDY OF SOME CHLORITE DETERMINATIVE METHODS, AND THEIR APPLICATION TO A MINERALIZED SHEAR ZONE AT CHIBOUGAMAU, QUEBEC

O. Roger Eckstrand
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Certain physical properties of 34 analysed chlorites were measured to establish determinative curves; these were used to show that chlorite composition variations may be a sensitive indicator of hydrothermal activity.

The major composition variables of chlorite are (1) the atomic ratio, $Fe^{+2}/(Fe^{+2}+Mg)$ ("iron-magnesium ratio"), and (2) the relative amounts of Si and tetrahedral Al as expressed by the number of Si atoms per 4 tetrahedral sites ("Si no."). The *b* cell dimension of chlorite with Si no. less than 3.0 varies linearly with iron-magnesium ratio according to the equation

$$Fe^{+2}/(Fe^{+2} + Mg) = 5.714\,b - 52.55$$

where *b* is in Ångstroms. Siliceous chlorite (Si no. greater than 3.0) has somewhat larger

b cell dimensions. The refractive index, β, varies non-linearly with iron-magnesium ratio according to the equation

$$Fe^{+2}/(Fe^{+2} + Mg) = 31.25(\beta - 1.575)^2 + 7.375(\beta - 1.575).$$

Either property yields iron-magnesium ratio to within about ±0.07. The $d(001)$ basal spacing (in Ångstroms) correlates roughly with Si no. according to the equation

$$\text{Si no.} = 3.960\, d(001) - 53.42$$

with an error of about ±0.20.

These determinative methods were applied to the Copper Rand sulphide deposit at Chibougamau, Quebec, which occupies the central portion of a broad shear zone cross-cutting meta-anorthosite. The following mineralogical sequence is found in passing inwards toward the ore zone:

	Meta-anorthosite	Outer zone	Intermed. zone	Central zone (includes ore)
Chlorite $\frac{Fe^{+2}}{Fe^{+2} + Mg}$	0.40	0.65	0.70	0.85
Chlorite Si no.	2.6	2.5	3.0	3.0
Other silicates	albite, epidote	paragonite	paragonite, chloritoid	muscovite, chloritoid
Carbonate	(minor calcite)	calcite	ankerite	ankerite, siderite

Changes in muscovite composition as deduced from basal spacing indicate a temperature gradient rising toward the ore zone.

Good correlation between birefringence, refractive index and b cell dimension in the Chibougamau chlorite suggests that birefringence, too, may be a sensitive indicator of iron-magnesium ratio in some cases.

TWINNING IN VECTOR SPACE

Alfred J. Frueh, Jr.
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Twinning of crystals belonging to a merohedral crystal class often results in the superposition of reciprocal lattice points and the appearance of a pseudo-lattice. This can be recognized from the diffraction data by the presence of systematic absences inconsistent with those absences expected from space group symmetry. Because of the superposition of much of the diffraction data, it has been assumed that Fourier methods cannot be applied in the solution of the crystal structures of twinned materials, unless the twins can be separated. However, using two examples (chromium boride, CrB; and arsenopyrite, FeAsS), it will be shown that the "Patterson Map" determined from the diffraction record of a twinned crystal bears a definite relation to the vector map of the untwinned crystal, and that the "Buerger Minimum Method" can be used to convert from vector space into crystal space.

SULPHOSALTS FROM MADOC, ONTARIO[1]

J. L. Jambor
Geological Survey of Canada, Ottawa

A sulphosalt occurring in coarse-grained carbonate rocks from Madoc, Ontario, has been identified as a new mineral. X-ray powder photographs and fluorescence analyses show that it is the antimony analogue of dufrenoysite and the composition is

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[1] Published by permission of the Director, Geological Survey of Canada.

$Pb_2(Sb,As)_2S_5$. Partial analyses gave Pb 50.6% (x-ray, av. of four) and S 20.2% (chem. av. of two); the theoretical antimony end member contains 50.6% Pb and 19.6% S.

