

In tributary loc.

DEPARTMENT OF
ENERGY, MINES AND RESOURCES

MINES BRANCH

SCIENTIFIC AND TECHNICAL PAPERS

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FOREWORD

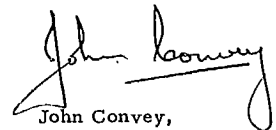
Information Circular IC 151 (June, 1963) was the first in a series of annual reviews of the scientific and technical papers published by the staff of the Mines Branch. This Information Circular is the sixth supplement to IC 151 and is divided into three sections.

Section 1 consists of the titles of papers published during 1968 in the Mines Branch Series (Monographs, Research Reports, Technical Bulletins, Information Circulars and Reprint Series) together with an abstract or summary of each paper. These reports are available from the Queen's Printer, Ottawa, at the prices indicated and may be ordered by the catalogue number given for each report. (Pre-1962 reports are listed in Canadian Government Sectional Catalogue No. 12, July 1962).

Section 2 lists the titles of all papers published in scientific and technical journals during 1968 by the Mines Branch staff. The periodicals containing these papers are available in many technical libraries.

Section 3 contains a list of the 1968 titles available in the Investigation Report Series and also of the titles from previous years that now have been released for general distribution. This series includes the results of investigations carried out by the Mines Branch at the request of industry and other government agencies and also of investigations initiated by the Mines Branch of specific materials and processes. Many Investigation Reports are not available because they are either confidential or of very limited interest. Those that are listed in the Information Circular are available for reference in the divisional files, but in most cases there are no additional copies for distribution. However, it is felt that even this limited availability will be of value to many individuals or companies with specific interests and will help prevent unnecessary duplication of investigations already made by the Branch.

I hope that this supplementary index will be as well received as the first in this series and that it will provide the reader with a more complete view of the work of the Mines Branch in aiding Canada's mineral and metallurgical industries.



John Convey,
Director

AVANT-PROPOS

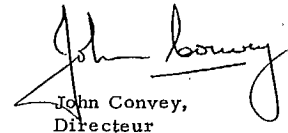
La Circulaire d'information IC 151 (juin 1963) était la première d'une série de revues annuelles des travaux scientifiques et techniques publiés par le personnel de la Direction des mines; La présente circulaire, qui comprend trois sections, est le sixième supplément à IC 151.

La première section comprend les titres des travaux publiés en 1968 dans les séries de la Direction des mines (monographies, rapports de recherches, bulletins techniques, et circulaires d'information), ainsi qu'un résumé ou un sommaire de chaque étude. On peut obtenir ces différents rapports chez l'Imprimeur de la Reine, à Ottawa, aux prix indiqués; en les commandant d'après leur numéro au catalogue. (La liste des rapports publiés avant 1962 figure dans le Catalogue partitif n° 12 du gouvernement canadien).

La section 2 comprend les titres de tous les travaux publiés par la Direction des mines en 1968 dans les revues scientifiques et techniques. Encore ici, un résumé de l'étude accompagne chaque titre, afin de donner au lecteur un aperçu de la teneur. Les périodiques où paraissent ces travaux sont à la disposition du public dans plusieurs bibliothèques techniques.

La section 3 énumère les titres des travaux qui ont paru dans la série des Rapports d'Investigations en 1968 et auparavant qui ont été rendus publics. Cette série comprend les résultats des recherches effectuées par la Direction des mines à la demande de l'industrie et d'autres services officiels, ainsi que les résultats des recherches entreprises par la Direction des mines sur des matériaux et procédés déterminés. Plusieurs de ces Rapports d'Investigations ne peuvent être consultés à cause de leur nature confidentielle ou du peu d'intérêt qu'ils présentent. Ceux qui sont énumérés dans la présente circulaire d'information peuvent être consultés dans les archives des diverses divisions, mais, dans la plupart des cas, il n'existe pas d'exemplaires pour la distribution au public. Cependant, on estime que même cette disponibilité limitée est de nature à favoriser de nombreux particuliers ou des sociétés qui s'intéressent à des domaines très précis et contribuera à éliminer le double emploi inutile en ce qui concerne les recherches déjà effectuées par la Direction.

J'espère que cet index supplémentaire sera aussi bien accueilli que les précédents dans cette série et qu'il présentera au lecteur un inventaire plus complet des travaux effectués par la Direction des mines au service des industries minérales et métallurgiques canadiennes.


John Convey,
Directeur

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Section 1 - Mines Branch Series

RESEARCH REPORTS

R 175 Ceramic Clays and Shales of Ontario

J.G. Brady* and R.S. Dean**

Forty-nine representative samples of Ontario clays and shales, mostly from well-populated areas, were investigated by X-ray diffraction, differential thermal analysis, drying and firing techniques, and chemical analysis. With the exception of the kaolinitic Cretaceous clays of the Missinaibi valley of northern Ontario, all samples were found to be low-fusion, heterogeneous materials. The shales have the most favourable properties for brick making, whereas many of the surface clays are suitable only for the manufacture of partition and drain tile.

Nine typical samples were selected for special study by plastography, thermogravimetry, dilatometry, and temperature-gradient firing. Processing problems, such as short firing ranges, heating and cooling cracks and kiln atmosphere, are discussed in relation to mineralogical composition.

The mineralogical investigation revealed that the Palaeozoic shale samples of Ontario contained a clay mineral suite consisting essentially of illite and chlorite. Common non-clay shale constituents included quartz, carbonates, and plagioclase.

A study of the differences between clay mineral suites derived from the Canadian Shield and the Palaeozoic sedimentary rocks led to the discovery of mineralogical criteria whereby the origin of the clay minerals within individual Pleistocene clay deposits could be recognized.

Clay containing the Palaeozoic clay mineral suite occurred throughout southern Ontario west of Toronto. Weathering alteration of these usually resulted in the formation of "frayed edge" clay mineral structures which often consisted of multi-component mixed-layer systems. In several instances both chlorite and illite were thus affected, although the alteration of the more labile trioctahedral chlorite was generally greater.

The Shield-derived clays contained highly varied, structurally disordered, clay mineral assemblages which were invariably rich in expandable phases, some of which occurred as unmixed minerals. A characteristic suite of non-clay constituents, rich in plagioclase, amphibole and K-feldspar, was also associated with the Shield-derived material.

Quarante-neuf échantillons représentatifs des argiles et des schistes d'Ontario, la plupart provenant de régions densément peuplées, ont été analysés par les procédés suivants: diffraction des rayons X, analyse thermique différentielle, séchage et cuisson, et analyse chimique. À l'exception des argiles de kaolin du Crétacé, qu'on trouve dans la vallée Missinaibi, Nord de l'Ontario, tous les échantillons sont constitués de matériaux hétérogènes et à basse température de fusion. Les schistes constituent d'excellentes matières premières pour la fabrication de la brique, alors qu'une bonne partie des argiles de surface ne peuvent servir qu'à la fabrication de blocs de cloisons et de tuyaux de drainage.

Neuf échantillons représentatifs furent mis à part pour une étude plus poussée: plastographie, thermogravimétrie, dilatométrie, et gradient de températures de cuisson. Des difficultés de traitement: courtes gammes de cuisson, fissures de cuisson et de refroidissement, et atmosphère du four, sont étudiées en fonction de la composition minéralogique.

L'examen minéralogique a démontré que les échantillons de schistes paléozoïques d'Ontario contiennent un groupe de minéraux argileux apparentés constitués essentiellement d'illite et de chlorite. Les composants non argileux des schistes comprennent le quartz, les carbonates et le plagioclase.

Une étude comparative entre les éléments minéraux argileux en provenance du Bouclier canadien et des roches sédimentaires du paléozoïque a fourni quelques critères minéralogiques qui permettraient de déterminer le lieu d'origine de minéraux argileux contenus dans un gisement donné d'argile du pléistocène.

Les argiles contenant le groupe de minéraux argileux du paléozoïque se rencontrent dans tout le sud de l'Ontario à l'ouest de Toronto. L'atmosphérisation de ces minéraux leur donne ordinairement une structure "à bords frangés" et ils sont souvent organisés en systèmes à couches mixtes inter-stratifiés sans ordre. Dans plusieurs cas, la chlorite et l'illite ont été tous deux altérés, bien que l'altération de la chlorite trioctaédrique, plus instable, soit plus prononcée.

Les argiles constitués d'éléments provenant du Bouclier contiennent des assemblages de minéraux argile très variés et mal structurés, qui sont tous riches en phases expansibles; quelques-uns de ces assemblages se présentent sous forme de minéraux purs. Un groupe caractéristique de composants non argileux, riches en plagioclase, amphibole et feldspath potassique, était associé aux matériaux rocheux provenant du Bouclier.

*Head, Ceramic Section and **Research Scientist, Ore Mineralogy Section, Mineral Processing Division.

Price: \$1.25

Cat. No. M 38-1/175

R 194 The Hydrogenation of Alberta Bitumen over Cobalt Molybdate Catalyst

M. A. O'Grady* and B. I. Parsons**

A laboratory investigation of the hydrogenation of Alberta bitumen over oxide and sulphide forms of commercial cobalt molybdate catalyst is described. Experiments were made with four reaction-bed preheater arrangements: a) porcelain berl saddles in both the preheater and the reaction bed (a no-catalyst system); b) porcelain packing in the preheater section, followed by the oxide form of cobalt molybdate catalyst in the reaction bed; c) the oxide form of the cobalt molybdate catalyst in both the preheater and the reaction bed; and d) the sulphide form of the cobalt molybdate catalyst in both the preheater and the reaction bed. Coke was found to form quickly in the systems where porcelain packing was used in the preheater section. Much improved operating life and activity were observed when the oil feed was brought up to temperature on catalyst packing. A marked increase in activity and operating stability was also observed when the bitumen was diluted slightly with a heavy gas-oil fraction. From the standpoint of the conversion of residuum to distillable oil, the all-sulphide catalyst system was more effective than the oxide, but the all-oxide system was more stable in operation and removed more sulphur. Under conditions where a high proportion of the products was in the liquid phase, the activity of the oxide system changed little with operation, whereas the activity of the sulphide catalyst decreased rapidly.

