

~~Ref desk~~

DEPARTMENT OF  
ENERGY, MINES AND RESOURCES

MINES BRANCH

SCIENTIFIC AND TECHNICAL PAPERS

PUBLISHED BY THE STAFF IN 1967

Dept. Energy, Mines & Resources  
MINES BRANCH  
SEP 24 1968  
LIBRARY  
OTTAWA, CANADA

OTTAWA

195  
INFORMATION CIRCULAR IC 205

Price \$1.00

217

247



© Crown Copyrights reserved

Available by mail from the Queen's Printer, Ottawa,  
and at the following Canadian Government bookshops:

HALIFAX  
*1735 Barrington Street*

MONTREAL  
*Æterna-Vie Building, 1182 St. Catherine St. West*

OTTAWA  
*Daly Building, Corner Mackenzie and Rideau*

TORONTO  
*221 Yonge Street*

WINNIPEG  
*Mall Center Bldg., 499 Portage Avenue*

VANCOUVER  
*657 Granville Street*

or through your bookseller

Price \$ 1.00

Catalogue No. M 38-3/205

*Price subject to change without notice*

ROGER DUHAMEL, F.R.S.C.  
Queen's Printer and Controller of Stationery  
Ottawa, Canada  
1968

## FOREWORD

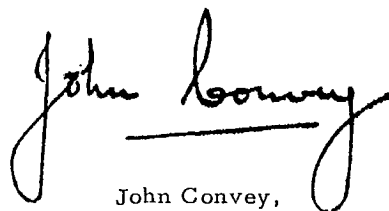
Information Circular IC 151 (June, 1963) was the first in a series of annual reviews of the scientific and technical papers published by the staff of the Mines Branch. This Information Circular is the fifth supplement to IC 151 and is divided into three sections.

Section 1 consists of the titles of papers published during 1967 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 1967 by the Mines Branch staff. The periodicals containing these papers are available in many technical libraries.

Section 3 contains a list of the 1967 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

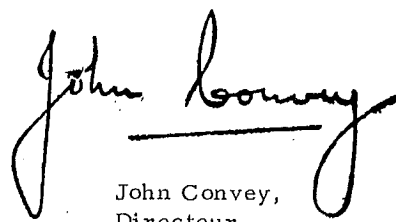
La Circulaire d'information IC 151 (juin 1963) était la première d'une série de revues annuelles des travaux scientifiques et techniques publiés par le personnel de la Direction des mines. La présente circulaire, qui comprend trois sections, est le cinquième supplément à IC 151.

La première section comprend les titres des travaux publiés en 1967 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 1967 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 1967 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

CONTENTS

	<u>Page</u>
Foreword.....	i
Avant-Propos.....	ii
Section 1 - Mines Branch Series	
Research Reports.....	1
Technical Bulletins.....	9
Information Circulars.....	16
Reprint Series.....	21
Section 2 - Papers Published in Periodicals	
→ Mineral Processing Division.....	35
Extraction Metallurgy Division.....	36
Mineral Sciences Division.....	36
Fuels Research Centre.....	38
Mining Research Centre.....	38
Physical Metallurgy Division.....	39
Section 3 - Available Investigation Reports	
→ Mineral Processing Division.....	41
Extraction Metallurgy Division.....	42
Mineral Sciences Division.....	42
Physical Metallurgy Division.....	42

### Previous Reports in This Series

Information Circular 151 (1962)

Information Circular 162 (1963)

Information Circular 171 (1964)

Information Circular 181 (1965)

Information Circular 195 (1966)

*SECTION 1 - MINES BRANCH SERIES*

## RESEARCH REPORTS

R 185 Ageing in Niobium-Rich Niobium-Hafnium-Carbon Alloys

D. C. Briggs\* and L. R. Harmatiuk\*\*, September 1966, 36 pages, Charts, Tables.

Dispersion hardening was investigated in niobium alloys with hafnium up to 12 wt% and carbon to 0.5 wt%. Experimental techniques included hardness measurement, metallography and X-ray analysis. Age-hardening was found at 1100° - 1200°C and related to precipitation of the complex monocarbide (Nb, Hf) C. The constitution of the alloys was determined at 1200°C and conclusions drawn concerning the constitution diagram at higher temperatures to 2200°C. A phase resembling the zeta phase in Ta-C alloys was observed in low-carbon alloys.

Les auteurs ont étudié le durcissement de dispersion dans les alliages au niobium contenant, au poids, jusqu'à 12% de hafnium et 0.5% de carbone. Les techniques expérimentales comprenaient la mesure de la dureté, la métallographie et l'analyse aux rayons X. Le durcissement par vieillissement se situe de 1100° à 1200°C et se rattache à la précipitation du monocarbure complexe (Nb, Hf) C. La constitution des alliages a été déterminée à 1200°C et les conclusions relatives au diagramme de constitution portent sur des températures s'élevant jusqu'à 2200°C. Les auteurs ont observé dans les alliages à faible teneur en carbone une phase qui ressemble à la phase zeta dans les alliages Ta-C.