The x-ray powder pattern of the Madoc mineral differs from those of kobellite and cosalite but is close to that of dufrenoysite. The strongest lines of the powder pattern are:

Dufrenoysite, $Pb_2As_2S_5$: 3.74 (10), 3.00 (9), 2.70 (8), 3.21 (6)
Madoc, $Pb_2(Sb,As)_2S_5$: 3.82 (10), 3.03 (8), 3.27 (7), 2.76 (6)

The sulphosalt is steel-grey in colour, with a metallic lustre, black streak, and conchoidal fracture. The hardness is 2½ and *D* 5.919 (pycnometer). In reflected light the mineral is white, with moderately strong anisotropism. Etch tests are: $HgCl_2$, $FeCl_3$, KCN, HCl neg.; KOH, HNO_3 positive. Chemical analyses and single crystal x-ray studies are being completed.

Associated minerals include pyrite, arsenopyrite, sphalerite, cuprian jamesonite, tetrahedrite, arsenian boulangerite, bournonite, and several other lead antimony sulphosalts of which at least three are new. One of these is known to be the antimony analogue of sartorite; x-ray powder patterns and etch tests show it to be unrelated to zinkenite and "keeleyite". A second sulphosalt is tentatively identified as the antimony analogue of baumhauerite.

The paragenesis is briefly described.

SEDIMENTARY PHOSPHATE FACIES

J. R. Kramer
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The equilibrium of fluorapatite, hydroxylapatite, calcite and dolomite with sea water of normal composition is considered from 0–30° C, and for total phosphate of 10^{-6} and 10^{-7} m/l. The stability of the minerals is considered with respect to pH and temperature.

The mineral abundance sequence with increasing temperature and pH is determined as fluorapatite, hydroxylapatite, dolomite, calcite. Fluorapatite is saturated in sea water at a pH 7.7 and 5° C and at a pH 6.0 and 30° C. Calcite is saturated at 0° C and pH 8.1 and at 30° C and a pH 7.6. The relatively great amount of carbonate in sea water (10^3 times greater than phosphate) obscures any phosphate precipitation if both carbonate and phosphate minerals are saturated. All minerals considered are stable at higher pH as the temperature decreases.

The geological model suggested for phosphate deposition is cold (either deep or northern latitudes) water and lack of clastic and carbonate deposition. The water should be reducing to keep iron precipitation negligible. The energy gradient for precipitation is suggested as temperature from an upwelling current.

This model fits well with literature descriptions of the mineralogy associated with the "Trenton" phosphates and carbonates of Eastern United States and the Phosphoria formation of Western United States.

DENNINGITE, A NEW TELLURITE MINERAL FROM MOCTEZUMA, SONORA, MEXICO

J. A. Mandarino,[1] S. J. Williams,[2] and R. S. Mitchell[3]

Denningite, $(Mn,Ca,Zn,Mg)Te_2O_5$, has been found in specimens from Mina Moctezuma, near Moctezuma, Sonora, Mexico. It occurs with native tellurium, tellurite, paratellurite, and several new tellurites, especially spiroffite $(Mn,Zn,Ca)_2Te_3O_8$.

Denningite occurs as colourless to pale green platy masses and, rarely, as small euhedral crystals. The crystals are thin plates, octagonal in outline. The mineral has a

hardness of 4, a specific gravity of 5.05, and an adamantine lustre. Denningite is optically uniaxial positive, ω is 1.89, and ϵ is 2.00. Some specimens show a small $2V$ up to 15 degrees.