Les auteurs décrivent des expériences de laboratoire en l'hydrogénation du bitume d'Alberta en présence des formes oxydées et sulfurées du catalyseur commercial "cobalt molybdate". L'expérience portait sur quatre arrangements du lit de réaction et du préchauffeur: a) selles de Berl en porcelaine à la fois dans le préchauffeur et dans le lit de réaction (système sans catalyseur); b) garnissage en porcelaine dans la section du préchauffeur, suivi de la forme oxydée du catalyseur "cobalt molybdate" dans le lit de réaction; c) la forme oxydée du catalyseur "cobalt molybdate" à la fois dans le préchauffeur et dans le lit de réaction; et d) la forme sulfurée du catalyseur "cobalt molybdate" à la fois dans le préchauffeur et dans le lit de réaction. On a constaté que le coke se formait rapidement dans les systèmes où le garnissage de porcelaine était utilisé dans la section du préchauffeur. Une grande amélioration de la durée d'utilisation et de l'activité a été observée quand l'huile d'alimentation sur le garnissage catalytique a été amenée à la température du catalyseur. Un accroissement marqué de l'activité et de la stabilité de fonctionnement a été aussi observé quand le bitume était dilué légèrement par une fraction lourde de gas-oil. Du point de vue de la conversion du résidu en huile distillable, le système utilisant la forme sulfurée du catalyseur s'est avéré plus efficace que le système à forme oxydée, mais ce dernier a fait preuve d'une plus grande stabilité de fonctionnement et éliminait plus de soufre. Quand une forte proportion des produits était à la phase liquide, l'activité du système à catalyseur oxydé a peu varié avec le temps, tandis que l'activité du catalyseur sulfuré a diminué rapidement.

* Technician and ** Research Scientist, Catalysis Section, Fuels Research Centre.

Price \$1.00

Cat. No. M38-1/194

R 196 Studies of the Double Layer at the Oxide-Solution Interface

S. M. Ahmed* and D. Maksimov**

The double layer at the oxide-solution interface has been examined by studying the equilibrium distribution of the potential-determining ions (H^+ and OH^-) at the interface as a function of their electrochemical potentials. The oxides investigated were alumina, cassiterite, hematite, magnetite, rutile, thorium, and zirconia in solutions of KNO_3 , KCl and $NaClO_4$. Information has been obtained on the zero point of charge, the surface charge densities (q_s), the differential capacities (C_s), and the effect of q_s on the interfacial tension. The data are discussed with respect to current theories of the double layer.

On a examiné la double couche électrique à l'interface oxyde-solution en étudiant la distribution à l'équilibre des ions qui déterminent le potentiel (H^+ et OH^-) à l'interface en fonction de leurs potentiels électrochimiques. Les travaux ont porté sur l'alumine, la cassitérite, l'hématite, la magnétite, le rutile, ainsi que les oxydes de thorium et de zirconium dans des solutions de KNO_3 , KCl et $NaClO_4$.

On a obtenu des renseignements sur la valeur du point de charge zéro, des densités superficielles de charge (q_s), des capacités différentielles (C_s), ainsi que sur l'effet de q_s sur la tension interfaciale. On a discuté les résultats en regard des théories courantes sur la double couche.

*Research Scientist, Surface Science Group, Mineral Sciences Division.

** Visiting Scientist (1964-68), from Skochinsk Mining Institute, Moscow, U. S. S. R.

Price \$1.25

Cat. No. M38-1/196

TECHNICAL BULLETINS

TB 90 The Effects of Alloying Additions upon the Polarization Behaviour of Aisi Type 430 Stainless Steel

G. J. Biefer* and J. G. Garrison**

Anodic and cathodic polarization measurements were performed in normal H_2SO_4 , with and without an addition of 0.5 normal NaCl, on AISI Type 430 stainless steels alloyed with each of Mo, V, W, Ta, Si, Re, Pd, and Ge. For each addition, the changes brought about in anodic and/or cathodic polarization behaviour were related to changes in corrosion resistance in sulphuric acid and in other aqueous corrodants.

Des mesures de polarisation anodique et cathodique ont été effectuées dans une solution de H_2SO_4 N et une autre de H_2SO_4 N et NaCl 0.5 N, sur les aciers inoxydables de type AISI 430 alliés tour à tour avec Mo, V, W, Ta, Si, Re, Pd, et Ge. A chaque addition, les changements notés dans la polarisation anodique ou cathodique étaient reliés aux changements de la résistance à la corrosion dans l'acide sulfurique et autres corrodants aqueux.

*Head and **Technical Officer, Corrosion Section, Physical Metallurgy Division.

Price: 75 cents

Cat. No. M34-20/90

TB 91 A Comparison of Field and Laboratory Corrosion Tests of AISI Type 430 Stainless Steels

J. G. Garrison* and G. J. Biefer**

Field tests and accelerated dip-and-dry laboratory tests were carried out to determine the effects of additions of uranium and molybdenum on the corrosion properties of AISI Type 430 stainless steel used as automotive trim.

A slight increase in corrosion resistance was obtained with an alloy containing 0.24% uranium, while no deleterious effect was experienced with an alloy containing 0.55% uranium. Increased corrosion resistance was observed with increased molybdenum for two alloys, one of which contained 1.02% and the other 2.03% molybdenum.

Correlation of results between the accelerated dip-and-dry laboratory tests and the field tests was not entirely satisfactory. There was, however, some area of agreement between these tests, and further use of the accelerated laboratory test appears warranted.

Les auteurs ont fait des essais accélérés d'immersion suivie du séchage en laboratoire, ainsi que des essais en service, afin de déterminer les effets des additions d'uranium et de molybdène sur les caractéristiques de corrosion de l'acier inoxydable de type AISI 430 employé comme garniture d'automobile.

Une légère augmentation de résistance à la corrosion a été obtenue pour un alliage contenant 0,24 p. 100 d'uranium. Une amélioration de la résistance à la corrosion a été observée à la suite d'une augmentation à 1,02 p. 100 de la teneur en molybdène dans un des deux allages, et à 2,03 p. 100 dans l'autre.

La corrélation des résultats des essais accélérés d'immersion suivie du séchage en laboratoire et des essais en service n'a pas été entièrement satisfaisante. Certains résultats ont concordé cependant dans les deux essais et il semble que d'autres essais accélérés en laboratoire soient justifiés.

*Technical Officer and ** Section Head, Corrosion Section, Physical Metallurgy Division.

Price: 50 cents

Cat. No. M 34-20/91

TB 97 The Fatigue Properties of Materials

E. G. Eeles* and R. C. A. Thurston**

Fatigue is the process responsible for the majority of service failures of engineering components and structures, and consequently its many ramifications have been intensively studied by physicists, metallurgists and engineers. The process consists essentially of two separate stages, crack initiation and crack propagation, which are affected differently by external variables. The mechanisms responsible for the development of these two stages, the parameters which control them, and the empirical relationships derived for the use of design engineers, are discussed on the basis of the most recent available information. Attention is drawn to those areas where further fundamental or applied research is required, and some of the limitations of existing theories are mentioned.

The fatigue properties of ultra-high-strength steels, aluminum alloys, titanium alloys, and composite materials (both metallic and non-metallic), are presented and discussed in terms of the foregoing review. In particular, the effects of the environment are examined in the light of the theme of the International Symposium on MATERIALS, KEY TO EFFECTIVE USE OF THE SEA, held in New York, N. Y., September 12 - 14, 1967.

La fatigue est la principale cause de rupture des matériaux et des charpentes. C'est pourquoi les ingénieurs, les physiciens et les métallurgistes ont minutieusement étudié les nombreuses manifestations de ce phénomène. Le déroulement de ce processus comprend deux principales étapes distinctes que les facteurs extérieurs influencent de façon différente: la naissance et la propagation des fissures. Cette étude se fonde sur les données les plus récentes et porte sur l'évolution de ces deux stades, les paramètres qui les régissent et les conséquences pratiques qu'on a étudiées à l'intention des concepteurs. On met l'accent sur les domaines qui nécessitent de plus amples recherches théoriques et expérimentales et l'on fait état de certaines des limites des théories actuelles.

Cette étude présente et analyse la fatigue la fatigue des aciers à très grande résistance, des alliages d'aluminium des alliages de titane et des matériaux mixtes (composés de matériaux métalliques et autres). Une place est réservée à l'étude de l'influence du milieu, à la lumière du thème du symposium international des Matériaux, Clé de l'Utilisation rationnelle des Océans, qui a eu lieu à New-York, du 12 au 14 septembre 1967.

*Research Scientist and **Head of Engineering Physics Section, Physical Metallurgy Division,

Price: \$1.00

Cat. No. M34-20/97

TB 98 Sea Water Crevice Corrosion Tests of Uranium-Bearing AISI Type 430 Stainless Steels

J. G. Garrison* and G. J. Bieffer**

Tests were conducted to determine the effects of uranium additions in the optimum range of about 0.25-0.5% on the resistance to crevice corrosion of AISI Type 430 stainless steel when immersed in sea water.

As compared with a similar uranium-free steel, there was an improved resistance to crevice corrosion for steels containing 0.24% and 0.55% uranium. However, reproducibility of the results was poor; none of the alloys tested performed well, and it was concluded that uranium additions cannot be relied upon to suppress crevice corrosion attack in Type 430 stainless steel.

Des épreuves ont été faites pour déterminer les effets des additions d'uranium, dans les proportions idéales d'environ 0,25 à 0,5 p 100, sur la résistance à la corrosion des fissures de l'acier inoxydable de type 430 AISI lorsqu'il est immergé dans l'eau de mer.

Par comparaison avec un acier semblable sans uranium, on a noté une résistance accrue à la corrosion des fissures chez les aciers contenant 0,24 p. 100 et 0,55 p. 100 d'uranium. Cependant, la reproductibilité des résultats a été médiocre; aucun des alliages soumis à l'épreuve n'a donné un bon rendement et on en a conclu qu'il ne faut pas compter sur les additions d'uranium pour supprimer l'attaque corrosive des fissures dans l'acier inoxydable de type 430.

*Technical Officer and **Head, Corrosion Section, Physical Metallurgy Division.

Price: 50 cents

Cat. No. M34-20/98

TB 99 Formulation and Growth of Present Ideas on Heat-Affected-Zone Cracking

K. Winterton*

Heat-affected-zone cracking is a problem in the metal-arc welding of hardenable steels. Encountered first in welding armour, the problem has persisted because high strength is now demanded in steels for many purposes.

There are four main factors responsible:

- a) The hardenability of the steel, which depends on carbon and alloy content.
- b) The cooling rate in the joint, which depends on heat input, thermal severity and ambient temperature.
- c) The hydrogen available in the heat-affected zone, most commonly derived from moisture in the electrode covering.
- d) Stresses built up in the joint because of thermal contractions.