\*Scientific Officer and \*\*former Student Assistant (deceased), Refractory Metals Section, Physical Metallurgy Division.

Price: 75 cents

Cat. No. M38-1/185

R 186 The Mechanical Properties of Zinc Single Crystals at High Strain Rates

A Schweighofer\* and F. W. Marsh\*\*, November 1966, 34 pages, Charts, Tables.

Mechanical properties of zinc single crystals when subjected to a strain rate of  $10^4 \text{ sec}^{-1}$  at room temperature were studied. Specimens were loaded in a drop-weight machine, and simultaneous load and deformation measurements were made electronically. Three groups of specimens were tested, the first with basal plane orientations close to the tensile axis, the second close to 45 degrees and the third close to 90 degrees.

Deformation of the first group was due to twinning, the second group exhibited ductile deformation, with pure glide, and the third group failed by cleavage with very short deformation times.

The increased strain rate resulted in decreased total plastic strain, increased coefficient of work hardening and increased fracture stresses.

All properties studied were found to be in good agreement with published results from previous work done at low strain rates and low temperatures.

Les auteurs ont étudié les propriétés mécaniques de monocristaux de zinc soumis à une vitesse de déformation de  $10^4 \text{ sec}^{-1}$  à la température ambiante. Les échantillons ont été placés dans un appareil d'essai par choc et les mesures de charge et de déformation ont été prises simultanément par procédé électronique. Trois groupes d'échantillons ont été soumis aux essais: dans le premier, le plan basal était à peu près parallèle à l'axe de traction; dans le deuxième il était incliné d'environ 45 degrés, et dans le troisième, d'environ 90 degrés, par rapport à cet axe.

La déformation du premier groupe était due au maclage. Le deuxième groupe a subi une



déformation ductile accompagnée d'un glissement pur, tandis que le troisième groupe s'est déformé par clivage avec des temps de déformation très courts.

L'augmentation de la vitesse de déformation a entraîné une diminution de la déformation plastique totale, une augmentation du coefficient d'écrouissage, et un accroissement des efforts de rupture.

Les auteurs ont trouvé que toutes les propriétés étudiées concordent avec les résultats publiés de travaux antérieurs effectués à de faibles vitesses de déformation et à de basses températures.

\*National Research Council of Canada Post-doctorate Fellow and \*\*Senior Scientific Officer, Engineering Physics Section, Physical Metallurgy Division.

Price: 75 cents

Cat.No. M38-1/186

R 187 The Composition and Properties of Ceramic Clays and Shales of Quebec

J.G. Brady\* and R.S. Dean\*\*, November 1966, 115 pages, Charts, Tables.

Forty-one representative samples of clays and shales were investigated by various firing methods and by X-ray diffraction, differential thermal analysis and chemical analysis. In addition, thirteen of the samples were studied by thermogravimetric analysis, thermal expansion and plasticity measurements, to determine their processing problems.

The results show that, with the exception of some refractory kaolin-rich samples occurring on the Canadian Shield which have a white to brown fired colour, the ceramic clays and shales of Quebec are common, heterogeneous, mainly red-firing materials. Most of the clays are suitable only for making common brick and tile because they have short firing ranges and high fired shrinkages at temperatures where they become dense and very hard. As a rule the shales are more suitable than the clays for making dense facing brick, because they usually have longer firing ranges. The Quebec Group shales are more refractory and usually have more plasticity and fewer processing problems than the Utica, Lorraine, Rockcliffe and Queenston shales of the St. Lawrence Lowlands. Some of the Quebec Group shales are probably suitable for the manufacture of sewer pipe.

The majority of the kaolin-rich samples, as they occur, are not suitable for ceramic products; many are contaminated with minerals containing iron.

The principal clay minerals in the common clays and shales are illite and/or chlorite. The majority of these samples contain mixed layer systems involving combinations of illite, and/or chlorite, with an expandable phase. Kaolin is a principal component of the kaolin-rich samples only. The principal non-clay minerals are quartz, feldspar, calcite, dolomite and pyrite. The principal constituents in thirteen fired specimens are quartz and feldspar with lesser amounts of cristobalite, mullite, hematite and rutile.

Les auteurs ont étudié quarante et un échantillons représentatifs d'argiles et de schistes à l'aide de diverses méthodes de cuisson, de la diffraction des rayons X, de l'analyse thermique différentielle et de l'analyse chimique. En outre, treize de ces échantillons ont été étudiés par analyse thermogravimétrique et soumis à des mesures d'expansion thermique et de plasticité afin de déterminer les difficultés de traitement que ces matériaux peuvent présenter.