Chemical analysis of 500 mg. yielded the following results: TeO_2 82.34%, ZnO 2.63%, MnO 10.28%, CaO 4.23%, MgO 0.20%, remainder 0.22%, total 99.90%. The remainder includes CdO 0.02%, PbO 0.01%, Sb_2O_3 0.00%, Al_2O_3 0.00%, FeO 0.00%, CoO 0.04%, NiO 0.00%, excess O_2 0.09%, H_2O 0.03%, insoluble 0.03%, V_2O_5 0.00%, TiO_2 0.00%, Na_2O 0.0%, and K_2O 0.0%. The empirical formula derived from these data is $(Mn_{0.56}Ca_{0.30}Zn_{0.12}Mg_{0.02})Te_{2.01}O_{5.02}$ or, simplified, $(Mn,Ca,Zn,Mg)Te_2O_5$.

Single-crystal x-ray data reveal that the mineral is tetragonal and has a space group of $P4_2/nbc$. The unit cell values are: $a = 8.78 \pm 0.05$, $c = 12.99 \pm 0.05$ Å, and $a:c = 1:1.479$. The unit cell contains $8[(Mn,Ca,Zn,Mg)Te_2O_5]$. Strongest x-ray powder spacings are: 4.40 (strong), 3.36 (strong), 3.11 (medium strong), 2.61 (medium strong), and 2.02 (medium strong).

Denningite is named in honour of Dr. Reynolds M. Denning, Associate Professor of Mineralogy at the University of Michigan, Ann Arbor, Michigan.

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[2] S. J. Williams Mineral Company, Scottsdale, Arizona.
[3] University of Virginia, Charlottesville, Virginia.

SEARCHING X-RAY DIFFRACTION POWDER DATA

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The use of x-ray diffraction powder data as a "fingerprint" to identify crystalline solids is dependent upon established data which must be available for searching in an effective efficient manner. The most complete compilation of data available is that published by the American Society for Testing Materials which lists about eight thousand compounds, of which five thousand are inorganic including about twelve hundred minerals. The organization of these data for efficient searching is being restudied having in mind the use of newer data processing equipment techniques. The types of indices under study will be described.

MINERAL PARAGENESES IN PELITIC SCHISTS, BARRIE AND CLARENDON TOWNSHIPS, ONTARIO

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Carleton University, Ottawa

A metasedimentary sequence trending northeast from the foot of Mazinaw Lake consists principally of interbedded carbonate rocks, mica schist and meta-graywacke. Some carbonate and pelitic members are fine grained and highly graphite. Individual horizons can be traced for up to twenty miles along strike. Study of the mineral associations and structure of this belt is in progress; mineral assemblages and textures of the pelitic schists indicate an increase in metamorphic grade across strike toward the northwest and along strike in the northeast direction. The rocks are all in the almandine amphibolite facies of progressive regional metamorphism. Grade increases from the staurolite-quartz subfacies in the west near Marble Lake to the sillimanite-almandine subfacies in the vicinity of Fernleigh. Mineral compatibilities in the schists are presented graphically; the distribution of major substituting elements among coexisting minerals and its bearing on metamorphic facies boundaries are discussed.

THE KIGLAPAIT LAYERED INTRUSION, COAST OF LABRADOR, CANADA

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A Precambrian layered intrusion of the Skaergaard type occupies an area of about 560 km^2 on the middle north coast of Labrador. Over a thickness of 7800 meters, it displays a virtually complete sequence of cumulates resulting from the fractionation of an alkali basalt magma.

A three-part Border zone and a Layered series are recognized. The layered series contains a lower zone of troctolite, which gives way upward through the appearance of clinopyroxene and black ore to an Upper zone of olivine gabbro. Strong progressive upward enrichment in ferrous and sodic end members takes place in the Upper zone, and the final rock is essentially a larvikite consisting of mesoperthite, fayalite, and ferroaugite.

The path of fractionation is defined with the aid of modal and mineral analyses. Mineral variation is illustrated quantitatively, and crystallization history is discussed in the light of known and extrapolated phase diagrams. Noteworthy features of the intrusion are the complete absence of quartz and the alkalic nature of the parent magma.