The origins of the salient ideas about the problem have been traced among the more important contributions to an abundant literature on the subject:

The fairly obvious dangers of heat-affected-zone cracking are dealt with briefly.

Methods of varying complexity, based mainly on the elimination of hydrogen and the control of heat input, are described for the prevention of heat-affected-zone cracking.

La fissuration due à la chaleur est un problème qui se pose dans le soudage à l'arc des aciers trempants. D'abord soulevé dans le soudage des armatures, ce problème subsiste à cause de la présente demande d'acier à haute résistance pour de nombreux usages.

Quatre facteurs principaux sont responsables:

- a) la trempabilité de l'acier qui dépend de la teneur en carbone et en métaux alliés;
- b) la vitesse de refroidissement dans les joints qui dépend de l'apport calorifique, de l'intensité de la chaleur et de la chaleur et de la température ambiante;
- c) l'hydrogène disponible dans la zone chauffée, provenant surtout de l'humidité contenue dans l'enrobage de l'électrode;
- d) les tensions accumulées dans le joint à la suite de contractions thermiques.

L'origine des idées marquantes relatives au problème a été retracée parmi les contributions les plus importantes à une abondante documentation sur le sujet. L'auteur traite brièvement des dangers les plus évidents de la fissuration due à la chaleur.

L'auteur décrit des méthodes plus ou moins complexes, de prévention de la fissuration due à la chaleur; ces méthodes sont fondées principalement sur l'élimination de l'hydrogène et le contrôle de l'apport calorifique.

*Head, Welding Section, Physical Metallurgy Division.

Price: 25 cents

Cat. No. 34-20/99

TB 100 A Method of Estimating the Amount of Hydrogen Required to Upgrade Residual Oils and Tars

B. I. Parsons*

The hydrogen required to refine (by hydrogenation) a high-residuuum oil is the sum of the hydrogen involved in four separate processes: (a) the hydrogen added to the residuum material to lower the specific gravity and improve hydrocarbon quality, (b) the hydrogen consumed in the removal of impurities, and the hydrogen removed from the system in the course of processing by the formation of (c) gases and (d) coke. In the following article a method is described for estimating the amount of hydrogen required in each step. The results of general (nominal) calculations for feed stocks of specific gravity 1.04, 0.98, 0.963 and 0.936 are presented in graphical form. Major factors taken into account in the calculations are the volume yield and specific gravity of the liquid product and the composition of the gases formed. Interpolation of the graphs for the preparation of estimates of hydrogen requirements for particular feed stocks and products is easy and quick. A typical application of the method to the processing of whole-crude and coker distillates from the Alberta Bituminous Sands Deposits is discussed.

La quantité d'hydrogène requise pour raffiner (par l'hydrogénation) un pétrole à résidus lourds se mesure à la quantité totale consommée dans quatre procédés individuels: a) l'hydrogène ajouté aux résidus pour abaisser le poids spécifique et améliorer la qualité de l'hydrocarbure, b) l'hydrogène consommé dans l'élimination des impuretés, et l'hydrogène éliminé du système au cours du traitement par c) la formation de gaz et d) la production de coke. L'auteur décrit une méthode qui permet d'évaluer la quantité d'hydrogène requise à chaque étape. Les résultats des calculs généraux (nominiaux) relatifs aux bruts d'alimentation pour des poids spécifiques de 1.04, 0.98, 0.963 et 0.936 sont présentés sous une forme graphique. Les principaux facteurs dont l'auteur a tenu compte dans les calculs sont le rendement volumétrique et le poids spécifique du produit liquide, et la composition des gaz formés. Il est facile et rapide de procéder à l'interpolation des graphiques et ainsi évaluer les quantités d'hydrogène requises pour des bruts d'alimentation et des produits particuliers. L'auteur donne aussi un exemple d'application de la méthode au traitement de brut entier et de distillats de cokéfaction provenant des sables bitumineux de l'Alberta.

*Research Scientist, Catalysis Section, Fuels Research Centre.

Price: 75 cents

Cat. No. M34-20/100

TB 101 Tentative Specifications: Test for Percolation Rate, or Coefficient of Permeability, of Fill

Ground Control Research Group, Mining Research Centre, Mines Branch

To provide the benefits of obtaining a measure of the percolation rate of fill that can be related to previous experience and to the practices of others, a tentative standard is proposed for use by Canadian mining companies. A draft of this tentative specification was examined by selected companies of the Mining Association of Canada which made suggestions for modifications. It is possible that further improvements can be made which will come to light after using the procedure. In this way, it is expected that the specification will evolve into a firm standard for Canada.

The report includes the specifications for a Quick Test to be used for routine quality control. Specifications for a Long Test are also provided for use in special studies and research.

Si un essai standard du taux de percolation du remblai était fait, l'expérience antérieure serait plus utile qu'à présent. Conséquemment, il est proposé qu'un tel essai soit entrepris pour usage par les sociétés minières canadiennes. Des compagnies choisies, de la Mining Association of Canada, ont commencé à examiner ce mémoire préparatoire sur les spécifications en vue d'y apporter quelques changements, si nécessaire. Il serait possible d'améliorer ce procédé après qu'il aurait été mis en application. De cette manière nous comptons que ce mémoire sur les spécifications évoluera en une réglementation reconnue à travers le Canada.

Ci-inclus dans le rapport, se trouvent les détails d'un essai rapide employé ordinairement pour déterminer le contrôle de la qualité du remblai. Les détails d'un essai prolongé sont aussi fournis pour les cas d'études spécialisées et pour la recherche.

Price: 50 cents

Cat. No. M34-20/101

TB 105 The Effect of Agitation in the Cyanidation of Gold Ores

B. H. Lucas* and W. A. Gow**

The effect of agitation on the leaching rate of gold from ore of the Lamaque Mining Company Limited was investigated. Leaching-solution velocities, relative to the ore particles, of from 25 to 150 cm per minute were studied by passing the solution at various flow rates through a static bed of the ground ore. The lowest velocity investigated was that occurring in an air-lift agitator. Along with the static-bed tests, other tests were made in which the slurry was stirred vigorously with a high-speed stirrer. These stirred tests were done to simulate high-speed agitation and were presumed to result in much higher velocities of solution relative to the ore than those used in the static-bed tests.

It was concluded that the rate of cyanide leaching of gold from this ore was independent of the solution velocity relative to the ore particles in the range of velocities studied. The practical significance of this is that the gold leaching rate from ore similar to that used in this work would be independent of the type of reactor used for leaching.

Les auteurs ont étudié l'effet de l'agitation sur le temps de lessivage du minerai d'or de la compagnie Lamaque Mining Limitée. Ils ont étudié des vitesses relatives solution-minerai de l'ordre de 25 à 150 cm par minute, obtenues en faisant passer la solution à des vitesses différentes à travers une couche statique de minerai broyé. La vitesse la plus faible étudiée a été celle produite dans un agitateur à injection d'air. En plus de ces essais comportant des couches statiques, on en a effectué d'autres où les boues étaient vigoureusement brassées dans un agitateur à grande vitesse. Ces essais de brassage ont été effectués pour simuler l'agitation à grande vitesse et étaient présumées produire des vitesses relatives solution-minerai beaucoup plus élevées que celles obtenues lors des essais avec couches statiques.

Les auteurs ont conclu que le temps de lessivage de ce minerai au cyanure dans la gamme des vitesses étudiées ne dépendait pas de la vitesse de la solution par rapport aux particules de minerai. Il ressort de cette étude que le temps de lessivage de minerais de cette nature ne dépend pas du genre de réacteur utilisé.

*Research Scientist and **Head, Hydrometallurgy Section, Extraction Metallurgy Division.

Price: 50 cents

Cat. No. M34-20/105

INFORMATION CIRCULAR

IC 195 An Index of the Scientific and Technical Papers Published by The Staff in 1966

Price: 50 cents

Cat. No. M 38-3/195

IC 197 Application of a New Method for the Calculation of Force Constants.

By Wolfgang Sawodny, Alois Fadini and Kurt Ballein. (Laboratory for Inorganic Chemistry of the Technische Hochschule, Stuttgart.) Received 13th August, 1964. SPECTROCHIMICA ACTA, Vol. 21, pp. 995-1006. Translated by A.H. Gillieson*#.

A method is presented which permits calculation, by means of a digital computer, of a complete set of force constants, using only the vibrational frequencies and the geometry of a molecule. The eigenvalues containing the vibrational frequencies are connected with the force constant matrix by the CAYLEY-HAMILTON theorem. This is resolved by the NEWTON method. As a first approximation the normal vibrations are assumed to be completely uncoupled. Then the known interactions of the kinetic energy are introduced stepwise and so a set of force constants is obtained which contains all the interaction terms of the potential energy.

Cette méthode permet, au moyen d'un calculateur digital, d'établir une série complète de constantes de force en utilisant uniquement des fréquences de vibration et la géométrie d'une molécule. Les valeurs propres contenant les fréquences de vibration sont reliées à la matrice de la constante de force par le théorème de Cayley-Hamilton. On résout l'équation par la méthode de Newton. Dans une première approche, on assume que les vibrations normales sont tout à fait libres. On introduit alors graduellement dans les calculs les interactions connues de l'énergie cinétique, de sorte qu'on obtient une série de constantes de forces contenant tous les termes d'interaction de l'énergie potentielle.

*Head, Spectrochemistry Section, Mineral Sciences Division.

#By permission of the authors, December 20, 1967.

Price: 50 cents

Cat. No. M 38-3/197

IC 198 Current Applications of Spectroscopic Analysis (Emission, X-Ray Fluorescence and Atomic Absorption) in Industry and Research in the United Kingdom

G. L. Mason*

This communication reports on a series of visits made to various industrial plants and research organisations in the United Kingdom during July and early August, 1967. The basic object of these visits was to obtain up-to-date information of current analytical applications of emission spectroscopy, covering as wide a field as possible, from minerals to metals. Further, since the allied techniques of X-ray fluorescence and atomic absorption could be covered just as easily at the same time, these were included in the survey. Also included in the itinerary, and reported herein, was an attendance at the Summer Conference of the Spectroscopy Group, held at Birmingham University on the 6th and 7th July. The theme of the Conference was "Accuracy of Spectroscopic Methods".