Les résultats indiquent que, sauf certains matériaux réfractaires à forte teneur en kaolin, qu'on retrouve dans le Bouclier canadien, et qui prennent à la cuisson une couleur blanche à brune, les argiles et schistes à céramique du Québec sont des matériaux ordinaires, hétérogènes qui prennent habituellement à la cuisson une couleur rouge. La majeure partie des argiles ne conviennent qu'à la fabrication de tuyaux de drainage et de brique ordinaire, à cause de leurs courtes gammes de cuisson et de forts retraits aux températures nécessaires pour les amener à un état dense et dur.

De façon générale, les schistes conviennent mieux que les argiles à la fabrication de brique de parement dense parce que leurs gammes de cuisson sont plus étendues. Les schistes du groupe de Québec sont plus réfractaires et ordinairement plus plastiques et présentent moins de difficultés lors du traitement que ceux des groupes Utics, Lorraine, Rockcliffe et Queenston des basses terres du Saint-Laurent. Quelques schistes du groupe de Québec pourraient probablement convenir à la fabrication de tuyaux d'égout.

La plupart des échantillons à forte teneur en kaolin ne peuvent servir seuls à la fabrication de produits céramiques. Plusieurs d'entre eux renferment des impuretés ferrifères.

Les principaux minéraux argileux dans les argiles et schistes ordinaires sont l'illite et la chlorite. La plupart de ces échantillons contiennent des systèmes à couches mixtes où l'on rencontre des combinaisons l'illite et (ou) de chlorite avec phase expansible. Le kaolin ne prédomine que dans les échantillons à forte teneur en kaolin. Les principaux minéraux non argileux sont le quartz, le feldspath, la calcite, la dolomie et la pyrite. Les principaux composants des treize échantillons soumis à la cuisson sont le quartz et le feldspath avec des quantités moindres de cristobalite, de mullite, d'hématite et de rutile.

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

Price: \$1.25

Cat. No. M38-1/187

R 188 Composition et Propriétés des Argiles et des Schistes à Céramique du Québec

J.G. Brady\* and R.S. Dean\*\*; June 1967, 123 pages, Charts, Tables.

Les auteurs ont étudié quarante et un échantillons représentatifs d'argiles et de schistes à l'aide de diverses méthodes de cuisson, de la diffraction des rayons X, de l'analyse thermique différentielle et de l'analyse chimique. En outre, treize de ces échantillons ont été étudiés par analyse thermogravimétrique et soumis à des mesures d'expansion thermique et de plasticité afin de déterminer les difficultés de traitement que ces matériaux peuvent présenter.

Les résultats indiquent que, sauf certains matériaux réfractaires à forte teneur en kaolin, qu'on retrouve dans le Bouclier canadien, et qui prennent à la cuisson une couleur blanche à brune, les argiles et schistes à céramique du Québec sont des matériaux ordinaires, hétérogènes qui prennent habituellement à la cuisson une couleur rouge. La majeure partie des argiles ne conviennent qu'à la fabrication de tuyaux de drainage et de brique ordinaire, à cause de leurs courtes gammes de cuisson et de forts retraits aux températures nécessaires pour les amener à un état dense et dur. De façon générale, les schistes conviennent mieux que les argiles à la fabrication de brique de parement dense parce que leurs gammes de cuisson sont plus étendues. Les schistes du groupe de Québec sont plus réfractaires et ordinairement plus plastiques et présentent moins de difficultés lors du traitement que ceux des groupes Utics, Lorraine, Rockcliffe et Queenston des basses terres du Saint-Laurent. Quelques schistes du groupe de Québec pourraient probablement convenir à la fabrication de tuyaux d'égout.

La plupart des échantillons à forte teneur en kaolin ne peuvent servir seuls à la fabrication de produits céramiques. Plusieurs d'entre eux renferment des impuretés ferrifères.

Les principaux minéraux argileux dans les argiles et schistes ordinaires sont l'illite et la chlorite. La plupart de ces échantillons contiennent des systèmes à couches mixtes où l'on rencontre des combinaisons l'illite et (ou) de chlorite avec phase expansible. Le kaolin ne prédomine que dans les échantillons à forte teneur en kaolin. Les principaux minéraux non argileux sont le quartz, le feldspath, la calcite, la dolomie et la pyrite. Les principaux composants des treize échantillons soumis à la cuisson sont le quartz et le feldspath avec des quantités moindres de cristobalite, de mullite, d'hématite et de rutile.

Forty-one representative samples of clays and shales were investigated by various firing methods and by X-ray diffraction, differential thermal analysis and chemical analysis. In addition, thirteen of the samples were studied by thermogravimetric analysis, thermal expansion and plasticity measurements, to determine their processing problems.

The results show that, with the exception of some refractory kaolin-rich samples occurring on the Canadian Shield which have a white to brown fired colour, the ceramic clays and shales of Quebec are common, heterogeneous, mainly red-firing materials. Most of the clays are suitable only for making common brick and tile because they have short firing ranges and high fired shrinkages at temperatures where they become dense and very hard. As a rule the shales are more suitable than the clays for making dense facing brick, because they usually have longer firing ranges. The Quebec Group shales are more refractory and usually have more plasticity and fewer processing problems than the Utica, Lorraine, Rockcliffe and Queenston shales of the St. Lawrence Lowlands. Some of the Quebec Group shales are probably suitable for the manufacture of sewer pipe.