The Kiglapait intrusion was emplaced in a terrane of gneisses and migmatites at the outer contact of the large Nain anorthosite mass. K-A dating at M.I.T. of a biotite from a younger marginal granodioritic intrusive indicates a minimum age for the intrusion of 1480±50 million years. Younger, sharply cross-cutting granites give an age of 1140±40 million years.

SOME DATA ON THE ACCURACY OF QUANTITATIVE DETERMINATIONS OF Nb BY *X*-RAY FLUORESCENCE ANALYSIS

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Characteristic *x*-ray fluorescent radiation can be used for quantitative determinations of Nb_2O_5 in pyrochlore concentrates (44 to 60% Nb_2O_5). The accuracy of the determinations is stated to be 0.3% maximum relative error or 0.1% probable relative error. Mineral samples were prepared by fusing in borax and adding BaO_2, a technique developed by Claisse (1956). Statistical analysis of the number of pulses totalized and study of a Norelco *x*-ray fluorescent unit revealed that such an accuracy could be attained fairly readily. This technique could be used for analysis of very small mineral fragments.

SEMI-QUANTITATIVE MINERALOGICAL ANALYSIS OF ORES AND ROCKS BY MEANS OF THE *X*-RAY DIFFRACTOMETER

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The application of the *x*-ray diffractometer to mineralogical analysis of a variety of rocks and ores has been investigated. Three different methods of quantitative analysis are outlined. These are an internal standard method, a method for measuring the mass absorption coefficient of a sample and a method for calculating the mass absorption coefficients of the constituents of a sample. Tests on a variety of known samples indicate that the minerals can be determined by each method with comparable accuracy, and the standard deviation on the error of analysis is about 5%. Further tests indicate that the chief source of error is in sample preparation.

MINERALOGY OF PEGMATITES FROM PALAMOS, SPAIN AND THEIR PETROGENETIC SIGNIFICANCE[1]

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The pegmatite occurrences of Faro de Palamós (Gerona, Spain) in the Catalan Mountain Range are described. These pegmatites form sheets in the coarse-grained porphyritic granite typical of this area. Big porphyroblasts up to 10 cm. in length occur in this granite, showing inclusions of quartz and biotite as well as biotite rims like a small basic front. The pegmatite dykes or sheets have a zoned structure comprising two main bands of aplite separated by coarse-grained roof pegmatites. The sheets have sharp and irregular contacts, and inclusions of flat xenoliths and granite relics can be seen in the margins. The main feature of these pegmatite rocks is the presence, in the aplite bands, of parallel lineations of reddish spessartite garnets. Pegmatites form the roof of this sheet and consist mainly of quartz, oligoclase, perthitic orthoclase, and muscovite.

The main evidence of the metasomatic origin of these large potash feldspar porphyroblasts are: (1) relics of aplite in pegmatite; (2) small aplitic inclusions and garnets in potash feldspar crystals; (3) large feldspar crystals penetrating into aplitic bands; (4) gradation of aplite into pegmatite; and (5) the banded aplites show the effects of tectonic action followed by recrystallization and potassium metasomatism.

The chemical similarity between granite, aplite, and granite porphyroblasts is clearly seen. Microscopic examination, field evidence, and chemical and x-ray data lead to the conclusion that the aplite-pegmatite complex was formed as the result of two principal phases of a metamorphic-metasomatic process: (1) The formation of banded aplites with garnets due to tectonic sliding that crushed the granite, transforming it into granite of aplitic character; and (2) A later dilationary tectonic phase accompanied by potassium metasomatism in the "movement zones," causing pegmatitic replacement.

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[1]Presented by title.

GEOCHEMISTRY OF SOME GRENVILLE SKARNS

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Coarse-grained skarns are abundant throughout the Grenville province wherever marble is found, and are the most common in regions of high metamorphic grade. The principal minerals present are pink calcite, clinopyroxene, scapolite, amphibole mica and sphene: some varieties are rich in potash feldspar and plagioclase, fluorite, quartz, apatite, allanite, zircon, pyrite, thorian uraninite and uranothorite.