Cette communication fait état d'une série de visites dans diverses entreprises industrielles et centres de recherches du Royaume-Uni en juillet et au début d'août 1967. Il s'agissait d'obtenir des données récentes en matière de spectroscopie d'émission, dans un domaine aussi vaste que possible, des minéraux aux métaux. Cette étude portait également sur les techniques connexes de la fluorescence aux rayons X et de l'absorption atomique, qu'il était facile de vérifier par la même occasion. L'itinéraire comprenait également la participation à la Conférence d'été des spécialistes en spectroscopie, dont un aperçu est donné dans la présente communication, qui s'est déroulée à l'université de Birmingham les 6 et 7 juillet 1967. Cette réunion avait pour thème "La précision des méthodes spectroscopiques".

*Senior Scientific Officer, Spectrography Section, Mineral Sciences Division.

Price: 75 cents

Cat. No. M 38-3/198

IC 200 Bibliography of High-Temperature Condensed States Research Published in Canada, October-December, 1967

Norman F. H. Bright*

This report contains bibliographic information concerning research work on high-temperature condensed states published in Canadian journals from October 1 to December 31, 1967.

Le présent rapport contient des renseignements bibliographiques sur les recherches effectuées sur les états condensés aux températures élevées, publiées dans les revues scientifiques canadiennes au cours de la période d'octobre 1 à décembre 31, 1967.

*Head, Physical Chemistry Section, Mineral Sciences Division.

Price: 50 cents

Cat. No. M 38-3/200

IC 201 Description and Use of an Ion Bombardment Camera and Ancillary Equipment

R. L. Cunningham* and Joyce Ng-Yelim**

This paper describes an ion bombardment camera and ancillary equipment consisting of a circular protractor, an orienting sphere, and an optical projector capable of directly producing stereographic and gnomonic projections from ion bombardment ejection patterns.

A unique feature of the equipment described is that it leads to a great simplification of several crystallographic techniques used widely in theoretical metallurgy, material sciences, physics, ceramics and crystal chemistry. It is proposed that the techniques described are also suitable for the teaching of elementary crystallography.

La présente étude contient la description d'un appareil à bombardement ionique et des ses accessoires, comprennent un rapporteur à limbe complet, une sphère qui permet de déterminer l'orientation des cristaux, et un projecteur optique capable de donner directement des projections stéréographiques et gnomoniques en partant des diagrammes d'éjection résultant du bombardement des cristaux.

L'appareil décrit ci-dessous possède une caractéristique unique qui permet de simplifier grandement plusieurs techniques cristallographiques utilisées en métallurgie théorique, sciences des matériaux, physique, céramique, et cristallographie des composés chimiques. Les techniques décrites pourraient être employées pour l'enseignement de la cristallographie élémentaire.

*Research Scientist and ** Technical Officer, Metal Physics Section, Physical Metallurgy Division.

Price: 50 cents

Cat. No. M 38-3/201

IC 202 Factors of Particular Significance to the Economics of Industrial Minerals

J. E. Reeves*

Industrial minerals are to some extent unusual because they are more sensitive to certain interrelated economic factors than are other products of the mining industry. The ascertainment of markets and the cost of transporting the products to market are likely to be more decisive than the grade of the deposit in effecting its development. The large volume of material that so often must be moved, i. e. the bulkiness of a commodity, strictly limits shipping distances and therefore the areas in which deposits can be developed. The expansion of urban areas tends to interfere with the supply of the particular mineral raw materials that feed this expansion. Several other factors, some relating in a special way to processing and marketing, are of more limited importance.

Les minéraux industriels sont quelque peu exceptionnels en ce qu'ils sont plus sensibles à certains facteurs économiques que d'autres produits de l'industrie minière. La décision d'exploiter un gisement peut souvent dépendre plus de la certitude de son écoulement et du coût de son transport que de sa qualité. Le volume considérable de matériaux qu'il faut fréquemment déplacer, autrement dit l'encombrement d'un produit, limite radicalement les distances de transport, et par le fait même, les régions se prêtant à l'exploitation de gisements. L'expansion des régions urbaines tend à nuire à l'approvisionnement de ces matières minérales brutes qui précisément l'alimentent. Plusieurs autres facteurs dont quelques-uns se rattachent plus spécialement au traitement et à la mise en marché, présentent une importance plus limitée.

*Senior Scientific Officer, Non-Metallic Minerals Section, Mineral Processing Division.

Price: 50 cents

Cat. No. M 38-3/202

IC 203 List of Certified Electrical Apparatus, Certified Fire-Resistant Conveyor Belting and Certified Diesel Engines for Coal Mine Use (Third Edition)

G. K. Brown*

The principal information presented in this circular is a complete list of the electrical apparatus which has been certified by the Department of Energy, Mines and Resources as being suitable for use in coal mines. In addition to the electrical apparatus there is a list of conveyor belting which has been certified fire-resistant by the Department, as well as details of diesel engines certified for use in an underground locomotive. The period covered is from the opening of the certification service, in September 1955, until April 10, 1969. This report is the third of a series of lists of certified apparatus which will be issued from time to time. The scope and background of the certification service are covered briefly in the preface, and references are given for those interested in obtaining more detailed information.

Les principaux renseignements contenus dans la présente circulaire prennent la forme d'une liste complète des appareils électriques que le ministère de l'Énergie, des Mines et des Ressources a approuvés pour utilisation dans les houillères. En plus

des appareils électriques, il s'y trouve une liste des courroies transporteuses que le Ministère a déclarées ignifuges, de même que des détails relatifs des moteurs diesel certifiés pour usage dans les locomotives souterraines. La période visée s'étend depuis la mise sur pied du service, en septembre 1955, jusqu'au 10 avril, 1968. La présente circulaire est la troisième d'une nomenclature d'appareils certifiés à être publiée de temps à autre. Le champ d'action et les antécédents du service de certification sont brièvement passés en revue dans la préface, et l'auteur mentionne des ouvrages de référence à l'intention de ceux qui pourraient désirer de plus amples informations.

*Head, Canadian Explosive Atmospheres Laboratory, Fuels Research Centre.

Price: 75 cents

Cat. No. M 38-3/203

IC 204 Bibliography of High-Temperature Condensed States Research Published in Canada January-March, 1968

Norman F. H. Bright*

This report contains bibliographic information concerning research work on high-temperature condensed states published in Canadian journals from January 1 to March 31, 1968.

Le présent rapport contient des renseignements bibliographiques sur les recherches effectuées sur les états condensés aux températures élevées, publiées dans les revues scientifiques canadiennes au cours de la période de janvier 1 à mars 31, 1968.

*Head, Physical Chemistry Section, Mineral Sciences Division.

Price: 50 cents

Cat. No. M 38-3/204

IC 205 An Index of the Scientific and Technical Papers Published by the Staff in 1967

Price: \$1.00

Cat. No. M 38-3/205

IC 206 Bibliography of High-Temperature Condensed States Research Published in Canada, April-June, 1968

Norman F. H. Bright*

This report contains bibliographic information concerning research work on high-temperature condensed states published in Canadian journals from April 1 to June 30, 1968.

Le présent rapport contient des renseignements bibliographiques sur les recherches effectuées sur les états condensés aux températures élevées, publiées dans les revues scientifiques canadiennes au cours de la période d'avril 1 à juin 30, 1968.

*Head, Physical Chemistry Section, Mineral Sciences Division.

Price: 50 cents

Cat. No. M 38-3/206

IC 208 Analyses of Coal and Coke During 1967

W. J. Montgomery* and G. C. Behnke**

The Solid Fuels Laboratory of the Fuels Research Centre is responsible for all analytical work on coal and coke encompassed by this publication, including that reported in the official "Analysis Directory of Canadian Coals" (which is published by the Mines Branch, but only at intervals of five or more years). This information circular, issued as the eighth of an annual series, tabulates the analyses of coal and coke samples analysed by the Division during 1967¹.

It must be clearly understood that no responsibility is taken by the Centre for the accuracy of the sampling procedures adopted for procuring the samples for which analyses are reported in this circular, excepting those taken by Centre officers.

Proximate analysis and sulphur values are reported on the "as received" basis only, whereas calorific values are reported on the "as received" as well as the "dry" basis. As an easy reference, the analyses are arranged by province and state.

Le laboratoire des combustibles solides, au Centre de recherches des combustibles, s'occupe de tous les travaux analytiques sur la houille et le coke mentionnés par la présente publication, y inclus les travaux dont il est fait rapport dans la publication, officielle de la Direction des mines intitulée: "Analysis Directory of Canadian Coals", qui paraît à intervalles

de cinq ans ou plus. La présente circulaire d'information, la huitième d'une série qui doit paraître annuellement, traite des analyses d'échantillons de houille et de coke analysés par le Centre au cours de 1967¹.

Il faut bien se rappeler que, sauf pour les échantillons prélevés par ses propres fonctionnaires, la Centre n'assume aucune responsabilité en ce qui concerne les techniques d'échantillonnage adoptées pour les analyses considérées dans la présente circulaire.

On indique les analyses quantitatives approximatives et les teneurs en soufre des échantillons "tels qu'ils nous sont parvenus", tandis qu'on mentionne les valeurs calorifiques des échantillons "tels qu'ils sont reçus" et "à sec". Pour les fins de référence, les analyses sont classées par province et par état.

*Head and ** Technician, Solid Fuels Laboratory, Fuels Research Centre.

¹There were no commercial samples of coke analysed during 1967.

Price: 75 cents

Cat. No. M 38-3/208

IC 210 Bibliography of High-Temperature Condensed States Research Published in Canada, July-September, 1968

Norman F. H. Bright*

This report contains bibliographic information concerning research work on high-temperature condensed states published in Canadian journals from July 1 to September 30, 1968.

Le présent rapport contient des renseignements bibliographiques sur les recherches effectuées sur les états condensés aux températures élevées publiées dans les revues scientifiques canadiennes au cours de la période de juillet 1 à septembre 30, 1968.

*Head, Physical Chemistry Section, Mineral Sciences Division.

Price: 50 cents

Cat. No. M. 38-3/210

REPRINT SERIES

RS 55 Slope Stability Studies at Knob Lake

D. F. Coates*, M. Gyenge** and J. B. Stubbins***. Reprinted from the Proceedings of the Third Canadian Symposium on Rock Mechanics, University of Toronto, January 15-16, (1965).

The object of the slope-stability studies at Knob Lake has been to obtain measurements in the open pits which, together with the results of laboratory tests, would permit the prediction of instability in the incompetent wall rocks. Some work is also being done in the brittle, hard wall rocks; however, only data concerning the incompetent rocks are presented here.

An initial study of the slides that had occurred in the past indicated that it might be possible to determine the strength of wall rocks at any particular section by obtaining core samples that could be tested in the laboratory. Then based on the strength obtained from the laboratory tests together with some knowledge of the structural geology and using the appropriate theory, it was hoped that ultimate pit slopes that would become unstable could be identified before the slopes were created.