The majority of the kaolin-rich samples, as they occur, are not suitable for ceramic products; many are contaminated with minerals containing iron.

The principal clay minerals in the common clays and shales are illite and/or chlorite. The majority of these samples contain mixed layer systems involving combinations of illite, and/or chlorite, with an expandable phase. Kaolin is a principal component of the kaolin-rich samples only. The principal non-clay minerals are quartz, feldspar, calcite, dolomite and pyrite. The principal constituents in thirteen fired specimens are quartz and feldspar with lesser amounts of cristobalite, mullite, hematite and rutile.

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

Price: \$1.25

Cat. No. M38-1/188 F

R 189 Computer Programs for X-Ray Crystallography. Part I: Bond and Angle Scan Program

E. J. Gabe\* March 1967, 20 pages, Charts, Tables.

This program, which is the first in the series, is designed to facilitate the interpretation of the results of crystal structure analysis. Using the unit cell data, the fractional atomic coordinates and the symmetry operations, the program finds the coordination, in terms of distances and angles, around a specified group of atoms of interest. The program will handle all types of symmetry and there are essentially no limits on the size of structure that can be dealt with, other than the size of the memory of the computer.

Ce programme, le premier d'une série, est conçu pour faciliter l'interprétation des résultats de l'analyse des structures cristallines. A l'aide des données de l'unité de la maille, des coordonnées fractionnaires atomiques et des opérations de symétrie, le programme permet de trouver, selon les distances et les angles, la coordination qui existe dans un groupe donné d'atomes. Le programme permettra d'étudier tous les genres de symétrie et il n'y a à peu près aucune limite à la dimension de la structure étudiée, excepté celle de la mémoire de l'ordinateur.

\*Research Scientist, Mineralogy Section, Mineral Sciences Division.

Price: 50 cents

Cat. No. M38-1/189

R 190 Mechanism of Low-Stress Brittle Fracture in Normally Ductile Materials

L. P. Trudeau\*, January 1967, 29 pages, Figures, Illustrations.

A mechanism is suggested for brittle failures, in service, from small flaws in normally ductile materials which exhibit an impact-energy transition behaviour. The theory suggests, and experiments confirm, that the minimum defect size required for fracture may be more than an order of magnitude smaller than the average size required. The necessary conditions for such a fracture are: (1) the material must exhibit dynamic nil-ductility behaviour under the conditions of stress, temperature and section size that apply in the structure; (2) there must be a defect of sufficient size to give rise to a stress field capable of sustaining a running fracture; and (3), at the base of this stress raiser, there must be a metallurgical imperfection or operative process capable of giving a fast increment of rupture over a microscopic distance comparable to the plastic zone size of a running fracture. The critical flaw size can be calculated from the dynamic  $K_{Ic}$ . Impact loading is not necessary for initiation.

L'auteur propose une explication du mécanisme de rupture fragile à l'usage, provenant de petites défauts dans des matériaux normalement ductiles qui présentent un comportement de transition énergétique sous l'impact. Selon sa théorie, confirmée par l'expérience, les dimensions minimales requises de la défaut pour provoquer une rupture peuvent être plus petites que les dimensions moyennes requises. Les conditions nécessaires à une telle rupture sont: (1) le matériau doit avoir un comportement dynamique de ductilité nulle sous les conditions normales de contrainte, de température et de dimensions de la section de la structure; (2) la paille doit être assez grande pour causer un champ de contraintes capable de faire progresser une rupture; enfin, (3) à l'origine de cette concentration de contraintes, il doit y avoir une imperfection métallurgique ou des conditions de chargement susceptibles d'accélérer la rupture sur une distance microscopique comparable aux dimensions de la zone de déformation plastique d'une rupture en progrès. Les dimensions critiques de la paille peuvent être calculées à partir du " $K_{Ic}$ " dynamique. La mise en charge par choc n'est pas nécessaire pour amorcer la rupture.

\*Research Scientist, Engineering Physics Section, Physical Metallurgy Division.

Price: 75 cents

Cat. No. M38-1/190

R 191 Computer Programs for X-Ray Crystallography. Part II: Program for Diffractometer Angle Settings

E. J. Gabe\*, July 1967, 25 pages, Figure.

This program calculates the three setting angles for a 4-circle diffractometer in the bisecting position ( $\omega = 0$ ). It is applicable to any system, and any type of systematic absence may be allowed for. The required angles may be calculated for any segment of reciprocal space.

Le présent programme calcule les trois angles de réglage pour un diffractomètre à 4 cercles en position bissectrice ( $\omega = 0$ ). Il s'applique à tout système et l'on peut tenir compte de tout genre d'absence systématique. Les angles requis peuvent être calculés pour tout segment d'espace réciproque.