Mineralogical composition varies widely, and over short distances (a few cm.). Nevertheless 5 main assemblages can be recognized: scapolite-pyroxene, pyroxenite, pink calcite rich, pyroxene-feldspar-quartz, purple fluorite rich. At numerous localities in S.W. Quebec and S.E. Ontario it may be demonstrated that these skarns show petrographic transition to normal Grenville amphibolites, marbles, granites, gneisses and pegmatites, which therefore have in part contributed to the formation of the skarns. Other contributory processes include *in situ* metasomatism, metamorphic differentiation, vein and pegmatite deposition, bulk flowage and injection. In most cases skarn formation was the last event recorded in the precambrian history of the region, but some of the skarns have been affected by later shearing.

Many radioactive deposits are located in the skarns or in related granitic and syenitic pegmatites. However some were clearly emplaced by fracture control and show no evident relationship to the host rocks. It is therefore difficult to relate all the radioactive deposits to the processes of skarn formation.

Chemical analyses were made of 6 scapolites, 6 pyroxenes and 2 feldspars. Spectro-

graphic trace element analyses were made for numerous elements in 40 scapolites, 38 pyroxenes, 29 calcites, 5 amphiboles and 2 feldspars.

The elements Ca, B, Be, Ga, Li, Mn, Y, Sr, Pb are commonly enriched in the skarn minerals. To these may be added F, Cl, S, P, Zr, TR, Ti, U, Th, in many cases. B is always richer than in the crust, and the same is probably true of Cl, Be, Li, Mn, Y, Sr and Pb.

The assemblage scapolite-diopside-sphene is the most widespread. It formed under upper amphibolite facies conditions, and is sufficiently common in many parts of the world to justify its retention as a new metamorphic facies characteristic of environments rich in CO_2 and Cl_2 but lower in H_2O.

Evidence of the environment of formation of the skarns is scanty and difficult to interpret, but a temperature of 300–400° C at a depth of 20–25 Km are reasonable. It is probable that the skarn-forming fluids were produced by remobilisation of crustal materials by plutonic metamorphism.

UPPER CONTACT PHASE OF THE SUDBURY MICROPEGMATITE

John S. Stevenson
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The upper portion of the micropegmatite member of the Sudbury Nickel Irruptive shows striking evidence of both assimilation and rapid cooling. This upper part is characterized by numerous assimilated inclusions of granitized, hangingwall quartzite and by an abundance of relict quartz that is outside of and not a constituent of the normal micrographic intergrowth of the micropegmatite. The generally fine-grained and aligned lath-like habit of the micropegmatite plagioclase immediately around and invading the inclusions, as compared with the coarse-grained and blocky plagioclase away from the inclusions, strongly suggests rapid cooling of micropegmatite magma around cold inclusions. Evidence of rapid cooling may also be seen in the fine-grained, aligned plagioclase laths of the micropegmatite where it invades and replaces the matrix of the overlying quartzite breccia.

MICROTEXTURAL SEQUENCES IN ROCKS AND ARTIFICIAL CRYSTALLIZATIONS

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Certain microtextures belonging to rocks and artificial crystallizations are shown to comprise sequences that unfold with continuing heat treatment. A textural sequence can be followed microscopically with polarized transmitted light where the crystallizing phase is nonopaque and birefringent. Other kinds of microscopy are helpful supplements.

A sequence can begin with a fibroid texture, reminding one of chalcedony or flamboyant vein quartz, and end with a granular texture or with a metacrystalline texture. The fibroid texture may be spherulitic. The metacrystalline texture may be conspicuously porphyroblastic.

Illustrations are taken from rocks, devitrifications, ceramics, and other materials. Factors are discussed that influence grain size and that determine the textural features and sequences. Uses of the information are indicated.