Laboratory studies were initially carried out on bag samples that were recompacted in the laboratory to the same densities that were measured in the field. The results of these tests indicated that recompacted samples had strength values commensurate with the strength deducted from previous slides. A series of operations were then conducted to obtain undisturbed samples for laboratory testing. This work is still proceeding but difficulties have been encountered in sampling and preparing specimens from a material which on a large scale is soft but on a small scale is made up of blocks of hard rock in a softer matrix.

*Head, **Project Leader, Mining Research Laboratories, Mining Research Centre. *** Chief Engineer, Knob Lake Operation, Iron Ore Company of Canada, Schefferville, Quebec.

Price: 25 cents

Cat. No. M 38-8/55

RS 56 Rock Mechanics Applied to the Design of Underground Installations to Resist Ground Shock from Nuclear Blasts

D. F. Coates*. Reprinted from the Proceedings of the Fifth Symposium on Rock Mechanics held at the University of Minnesota, May (1962).

Underground installations designed to resist the effects of nuclear explosions are generally of a permanent nature and hence cannot be treated exactly like mining openings. For example, scaling of walls and backs may not be possible after the installation is completed; rehabilitation and replacement of sets in deteriorated sections generally is not possible; support such as rock bolting must resist corrosion. Also, the shape of openings cannot normally be modified after experience has indicated the nature of ground reaction.

The phenomenology of nuclear explosions is now fairly well known. Effects such as the various types of radiation, fallout, air blast and ground shock can be predicted for engineering purposes. For underground installations, ground shock, or the dynamic stress wave, produced by a nearby explosion provides one of the main design conditions for the main openings and their associated service entrances and exits as well as for the structures and equipment contained within the openings. Beyond a certain range these effects can be provided for through dynamic design methods. However, within a certain range it almost becomes impossible to provide protection against the high-intensity ground stress and motion that is created by the explosion.

Whereas designs for such installations can be made, many assumptions are required that should be examined by research work. The majority of such research should be on the behaviour of rocks and structural systems under dynamic loading, which can be done without necessarily using nuclear explosives.

*Head, Mining Research Centre.

Price: 25 cents

Cat. No. M 38-8/56

RS 57 1. Deformation Around a Mine Shaft in Salt

K. Barron and N.A. Toews*. Reprinted from the Proceedings of the First Canadian Symposium on Rock Mechanics, Queen's University, Kingston, December 6-7, (1963).

The recovery of potash from the vast deposits in Saskatchewan has presented conditions unique in Canadian mining history. Recognizing this, The International Minerals and Chemical Corporation (Canada) Ltd. proposed that research be initiated, in both the potash and the overlying salt, to obtain information pertinent to mine design, stability, safety and economy. This resulted in a cooperative research program involving the company, Dr. S. Serata, consultant, and the Mines Branch, Department of Mines and Technical Surveys, Ottawa.

Initial studies were made in the unlined portion of the shaft in the salt above the potash beds. Measurements were made of displacements, relative to the shaft axis, of points on the surface of the shaft and within the solid surrounding the shaft. A diametral extensometer and an extensometer to measure the longitudinal deformation of boreholes around the shaft were used.

The objective of these measurements was to obtain data on the creep (or deformation as a function of time) of salt around a simple opening and to correlate this data with theoretical ideas on the behaviour of the material.

A successful correlation would contribute considerably to a better understanding of material behaviour and of loading conditions and thus aid the solution of the problems in the design of openings in salt. A further objective was to investigate whether such data might be used as an indication of shaft stability; this is particularly important in relation to both safety and maintenance.

This paper presents the measurements obtained and the approach taken to their interpretation by the Mines Branch. It is shown that the radial displacement, U_r , for a point in the solid at a radius r from the shaft axis may be expressed in the form: $U_r = pB(a^2/r)\log_{10}(1 + bt)$ where B and b are constants, a is the shaft radius, t is the time and p is the pressure. In particular, the results obtained for points at depths of 4, 7 and 10 feet in the walls of the 18-foot-diameter shaft are represented by: $U_r = -7.7 \times 10^{-3} (a^2/r) \log_{10}\{1 + (t/2.70)\}$ where U_r , a and r are in inches and t is the time in days. Surface points do not conform to the $1/r$ proportionality, but the time function is the same.

The form of the above results suggests that this type of measurement may be used to determine the shear creep function of the material in situ. This is important in correlating laboratory and field studies.

The divergence on the surface data from the general relationship at depth in the shaft wall indicates the possibility that a change in material properties has occurred between the surface and 4-foot depth. There is insufficient data available to pronounce on shaft stability in this case other than to say that there is no evidence of a loss of stability owing to excessive deformation during the time of measurement. It appears, however, that a method might be developed, based on measurements of this type, for monitoring shaft stability with respect to the effects of excessive deformation.

On the basis of certain assumptions, a possible method of estimating stress from deformation measurements is proposed. The assumptions are, in part, substantiated by the data available. Additional measurements are suggested that are needed to confirm the above results.

With further work it should be possible to provide analytical data to assist in the judgment of shaft stability and in the design of excavations in salt.

*Research Scientists, Rock Mechanics Laboratory, Mining Research Centre.

2. Rock Mechanics at International Minerals and Chemical Corporation (Canada) Limited

George Zahary*. Reprinted from the Proceedings of the Third Canadian Symposium of Rock Mechanics, University of Toronto, Toronto, January 15-16 (1965).

Considerable emphasis has been placed on rock mechanics at this highly mechanized potash mine to insure that safe mining conditions prevail. Underground conditions are ideal for the study of ground movement. To insure maximum safety, tests to destruction in the mine are not permitted. Evaluations of ground stability are based on laboratory work and underground measurements. Ground movement is measured on bolts anchored in the roof, floor, and walls of the openings with specially designed instruments. The pattern of vertical and horizontal closure of an opening with time is shown, and strain patterns in the roof and walls are calculated.

*Research Scientist, Elliot Lake Laboratory, Mining Research Centre.

Price: 25 cents

Cat. No. M 38-8/57

RS 58 X-Ray Spectrographic Analysis of Minute Mineral Samples

D. C. Harris* and E. J. Brooker**. Reprinted from The Canadian Mineralogist, Vol. 8, Part 4, (1966).

X-ray spectral intensity ratios are used to determine directly atomic ratios in powdered mineral samples of one-milligram size. Standardization and working curves for the determination of Cu/Fe, Pb/Sb and Ag/Sb are given. Effect of varying sample size is discussed.

*Research Scientist, Mineralogy Section, Mineral Sciences Division. ** Department of Geology, University of Toronto.

Price: 25 cents

Cat. No. M 38-8/58

RS 59 1. Comparison of U and Mo in Improving the Corrosion Resistance of AISI 430 Stainless Steel

G. J. Biefer* and J. G. Garrison**. Reprinted from Materials Protection, Vol. 7, page 39, (1968).

A comparison of molybdenum and uranium as a means of improving corrosion resistance of ferritic AISI Type 430 stainless steel is shown by laboratory tests.

*Head and **Technical Officer, Corrosion Section, Physical Metallurgy Division.

2. How Uranium Affects Corrosion of Resulfurized Stainlesses

G. J. Biefer* and W. M. Crawford**. Reprinted from Metal Progress, Vol. 90, (6) 119-120, (1966).

Addition of up to 1.57% U to types 416 and 430F (both resulfurized grades) increases their resistance to nitric acid at room temperature. Alterations in sulfide compositions and shapes (from stringers to globules) are apparently responsible.

*Head, Corrosion Section, and **Research Scientist, Ferrous Metals Section, Physical Metallurgy Division.

3. Corrosion Fatigue of Structural Metals in Mine Shaft Waters

G. J. Bieffer* Reprinted from Canadian Mining and Metallurgical Bulletin, June (1967).

Fatigue and corrosion fatigue measurements were carried out on five commercially available metals -- four steels and an aluminum alloy -- which are used as structural materials in mine shaft conveyances. In the corrosion fatigue measurements, drain waters collected in the shafts of three different Canadian mines were used as corrosents. The mine waters had been selected on the basis of their relatively large differences in acidity and/or composition.

It was found that the corrosion fatigue strength of the four steels were similar, despite their differences in tensile properties, and that the type of water used in the tests had little effect on the results. Mild steel showed the highest and most consistent values of the damage ratio (ratio between the corrosion fatigue and the plain fatigue strengths at 10^7 cycles).

The corrosion fatigue behaviour of the aluminum alloy (ASTM Type 6061-T6) was found to differ markedly in the three mine waters. A high damage ratio (i.e., superior performance) was shown in a mine water in which the corrosion attack was uniform; much lower damage ratios were shown in waters which produced localized corrosion attack. Corrosion rates were too low to be determined conveniently by conventional weight-loss methods, but calculations from polarization curves provided a rapid demonstration that corrosion rates were distinctly lower in the mine water which produced high damage ratios.

*Head, Corrosion Section, Physical Metallurgy Division.

Price: 25 cents

Cat. No. M 38-8/59

RS 60 Critical Resolved Shear Stress of Lead

F. Weinberg* Reprinted from the Canadian Journal of Physics, Volume 45, (1967).

Measurements of the critical resolved shear stress of lead are reported as a function of temperature, purity, solute additions, and orientation. By annealing in situ it was found that the value of the CRSS can be reduced, the scatter between specimens decreased, and the same specimen can be tested a number of times.

Over the temperature range 4.2°K to 600°K (the melting point) the CRSS decreased from 53g/mm² to approximately 10/mm². Between 100°K and 300°K the temperature dependence of the CRSS is the same as that of the shear modulus.

It was found that the CRSS is relatively insensitive to differences in the trace impurity level and to solute additions of 0.1% Sn and 0.02% Cu. Additions of 1.0% Sn appreciably increase the CRSS at low temperatures.

The orientation dependence of the CRSS is similar to that shown for copper, with higher values at the edges and corners of the stereographic triangle.

Under optimum conditions the average value of the CRSS of lead is 34g/mm² at 78°K. This value is anomalously high when compared to that of copper, using $\sigma \propto b\mu N^{\frac{1}{2}}$ for the flow stress to make the comparison.

*Head, Metal Physics Section, Physical Metallurgy Division.