\*Research Scientist, Mineralogy Section, Mineral Sciences Division.

Price: 50 cents

Cat. No. M38-1/191

R 192 The Analysis of Stress for the Prediction of Crater Boundaries

K. Sassa\*, G. E. Larocque\*\*, D. F. Coates\*\*\* and J. A. Darling\*\*\*\*, November 1966, 82 pages, Charts, Tables, Figures.

A method of analysis is developed to compute the stress distribution resulting from detonation of a contained spherical charge in an elastic medium in the vicinity of a free face. This analysis uses the dynamic elastic properties of the medium, and the direct dilatational displacement and particle-velocity wave-shapes produced by the explosive, as a function of distance. Principal stresses at a point, as a function of time, are computed by super-position of the stress components due to the direct dilatational wave and the reflected dilatational and shear waves, using plane-wave-reflection theory. A computer program has been written to perform this analysis.

Laboratory and field measurements were used to obtain the necessary data to determine stress distribution and to predict crater dimensions. In the field experiments, a direct dilatational-wave, linear array and a shear-wave linear array were used to determine all displacements and particle-velocity wave-shape data, as well as the dilatational-wave velocity and shear-wave velocity. It was found that only moderate changes occurred in displacement and particle-velocity wave-shape with distance. Both displacement and particle velocity decayed with distance according to a power law relationship in the range considered.

Two explosives were used in the field program. It was found that the ratio of the detonation pressures of these two explosives, corrected to the ratio of the imposed pressure of these two explosives by means of an acoustical coupling relationship, were in agreement with the ratio of the peak radial stress as determined in the computer program for the two explosives at equal distances from a shot centre.

Some agreement was found between predicted crater dimensions and those actually observed.

Une méthode d'analyse a été créée pour calculer la distribution de la tension résultant de la détonation d'une charge sphérique confinée dans un milieu élastique au voisinage d'une surface libre. Cette analyse utilise les propriétés élastiques dynamiques du milieu, ainsi que le déplacement direct en dilatation et les formes d'onde de la vitesse des particules produites par l'explosif, en fonction de la distance. Les éléments principaux de la tension en un point sont calculés en fonction du temps en superposant les composantes de la tension produite par l'onde incidente de dilatation et par les ondes réfléchies de dilatation et de distorsion, en faisant appel à la théorie de la réflexion des ondes planes. Un programme pour l'ordinateur a été écrit afin de faire cette analyse.

Des mesures obtenues en laboratoire et sur le terrain ont été utilisées afin d'obtenir les données nécessaires pour déterminer la distribution de la tension et pour prédire les dimensions des cratères. Dans les essais sur le terrain, on s'est servi d'un réseau linéaire pour l'onde incidente de dilatation et d'un réseau linéaire pour l'onde de distorsion, afin d'obtenir des données sur les formes d'onde de la vitesse des particules, l'ensemble des déplacements, ainsi que les vitesses des ondes de dilatation et de distorsion. On a trouvé que les formes d'onde de la vitesse des particules et le déplacement ne subissent pas de variation radicale avec la distance. Le déplacement et la vitesse matérielle s'amortissent tous deux comme une puissance de la distance dans le domaine étudié.

Deux explosifs ont été utilisés dans les travaux sur le terrain. On a trouvé que les formes d'onde de la vitesse des particules et le déplacement ne subissent pas de variation radicale avec la distance. Le déplacement et la vitesse des particules s'amortissent tous deux comme une puissance de la distance dans le domaine étudié.

Deux explosifs ont été utilisés dans les travaux sur le terrain. On a trouvé que le rapport des pressions de détonation de ces deux explosifs, ajusté au rapport des pressions imposées des deux explosifs au moyen d'une relation de couplage acoustique, était en accord avec le rapport des tensions radiales de pointe, déterminées par le programme de calcul pour les deux explosifs à des distances égales du centre de détonation.



On a trouvé un certain accord entre les dimensions prévues des cratères et les dimensions observées en fait.

\*Department of Mineral Science and Technology, Kyoto University, Kyoto, Japan; former National Research Council of Canada Research Fellow (1963-1965);\*\*Research Scientist and \*\*\*Head, Mining Research Laboratories,\*\*\*\*Research Scientist, Canadian Explosives Research Laboratory, Mining Research Centre.

Price: \$1.25

Cat.No. M38-1/192

R 193 Pillar Loading. Part IV: Inclined Workings

D. F. Coates\*, December 1966, 31 pages, Figures, Tables.

The new hypothesis that was recently developed for the determination of pillar loads was subsequently modified in the light of extensive experimental work. The resulting equations include significant factors not contained in the older tributary area theory. In this way, an improved basis is provided for predicting pillar loads.

In the new theory, and also in the experimental work, it was assumed that the principal stresses in the formulation were perpendicular and parallel to the plane of the orebody. It was implied that when the principal field stresses were inclined to the plane of the orebody, the theory could still be used by only taking into account the components perpendicular and parallel to this plane. However, experimental substantiation of this assumption was required.