Price: 25 cents

Cat. No. M 38-8/60

RS 61 An Investigation of Secondary Hardening of a 1% Vanadium - 0.2% Carbon Steel

E. Smith* Reprinted from the Acta Metallurgica, Vol. 14, (1966).

Steel samples were quenched into oil, tempered and examined by transmission electron microscopy. The structure of the quenched steel was very similar to that of plain carbon steels of similar carbon content. Most of the ferrite grains were needles or large untwinned plates. Within the grains was a very high density of dislocations and also a Widmanstätten precipitate of iron carbide, formed during the quench. This structure was resistant to tempering up to about 20 hr at 500°C when the secondary hardening reaction appeared to begin. Peak hardness coincided with the formation of coherent platelets of vanadium carbide only a few unit cells in thickness and about 100 Å in diameter. The dislocation network was stable under these conditions and appeared to be held by the precipitates.

The fall from peak hardness was accompanied by increase in size and reduction in number of the vanadium carbide particles. At the same time the dislocation network cleared from the grains accompanied by polygonization and recrystallization of the ferrite.

Attempts were made to correlate measurements of strength and particle density with various theories for precipitation

hardening. Moderate agreement was found with theories dependent on particle strength and spacing, but not for hardening based on coherency strains.

Des échantillons de l'acier, après trempe à l'huile et revenu, ont été examinés par transmission au microscope électronique. La structure de l'acier trempé ne diffère pas sensiblement de celle des aciers au carbone de même teneur en carbone. La plupart des grains de ferrite sont sous forme d'aiguilles, ou de larges plaquettes, sans macle. A l'intérieur des grains, on observe une densité élevée de dislocations ainsi qu'une précipitation de carbure de fer en structure de Widmanstätten, qui proviennent de la trempe. Cette structure résiste au revenu jusqu'à environ 20 heures à 500°C; à partir de là débute le processus du durcissement secondaire. Le pic de dureté coïncide avec l'apparition de petites plaquettes cohérentes de carbure de vanadium de quelques plans atomiques seulement d'épaisseur et d'environ 100 Å de large. Le réseau de dislocations reste stable à ce stade, sans doute du fait des précipités.

La diminution de dureté, au delà du pic, s'accompagne d'une augmentation de la dimension et d'une réduction du nombre de particules de carbure de vanadium. Simultanément, le réseau de dislocations disparaît des grains, en même temps que la ferrite polygonise et recristallise.

Les tentatives faites pour relier les mesures de résistance et la densité des précipités à diverses théories sur le durcissement de précipitation ont révélé une concordance raisonnable lorsque la théorie utilisée fait intervenir la résistance et l'espacement des particules, mais non lorsque'elle base le durcissement sur les tensions de cohérence.

Stahlproben wurden in Öl abgeschreckt, getempert und im Elektronenmikroskop durchstrahlt. Die Struktur des abgeschreckten Stahles war ähnlich der Struktur von einfachem Kohlenstoffstahl mit gleichem Kohlenstoffgehalt. Die meisten Ferritkörner waren Nadeln oder große nicht verzwilligte Plättchen. Innerhalb der Körner war die Versetzungsdichte sehr hoch. Ferner beobachtete man während des Abschreckens gebildete Widmannstätten-Ausscheidungen von Eisenkarbid. Diese Struktur war beim Tempern stabil bis zu 20 Std. bei 500°C. Dann schienen Prozesse der Sekundärverfestigung einzusetzen. Die größte Härte fiel zusammen mit der Bildung von kohärenten Plättchen aus Vanadiumkarbid, wenige Elementarzellen dick und etwa 100 Å im Durchmesser. Unter diesen Bedingungen war das Versetzungsnetzwerk stabil und schien durch die Ausscheidungen festgehalten zu werden.

Die Abnahme von der Maximalhärte war verbunden mit einer Zunahme der Größe und einer Verminderung der Anzahl der Vanadiumkarbidteilchen. Gleichzeitig löste sich das Versetzungsnetzwerk von den Körnern, verbunden mit Polygonisation und Rekristallisation des Ferrit.

Es wurden Versuche unternommen, die Messungen von Festigkeit und Teilchendichte mit verschiedenen Theorien der Verfestigung durch Ausscheidung zu korrelieren. Eine mäßige Übereinstimmung wurde gefunden für Theorien, die auf Teilchenfestigkeit und Teilchenabstand aufbauen, nicht aber für Verfestigung auf Grund von Kohärenzverzerrungen.

*Research Scientist, Metal Physics Section, Physical Metallurgy Division.

Price: 25 cents

Cat. No. M 38-8/61

RS 62 A New Copper-Iron Sulfide

L. J. Cabri*. Reprinted from *Economic Geology*, Vol. 62, 910-925, (1967)

A copper-iron sulfide mineral from Noril'sk, Western Siberia, discovered and described as cubic chalcopyrite by Bud'ko and Kulagov (4), is shown to be a discrete mineral entity and not to be confused with cubic chalcopyrite. The term cubic chalcopyrite does, in fact, refer to a valid phase, which is the face-centered cubic high-temperature polymorph of chalcopyrite.

The new sulfide mineral tarnishes very rapidly in air, changing from the chalcopyrite color to hues of pink and brown, and eventually becoming iridescent. Electron-probe microanalyses of several grains using synthetic standards gave Cu = 36.1, Fe = 31.6, S = 31.9, Ni = 0.7 total = 100.3%. The strongest of the X-ray powder diffraction lines (in Å) are 3.04(10), 2.656(5), 1.879(9), 1.598(7), 1.210(5), 1.079(6), and 1.0193(5). The (110) reflection at 7.52Å(3) clearly differentiates it from cubic chalcopyrite. Single-crystal X-ray diffraction indicates that it has a large cubic cell with $a = 10.648 \text{ Å}$, possible space group I43m, and a probable composition of $\text{Cu}_{18}(\text{Fe}, \text{Ni})_{18}\text{S}_{32}$. This composition gives a calculated specific gravity of 4.36 (measured value 4.24). High-temperature X-ray diffraction, D. T. A., and quench experiments indicate that on heating to about 80°C the mineral breaks down to "tetragonal" cubanite and minor bornite. On slow cooling the original mineral is reformed.

Since this new mineral closely resembles the qualitative descriptions for chalcopyrrhotite in the literature, attempts to find it in specimens from the type chalcopyrrhotite locality were made, but none was found.

*Research Scientist, Mineralogy Section, Mineral Sciences Division.

Price: 25 cents

Cat. No. M 38-8/62

RS 63 Preplating High-Strength Steels with Copper to Prevent Embrittlement During Chromium Plating

C. Freeman*, W. Dingley**, and R. R. Rogers***. Reprinted from *Electrochemical Technology*, Vol. 6, No. 1-2, Jan.-Feb. (1968).

High strength steel Types 1062, 4037, and E4340 are severely embrittled when electroplated with chromium by a standard procedure. However, no significant embrittlement occurs when these steels are (a) given a special acid treatment and (b) electroplated with copper in a stable cyanide bath, prior to the chromium plating.

*Technician, ** Technical Officer, ***Research Scientist, Head, Corrosion Section, Extraction Metallurgy Division.

Price: 25 cents

Cat. No. M 38-8/63

RS 64 The Medium in Continuous-Vacuum Filtration

N. Nemeth* and L. L. Sirois**. Presented at the Annual Meeting, AIME, New York, February 25-29, (1968).

The filter is an apparatus designed to hold the filter medium. At such a medium takes place the entire liquid-solid or gas-solid separation process. Hence, the medium is really the essence of filtration. Yet, the medium, an originally clean porous substance with trapped solids in it, is perhaps the most neglected part of filtration research.

Basically three problems prevail at the medium:

- i) Penetration of solids and their blinding of the medium and the influence of such blinding on the resistance to flow.
- ii) The behavior of the medium in long-term repetitive filtration.
- iii) The filter effect phenomenon whereby the flow rate, on filtering an apparently clear liquid through a medium, decreases with time.

This study undertakes to investigate these fundamental processes.

*Scientific Officer and ** Research Scientist, Metallic Minerals Research Laboratory, Mineral Processing Division.

Price: 25 cents

Cat. No. M38-8/64

RS 65 Dead Time Correction in X-Ray Spectrography

Dorothy J. Reed* and A. H. Gillieson** Reprinted from the Canadian Spectroscopy Vol. 13, Issue No. 3, May(1968).

The customary dead time correction applied to X-ray counting rates has been found unsatisfactory for the counting equipment used in the Mineral Sciences Division of the Mines Branch.

Using a range of wavelengths from CrK_{α} to BaK_{α} and foils of several materials, an amended formulation for calculating dead time and the true counting rate has been developed by the multifoil technique. Results obtained by a single foil and a two-source method agree well with the multifoil ones using the amended formula.

La formule usuelle de correction pour le temps mort d'un compteur s'est avérée insatisfaisante lorsque appliquée aux instruments utilisés dans les laboratoires de la Division des Sciences Minérales de la Direction des Mines. Une nouvelle formule est proposée pour établir les taux de comptage vrais: cette formule a été établie par la technique multifoil pour les longueurs d'ondes variant de CrK_{α} jusqu'à BaK_{α} . Les résultats obtenus par la technique single foil avec deux sources s'accordent assez bien avec ceux obtenus par la technique multifoil, lorsque la nouvelle formule est utilisée pour établir les taux de comptage vrais.

*Research Scientist, and **Head, Spectrochemistry Section, Mineral Sciences Division.

Price: 25 cents

Cat. No. M 38-8/65

RS 66 The Application of Ore Microscopy to Mineral Beneficiation

W. Petruk*. Reprinted from Canadian Mining Journal, June (1968).

This paper presents a brief description of the application of ore microscopy to mineral beneficiation. The microscopic examination generally serves to identify the minerals, to gain some idea of their composition, and to enable the textural relationships to be elucidated. In some cases, microscopic study is augmented by X-Ray diffraction, and by chemical, spectrographic or electron-microprobe analyses. In other cases, a statistical treatment based on grain counting of mill products provides useful information on the efficacy of beneficiation procedures.

*Research Scientist, Mineralogy Section, Mineral Sciences Division.

Price: 25 cents

Cat. No. M 38-8/66

RS 67 Plate-Load Testing on Rock for Deformation and Strength Properties

D. F. Coates* and M. Gyenge**, Reprinted from *Testing Techniques for Rock Mechanics*, American Society for Testing and Materials Special Technical Publication No. 402, (1966).

Plate-load tests were conducted underground on rock to determine in situ strength and deformation properties. The plate-load test provides information on the rock mass properties as opposed to the strength of the rock substance. When a plate is placed on the surface of the material to be tested and the contact pressure increased, the plate deflects as the material deforms, and shear failure of the material ultimately occurs.