The work described in this report includes an examination of the theoretical implications of having the principal field stresses inclined to the plane of the orebody, and also includes measurements on models for these cases. The rigorous solution of the closure of an elliptical opening from the theory of elasticity is identical with the solution that would be obtained from the pillar loading hypothesis. In addition, the experimental work on model pillars showed good agreement with the predicted values obtained from the equations provided by the new theory.

The main conclusion from this work is that the use, in the previously reported derived equations, of only the components of principal field stresses perpendicular and parallel to the plane of an orebody has been substantiated as valid for the determination of pillar loading.

La nouvelle hypothèse qui a récemment été élaborée pour déterminer la charge sur les piliers a été modifiée par la suite à la lumière de travaux expérimentaux considérables. Les équations qui en découlent comprennent d'importants facteurs dont on ne tenait pas compte dans l'ancienne théorie des zones tributaires. Nous disposons désormais d'une meilleure base pour déterminer les charges sur les piliers.

Dans la nouvelle théorie ainsi que dans les travaux expérimentaux, on a pris pour acquis que les contraintes principales dans la formulation étaient perpendiculaires et parallèles au plan du gisement. Il était sousentendu que lorsque les principales contraintes du terrain étaient obliques au plan du gisement, la théorie pourrait encore être utilisée en ne tenant compte que des contraintes perpendiculaires et parallèles à ce plan. Il fallait toutefois prouver expérimentalement le bien-fondé de cette hypothèse.

L'auteur étudie aussi les implications théoriques des cas où les contraintes principales du terrain s'exercent obliquement au plan du massif, et décrit aussi les mesures effectuées sur des modèles pour des cas semblables. La solution exacte de la fermeture d'une ouverture elliptique, selon la théorie de l'élasticité, est identique à la solution obtenue à partir de l'hypothèse de la charge sur les piliers. En outre, les travaux expérimentaux effectués sur des modèles de piliers ont bien confirmé les valeurs obtenues à l'aide des équations fournies par la nouvelle théorie.

La principale conclusion de ces travaux est qu'on a démontré la validité, dans la détermination de la charge sur les piliers, de l'utilisation, dans les équations dérivées déjà mentionnées, des seules composantes des contraintes principales du terrain perpendiculaires et parallèles au plan d'un gisement.

\*Head, Mining Research Laboratories, Mining Research Centre.

Price: 75 cents

Cat. No. M38-1/193

## TECHNICAL BULLETINS

TB 84 Measurement of the Surface Areas of Powders by Krypton Gas Adsorption Method.  
Construction and Operation of the Apparatus

S.M. Ahmed\*, July 1966, 32 pages, Tables, Figures.

An apparatus has been constructed for studying the adsorption of Kr on finely divided materials of low as well as high specific surface areas, in the low-pressure range, 1 mm<sub>Hg</sub>, at -196°C. The apparatus is designed to handle four samples at a time. The use of a thermistor in measuring the low pressures to a high accuracy is found to offer several advantages over the conventional methods of measuring pressures. The adsorption isotherms have been used to calculate the specific surface areas of powders by the B. E. T. method. The applicability of the Harkins-Jura equation for the determination of the surface areas has also been investigated.

On a mis au point un appareil qui permet de mesurer l'adsorption du Kr sur les matériaux finement pulvérisés d'aires de surface spécifiques, aussi bien petites que grandes, dans la gamme des basses pressions, 1 mm<sub>Hg</sub> à -196°C. L'appareil a été conçu de façon à pouvoir traiter quatre échantillons à la fois. La mesure des basses pressions à l'aide d'un thermistor, permettant d'atteindre un haut degré de précision, offre plusieurs avantages sur les méthodes classiques de mesure des pressions. On a utilisé les isothermes d'adsorption pour calculer les aires de surface spécifiques des poudres, par la méthode B. E. T. On a également étudié l'application possible de l'équation Harkins-Jura pour déterminer les aires de surface.

\*Research Scientist, Mineral Physics Section, Mineral Sciences Division.

Price: 50 cents

Cat. No. M34-20/84

TB 85 Factors Influencing the Application of Bacterial Leaching to a Canadian Uranium Ore

V. F. Harrison\*, W. A. Gow\*\* and M. R. Hughson\*\*\*, December 1966, 28 pages, Tables, Figures.

Laboratory tests were conducted to investigate the effects of particle size and composition of the leaching solution on the extraction of uranium from an Elliot Lake ore in the presence of bacteria. It was shown that the leaching of particles coarser than 4 mesh in the presence of the Ferrobacillus-Thiobacillus group of bacteria was a very slow process, with only 70% of the uranium being extracted in thirty-two weeks. Uranium extractions of 90% were obtained when leaching particles finer than 4 mesh, in periods ranging from five to twenty weeks. The work showed that for ores coarser than 8 mesh it was necessary to add initially to the leach solution 1.0 g Fe<sup>++</sup>/l and nutrient salts containing nitrogen, phosphorus and potassium. Extraction rate of uranium increased with initial iron concentrations of up to 1.0 g Fe<sup>++</sup>/l. The addition of iron and nutrient was not required for ores finer than 8 mesh. The work also indicated that the extraction rate is determined by the rate at which the leaching solutions can penetrate the particles to depth. Further tests showed that bacterial leaching could be used to recover most of the uranium from reject mill products such as flotation tailings. Mineralogical studies were done to determine how bacterial leaching affected the minerals present in the Elliot Lake ore.

Les auteurs ont effectué des essais de laboratoire pour déterminer les effets de la granulométrie et de la composition de la solution de lessivage sur l'extraction de l'uranium d'un minerai d'Elliot Lake en présence de bactéries. Ils ont démontré que le lessivage des particules ne traversant pas le tamis de 4 mailles, en présence du groupe de bactéries Ferrobacillus-Thiobacillus, était un procédé très lent, ne permettant d'extraire que 70 p. 100 de l'uranium en 32 semaines. On a extrait 90 p. 100 de l'uranium en lessivant des particules traversant le tamis de 4 mailles, en des périodes de cinq à vingt semaines. L'étude a montré que, pour du minerai tamisé à plus de 8 mailles, il était

nécessaire d'ajouter au préalable à la solution de lessivage 1.0 g de  $Fe^{++}/l$  et des sels nutritifs contenant de l'azote, du phosphore et du potassium. La vitesse d'extraction de l'uranium a augmenté avec des concentrations initiales de fer allant jusqu'à  $1.0 Fe^{++}/l$ . L'addition de fer et de matières nutritives ne s'est pas avérée nécessaire pour du minerai traversant le tamis de 8 mailles. L'étude indique aussi que la vitesse d'extraction est déterminée par la vitesse à laquelle les solutions de lessivage peuvent s'infiltrer à l'intérieur des particules. D'autres essais ont démontré que le lessivage bactérien pourrait être utilisé pour récupérer la plus grande partie de l'uranium des rebuts de l'usine de traitement, comme les résidus de la flottation. Des études minéralogiques ont été effectuées pour déterminer comment le lessivage bactérien affecte les minéraux présents dans le minerai d'Elliot Lake.

\*Senior Scientific Officer, \*\*Head, Hydrometallurgy Section, \*\*\*Scientific Officer, Mineralogy Section, Extraction Metallurgy Division.

Price: 50 cents

Cat. No. M34-20/85

TB 86 A Low-Pressure Cyclone for De-Sanding Industrial Water

J. Visman\* and C. F. J. Rozenhart\*\*, February 1967, 20 pages, Figures, Tables.

The treatment of water before and after its use in an industrial plant or municipal system is of growing importance in view of the ever-expanding demand for pure water and the increasing pollution of water in industrial areas.

The first step in the process of purification is to remove solids from the water as it enters the plant or leaves the system.

In this report a description is given of a cyclone separator for solids removal at low pressure. Compact construction, low power consumption, and sharp separation (10 to 20 microns) are the features that make this cyclone a desirable, and often necessary, separator for eliminating highly varying amounts of solids from industrial waters, plant effluents, and municipal sewage.

Performance data of a commercial installation are presented as an illustration of the applicability of this separator for the primary purification of industrial water.

Le traitement de l'eau, avant et après son utilisation dans une usine industrielle ou un réseau municipal, a de plus en plus d'importance en vue de la demande toujours plus grands pour de l'eau pure, ainsi que la pollution croissante de l'eau dans les régions industrielles.

Le premier pas dans le processus de l'épuration est l'extraction des solides de l'eau entrant ou quittant le système.

Dans ce rapport, on donne une description d'un séparateur à cyclone pour éliminer les solides à basse pression. Une construction compacte, une faible consommation d'énergie et une séparation précise (10 à 20 microns) sont les caractéristiques qui font de ce cyclone un séparateur désirable et souvent nécessaire pour éliminer les quantités très variantes de solides des eaux industrielles, des effluents d'usines et des eaux d'égouts municipaux.

Les résultats de performance d'une installation commerciale sont présentés pour illustrer l'applicabilité de ce séparateur à l'épuration primaire de l'eau industrielle.

\*Head and \*\*Technical Officer, Western Regional Laboratory (Edmonton, Alberta); Fuels Research Centre.

Price: 50 cents

Cat. No. M34-20/86

TB 87 Effects of Various Alloying Additions on the Corrosion of AISI Type 430 Ferritic Stainless Steel

G. J. Bieffer\*, March 1967, 26 pages, Tables, Figures.

As part of a larger research project aimed at determining the effect of alloying elements upon the corrosion behaviour of ferritic stainless steels, aqueous corrosion tests were carried out upon AISI Type 430 stainless steels containing additions of each of Mo, V, W, Ta, Si, Re, Pd and Ge, and upon a control steel, AISI Type 304 stainless.