Tests were conducted on three different materials: iron ore, paint rock, and ash rock. The results were compared, in some cases, with the results of laboratory testing and, in other cases, with the results of analyzing failures of the rock mass. Moderately good agreement was obtained between these independent methods of determining the material properties. However, the principal aspect that emerges is the dispersion of strength values that must be expected in testing geological materials.

Suggested specifications are given for plate-load testing, conventional uniaxial compression testing, and classification uniaxial compression testing.

*Head, **Scientific Officer, Rock Mechanics Laboratory, Mining Research Centre.

Price: 25 cents

Cat. No. M 38-8/67

RS 68 1. Stress Measurements at Elliot Lake

D. F. Coates* and F. Grant**, Reprinted from *The Canadian Mining and Metallurgical Bulletin Transactions*, Vol. LXIX, pp. 376-382, (1967).

As the problems concerning rock mechanics in Canada occur mainly in the mineral industry, the Federal Government recently established a field research group at Elliot Lake, Ontario. One of the first projects with which this group has been occupied is that of measuring the in situ stresses in and around mines.

The most intensive work has been done in one of the local uranium mines located on the south limb of the west-plunging syncline that contains the orebody. The average dip of the formation here is 14 degrees. Mining is being conducted at depths of from 600 ft. to 1,400 ft. below surface.

Stresses of up to 15,600 psi, measured in the pillars, are higher than expected. Even higher stresses may exist, because in some of the stress-measuring holes, the cores disced and measurements could not be taken. These stresses, however, do not cause working of the pillars.

The field stress results were also surprising in that, at the location of the measurements, the vertical stress was found to be about twice the gravitational stress, with the horizontal stresses being about three times the gravitational stress. Clearly, the rocks still retain stresses from the folding, faulting and intrusive action that has occurred in geological time.

*Head, **Scientific Officer, Mining Research Laboratories, Mining Research Centre.

2. A comparison of Two Methods for Measuring Stress in Rock

W. L. Van Heerden* and F. Grant**, Reprinted from *The International Journal of Rock Mechanics and Mining Sciences*, Vol. 4, pp. 376-382, (1967).

As part of an extensive program of measuring rock stresses, a series of comparative measurements were made in a Canadian uranium mine by means of a strain cell developed at the South African Council for Scientific and Industrial Research and of a borehole deformation meter developed at the U. S. Bureau of Mines. An analysis of the results, taking account of certain sources of error, shows that there is satisfactory agreement between the results obtained with the two methods.

*Exchange Research Officer from National Mechanical Engineering Research Institute, South African Council for Scientific and Industrial Research, Pretoria, South Africa, at Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada. **Scientific Officer, Mining Research Laboratories, Mining Research Centre.

Price: 25 cents

Cat. No. M38-8/68

RS 69 The Grain-Size Dependence of the Electromechanical Properties in Lead Zirconate-Titanate Ceramics

A. H. Webster* and T. B. Weston**, Reprinted from *Canadian Ceramic Society Journal*, Vol. 37, pp. 41-44, July-August, (1968).

The dependence of the electromechanical properties of unmodified lead zirconate-titanate ceramics on the grain size of the ceramic has been determined for materials with compositions on both sides of the rhombohedral/tetragonal boundary. High-density ceramics with average grain diameters from about 1.5 μm to 8 μm were examined. It was found that the dielectric constant before poling, and the dielectric and mechanical losses all decreased with increasing grain size. The coercive field was found to be largely independent of grain size in the range examined.

*Research Scientist, Physical Chemistry Section, Mineral Sciences Division; ** Research Scientist, Ceramic Section, Mineral Processing Division.

Price: 25 cents

Cat. No. M 38-8/69

RS 70 Corrosion of Metals by Aqueous Solutions of the Atmospheric Pollutant Sulfurous Acid

W. McLeod* and R.R. Rogers**. Reprinted from *Electrochemical Technology*, Vol. 6, No. 7-8, July-Aug., (1968).

It has been found here that the corrosion rate of a metal in an acid such as H_2SO_3 , HNO_3 , H_2CO_3 , or HCl , having a normality between $N/1$ and $N/10,000$ is related to the concentration of the acid in accordance with the equation $Corrosion\ Rate = a \times (Acid\ Normality)^b$ where a and b are constant for each combination of acid and metal and where the temperature is $25^\circ C$. Having determined the values of a and b for a considerable number of these acid-metal combinations, it was possible to compare the corrosion rates of the various metals in sulfurous acid with those of the same metals in the well-known nitric, sulfuric, and hydrochloric acids, and to determine the corrosion rates of the metals in sulfurous acid of different normalities.

*Research Scientist and ** Head, Corrosion Section, Extraction Metallurgy Division.

Price: 25 cents

Cat. No. M 38-8/70

RS 71 Atmospheric and Surface Effects on the Fatigue Properties of Aluminum Alloys

E. G. Eeles* and R. C. A. Thurston**. Presented at The Sixth Congress of the International Council of the Aeronautical Sciences, Deutsches Museum, Munchen, Germany/September 9-13, (1968).

Two commercial aluminum alloys were cyclically stressed in moist and dry air. The data obtained give substantial support to the hypothesis that variable cracking of the surface oxide is responsible for environmental fatigue effects.

Processing in kerosene was found to have differing effects on the two alloys. A polar organic compound added to kerosene produced a significant reduction in the scatter of data from one alloy.

*Research Scientist and **Head, Engineering Physics Section, Physical Metallurgy Division.

Price: 25 cents

Cat. No. M 38-8/71

RS 72 1. Tunnelling in Canada

M. A. Twidale* and A. Ignatieff**. Reprinted from the *Proceedings of the I. M. E. Symposium on Shaft Sinking and Tunnelling*, Olympia, London, July 15-17, (1959).

In Canada, such a wide range of mineral deposits and rock types is encountered that it is not possible to describe Canadian tunnelling operations in terms of average conditions.

As representative examples, three widely different tunnelling projects are described: the Princess Colliery tunnel, driven through structurally weak and water-bearing sediments; the Kemano hydro-electric tunnel, of large bore, through igneous rock; and the Geco copper-zinc mine development, of medium size, at shallow depth in competent rock.

These descriptions are followed by a brief discussion of special features and trends in Canada under the principal operations of tunnelling practice.

*Senior Scientific Officer, Mining Research Centre; ** Deputy Director of Mines Branch.

2. Rapid Development of Longwall Retreating in the Submarine Area of the Sydney Coalfield of Nova Scotia

L. Frost* and H. Zorychta**. Reprinted from the *International Conference on Rapid Excavation in Coal Mines*, INICHAR, Liège (Belgium), (1963). (A French version is issued as Reprint Series RS 73)

This report describes techniques of rapid development of longwall retreating in the submarine coal mines of Dominion Steel and Coal Corporation, Sydney, N. S. Mining equipment, roadway development, transportation of workmen, material and ventilation are described. Some of the ground control problems encountered in rapid development for longwall retreat mining are discussed along with some pressure measurements made in waste rock using hydraulic pack dynamometers.

*Chief Mining Engineer, Dominion Steel and Coal Corporation; ** Research Scientist (Glace Bay, Nova Scotia), Mining Research Centre.

Price: 25 cents

Cat. No. M 38-8/72

RS 73 Exploitation Rapide d'une Taille Rabattante dans le District Sous-Marin de Sydney en Nouvelle-Écosse

L. Frost* and H. Zorychta**. Reprinted from the International Conference on Rapid Excavation in Coal Mines, INICHAR, Liège (Belgium), (1963).

Ce rapport décrit les techniques du développement rapide de l'extraction par la méthode de longue taille à rebour des charbonnages sous-marins de la Corporation Dominion Steel and Coal à Sydney, Nouvelle-Écosse. L'équipement de mine, le développement des voies de communication, le transport des ouvriers, la distribution du matériel, et la ventilation sont décrits. Quelques problèmes du contrôle de la pression des terres rencontrés dans l'extraction par la méthode de longues tailles à rebour sont discutés ainsi que les méthodes de mesures des pressions faites dans les remblais par des dynamomètres hydrauliques.

*Ingénieur en chef des mines, opérations à charbon, de la Corporation Dominion Steel and Coal et ** Chercheur scientifique (Glace Bay, Nouvelle Écosse) du Centre de la recherche minière.

Price: 25 cents

Cat. No. 38-/73 (F)

RS 74 Hot-Working Mechanisms

H. J. McQueen*. Reprinted from Materials Technology - An Inter-American Approach, American Society of Mechanical Engineers, New York, pp 379-388, (1968).

Before introducing the results of hot-working experiments, the techniques and their limitations are described. Microstructural observations and mechanical measurements are discussed separately. The microstructure of hot-worked single-phase alloys consists of polygonized cells; the degree of polygonization increases with rise in temperature, decrease in strain rate and greater facility of dislocation cross-slip and climb. The mechanism thus appears to be dynamic recovery without recrystallization. Recrystallization in the course of deformation may occur in multi-phase alloys. It is shown that the most suitable empirical expression relating strain rate, temperature and flow stress can be interpreted in terms of a stress-aided, thermally activated process.

*Research Scientist, Metal Physics Section, Physical Metallurgy Division.

Price: 25 cents

Cat. No. M 38-8/74

RS 75 The Origin of Pleochroism in Erythrite

G. H. Faye* and E. H. Nickel**. Reprinted from The Canadian Mineralogist, Vol. 9, pp. 493-504, (1968).

Optical absorption measurements show that the pleochroism of erythrite is due to variations in the main absorption envelope in the 400 to 600-m μ region as crystallographically oriented sections are rotated in linearly polarized light. The absorption envelope arises from the ${}^4T_1(F) \rightarrow {}^4T_1(P)$ transition, with contributions from transitions derived from 2G and 2H levels, in octahedrally coordinated Co^{2+} ions, of which there are two kinds (Co_I and Co_{II}) in erythrite. The pleochroism is related to the interaction of the electric vector of light with electrons located in specific t_{2g} orbital lobes of ions in the Co_I and Co_{II} sites.

The validity of the present interpretation rests on the assumptions that erythrite is isostructural with vivianite and symplectite and that the principal optical directions are essentially coincident with the "molecular axes" of the Co^{2+} -bearing octahedra.

*Research Scientist, Special Analysis and Research Section. ** Head, Mineralogy Section, Mineral Sciences Division.

Price: 25 cents

Cat. No. M 38-8/75

RS 76 Continuous-Strip Galvanized Coatings at Elevated Temperatures

J. J. Sebiesty*. Reprinted from Electrochemical Technology, Vol. 6, No. 9-10, Sept.-Oct. (1968).

The elevated-temperature deterioration of a continuous-strip galvanized product has been investigated by air-atmosphere heating in the temperature range 150°-400°C (300°-750°F) for periods up to 20 weeks. Various forms and degrees of deterioration were revealed which were dependent on the conditions of exposure. The principal mechanism of failure involved the development of local iron-zinc reaction outbursts which caused breakup and separation of the zinc layer and, in more advanced stages, intergranular penetration and embrittlement of the steel substrate. The significance of the experimental findings to elevated-temperature use of the strip material tested is discussed.

*Research Scientist, Non-Ferrous Metals Section, Physical Metallurgy Division.

Price: 25 cents

Cat. No. M 38-8/76

RS 77 The Densities of Liquid Tin, Lead, and Tin-Lead Alloys

H. R. Thresh*, A. F. Crawley**, and D.W.G. White**. Reprinted from Transactions of the Metallurgical Society of AIME, Vol. 242., May (1968).

The densities of liquid tin, lead, and Sn-Pb alloys have been measured over a range of temperature above the liquidus. In all cases, data can be adequately represented by an equation of the type $p = a + bT$. For pure tin, the values of a and b are, respectively, 7.139 and 7.125×10^{-4} , and for pure lead, 11.060 and 12.220×10^{-4} . At constant temperature, molar volumes in the Sn-Pb system vary linearly with composition.

*Formerly Research Scientist, Metal Physics Section, Physical Metallurgy Division, now with Chase Brass and Copper Co., Cleveland, Ohio. ** Research Scientists, Non-Ferrous Section, Physical Metallurgy Division.

Price: 25 cents

Cat. No. M 38-8/77

Section 2 - Papers Published in Periodicals

MINERAL PROCESSING DIVISION

- "The Grain-Size Dependence of the Electrochemical Properties in Lead Zirconate-Titanate Ceramics" by A. H. Webster and T. B. Weston. Journal, Canadian Ceramic Society, 37, July-August (1968).
- "Recent Developments in the Potash Industry" by C. M. Bartley. Annual Review, The Northern Miner, (1968).
- "Developments in Canada's Cement Industry" by N. G. Zoldners. Canadian Pit and Quarry, 9, No. 4, April (1968).
- "Lightweight Aggregates in Canada" by H. S. Wilson. Canadian Pit and Quarry, 9, No. 9, September (1968).
- "Ensayo acelerado para determinar la resistencia a la compresion del concreto a los 28 dias" by V. M. Malhotra, N. G. Zoldners, R. Lapinas. Revista IMCYC - Instituto mexicano del cemento y del concreto A. C., 6, No. 34, (1968).
- "Production and Utilization of Lightweight Aggregates" by H. S. Wilson. United Nations Industrial Development Organization (Report ID/WB. 16 (1)), 126 pages, April (1968).
- "Milling and Process Metallurgy - Technical Advances in Canada" by D. E. Pickett. Canadian Mining Journal, February (1968).
- "Grinding Studies to Determine Variables Affecting Size Distribution" by L. L. Sirois, T. Nagahama and D. E. Pickett. Proceedings 5th Annual Meeting of the Canadian Gold Metallurgists, (1968).
- "Concentration of Tantalum from the Bernic Lake Pegmatite Deposit, Manitoba" by D. Raicevic. CIM Bulletin, 61, No. 680, December (1968).
- "Asbestos 1967" by A. A. Winer. Canadian Mining Journal, February (1968).
- "Industrial Minerals 1967" by R. K. Collings. Canadian Mining Journal, February (1968).
- "Some Experiences in Isostatic Pressing of High-Calcine Bodies" by K.E. Bell. Journal, Canadian Ceramic Society, 11, pp 38-40, (1968).
- "Experimental Study Relating Thermal Conductivity to Thermal Piercing of Rocks" by V. V. Mirkovich. International Journal of Rock Mechanics and Mining Sciences, 5, pp 205-218, Pergamon Press, (1968).
- "Accelerated Testing of Concrete" by V. M. Malhotra and N. G. Zoldners. Canadian Pit Quarry, 9, No. 12, (1968).
- "Sorting by Electronic Selection" by R. A. Wyman. Proceedings of the Ore Concentration in Water-Short Areas, New York, U.S.A., February, 1966, New York, United Nations, (1968).
- "On the Need for Preaching" by J. E. Reeves. A Contribution to Industrial Minerals Division (SME) Column "In the Aggregate", Mining Engineering, November (1968).
- "The Canadian Ceramic Industry" by J. G. Brady. Journal, British Ceramic Society, 5, No. 2, 143-156 (1968).

EXTRACTION METALLURGY DIVISION

- "Kinetics of Silver Cementation on Zinc in Alkaline Cyanide and Perchloric Acid Solutions" by H.E.A. von Hahn and T.R. Ingraham. Canadian Metallurgical Quarterly, 7, No. 1, 15-26, (1968).
- "Technical Note: Protection of Stainless Steels from Corrosion when in Contact with Complex Acid Ore-Leaching Solutions" by A. W. Lui and R. R. Rogers. Canadian Metallurgical Quarterly, 7, No. 1, 61-63, (1968).
- "Equilibria in the Sodium Oxide-Sulphur Trioxide - Water System" by T. R. Ingraham and M.C.B. Hotz. Canadian Metallurgical Quarterly, 7, No. 3, 139-145, (1968).
- "Phase Relationships in the Sodium Sulphate-Sulphuric Acid and Sodium Pyrosulphate - Water Systems" by M.C.B. Hotz and T. R. Ingraham. Canadian Metallurgical Quarterly, 7, No. 3, 147-151, (1968).
- "Polynomial Equations for Computer Calculation of Temperature from Thermocouple Emf" by D. Fraser and R. F. Pilgrim. Canadian Metallurgical Quarterly, 7, No. 3, 167-171, (1968).
- "The Function of Sodium Chloride in Sulphation Roasting" by M. C. B. Hotz, R. C. Kerby and T. R. Ingraham. Canadian Metallurgical Quarterly, 7, No. 4, 201-203, (1968).
- "The Sulphation of Nickel and Cobalt Ferrites and Sulphides by Molten Sodium Pyrosulphate and Sodium Bisulphate" by M. C. B. Hotz, R. C. Kerby and T. R. Ingraham. Canadian Metallurgical Quarterly, 7, No. 4, 205-210, (1968).
- "Development of a Combination Shaft and Electric Furnace" by R.A. Campbell, G. V. Sirianni, G.N. Banks, R.L. Sachdeva, and G. E. Viens. Canadian Mining and Metallurgical Bulletin, 61, No. 670, 174-178, June (1968).
- "Recent Improvements in Gold Milling Operations through Cooperative Efforts" by C.S. Stevens and W. A. Gow. Canadian Mining and Metallurgical Bulletin, 61, No. 671, 379-382, March (1968).

"Thermodynamics of the Thermal Decomposition of Aluminum Sulphate; the Al-S-O System from 850° to 1050°" by T. R. Ingraham. Transactions, Metallurgical Society, AIME, 242, 1299-1302, (1968).

"Kinetics of the Formation of $MnSO_4$ from MnO_2 , Mn_2O_3 , and Mn_3O_4 and its Decomposition to Mn_2O_3 or Mn_3O_4 " by T. R. Ingraham and P. Marier. Transactions Metallurgical Society, AIME, 242, 2039-2043, (1968).

"Producing High-Purity Tungsten from Canadian Scheelite Mines" by J. A. Vezina. Northern Miner, Annual Review, November (1968).

"Combined Shaft-Electric Furnace Developed by Federal Mines Branch" by G. E. Viens and R. A. Campbell. Northern Miner, Annual Review, November (1968).

Preplating High-Strength Steels with Copper to Prevent Embrittlement During Chromium Plating" by C. Freeman, W. Dingley, and R. R. Rogers. Electrochemical Technology, 6, No. 1-2, 64-66, January - February (1968).

"Ways to Electroplate High-Strength Steel without Embrittlement" by R. R. Rogers. Metal Progress, 93, No. 6, 91-93, June (1968).

MINERAL SCIENCES DIVISION

"The Optical Absorption Spectra of Some Andradites and the Identification of the ${}^6A_1 \rightarrow {}^4A_1$ ${}^4E(G)$ Transition in Octahedrally Bonded Fe^{3+} " by P. G. Manning. Canadian Journal of Earth Sciences, 5, 89, (1968).

"Optical Absorption Spectra of the Garnets Almandine-Prrope, Pyrope and Spessartine and Some Structural Interpretations of Mineralogical Significance" by P. G. Manning. Canadian Mineralogist, 9, 237, (1967).

"Dead-Time Correction in X-Ray Spectrography" by Mrs. D. J. Reed and A. H. Gillieson. Canadian Spectroscopy, May (1968).

"Correlation of Absorption Spectra and Structure of Some Co(II)- and Ni(II)- 2, 2 - Biquinoline Complexes" by G. H. Faye and J. L. Horwood. Canadian Journal of Chemistry, 45, 2335, (1967).

"The Optical Absorption Spectra of Certain Transition Metal Ions in Muscovite, Lepidolite and Fuchsite" by G. H. Faye. Canadian Journal of Earth Sciences, 5, 31, (1968).

"A Short-Circuiting Technique for Breaking Down Large Analytical Gaps in D. C. Arc Spectroscopy" by B. Nebesar. Canadian Spectroscopy, 13, 11, (1968)

"A New Technique for Incorporation of Aqueous Liquids in Sodium Peroxide Melts" by B. Nebesar. Laboratory Practices, 17, 357, (1968).

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Section 3 - Available Investigation Reports

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- IR 66-2 "X-Ray Diffraction Investigation of Eight Bayer Process 'Red Mud' Residues from the Aluminum Company of Canada, Limited, Arvida, Quebec", R. S. Dean, December (1965).
- IR 66-7 "Gravity Concentration of a Chromite Ore from Bourret Explorations, Thetford Mines, Quebec", G. W. Riley, February (1966).
- IR 66-28 "Assessment of a Trap Rock for Use as a Concrete Aggregate", F. E. Hanes, March (1966).
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- IR 67-84 "Investigation of the Coking Properties of Coal from No. 4 Seam, Smoky River Area, Alberta. Part II: Evaluation of Smoky River Coals Blended with Japanese Coking Coals (Project 3-2-1/20-1)", J. C. Botham and E. W. Montgomery, November (1967).
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