It was found that Mo, V and W additions each conferred improved corrosion resistance in non-oxidizing normal sulphuric and normal hydrochloric acid solutions. W was the most effective and V the least effective at the lower addition levels, below 1%.

Mo and, to a lesser extent, Re were the only additions that conferred increased resistance to oxidizing normal ferric chloride solution, while all the additions except Re and Ta were, to at least some extent, deleterious to corrosion resistance in boiling 65% nitric acid.

Pd additions were unique in that, in the range 0.46-1.91%, they brought about passivation in normal sulphuric acid, thus out-performing AISI Type 304 stainless steel in that medium. However, Pd additions of less than 0.46% were deleterious to corrosion resistance in sulphuric acid, whereas Pd additions at all levels were deleterious to corrosion resistance in the other test solutions.

A Type 430 steel containing 3.11% Mo showed corrosion resistance most nearly approaching that of Type 304 steel in the sulphuric acid, hydrochloric acid and ferric chloride solutions. However, this steel had extremely poor resistance to boiling 65% nitric acid, while the Type 304 steel (as expected) showed excellent resistance to this medium.

Dans le cadre d'un plan directeur de recherches visant à déterminer l'effet des éléments d'alliage sur le comportement à la corrosion des aciers inoxydables ferritiques, des essais de corrosion aqueuse ont été faits sur des aciers inoxydables AISI type 430 renfermant respectivement du molybdène, du vanadium, du tungstène, du tantale, du silicium, du rhénium, du palladium et du germanium, et sur un acier inoxydable de contrôle AISI type 304.

On a constaté que les additions de molybdène, de vanadium et de tungstène confèrent une résistance accrue à la corrosion dans des solutions non oxydantes normales d'acide sulfurique et chlorhydrique. Le tungstène est le plus efficace et le vanadium le moins efficace si les additions sont infimes, soit moins de 1 p. 100.

Le molybdène, et à un moindre degré le rhénium, sont les seules additions qui confèrent une résistance accrue à une solution oxydante de chlorure ferrique normale alors que toutes les additions sauf celles de rhénium et de tantale, jusque dans une certaine mesure du moins, ont abaissé la résistance à la corrosion dans l'acide nitrique à 65 p. 100 en ébullition.

Les additions de palladium ont donné des résultats uniques du fait que dans les proportions de 0.46 à 1.91 p. 100 elles ont rendu le métal à peu près inattaquable à l'acide sulfurique normal, lui donnant ainsi un rendement supérieur à celui de l'acier inoxydable AISI type 304 dans cet acide. Cependant, des additions de palladium en quantités inférieures à 0.46 p. 100 ont abaissé la résistance à la corrosion dans l'acide sulfurique, tandis que les additions de palladium à tous les niveaux ont affaibli la résistance à la corrosion dans toutes les autres solutions d'essai.

Un acier du type 430 contenant 3.11 p. 100 de molybdène a résisté à la corrosion à peu près de la même façon que l'acier de type 304 dans les solutions d'acide sulfurique, d'acide chlorhydrique et de chlorure ferrique. Cependant cet acier offre une très faible résistance à l'acide nitrique à 65 p. 100 en ébullition, tandis que l'acier du type 304 (comme prévu) y a très bien résisté.



\*Head, Corrosion Section, Physical Metallurgy Division.

Price: 50 cents

Cat. No. M34-20/87

TB 88 A Computer Program For Calculating Principal Stresses in Photoelasticity

M. Gyenge\*, March 1967, 17 pages, Figures.

Slope stability research is being conducted to increase our knowledge of the mechanics of rock slopes -- a subject of great importance in open pit mining. Stress analysis problems, where the major active force is gravity, give rise to several special requirements when photoelastic models are being used.

The use of a computer program for the separation and computation of the principal stresses means that the stress distribution within the entire model can be obtained quickly. It saves enormous amounts of time in comparison with manual computation, and therefore the efficiency of the model testing procedure is greatly increased.

L'auteur poursuit des recherches sur la solidité des pentes afin d'accroître nos connaissances de la mécanique des pentes rocheuses. C'est un sujet d'importance considérable pour les exploitations à ciel ouvert.

Les problèmes d'analyse des contraintes, là où la force active la plus importante est la gravité, donnent lieu à plusieurs exigences spéciales lorsque des modèles photoélastiques sont utilisés.

L'usage d'un programme d'ordinateur pour la séparation et le calcul des contraintes principales signifie que la répartition des contraintes dans l'ensemble du modèle peut être obtenue rapidement. Il permet d'épargner beaucoup de temps en comparaison du calcul ordinaire et d'accroître ainsi de beaucoup l'efficacité de la méthode d'essai des modèles.

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

Price: 50 cents

Cat. No. M34-20/88

TB 89 The Construction and Operation of a Micro-Cone-Softening Apparatus

A. Jongejan\*, June 1967, 39 pages, Illustrations, Figures.

The construction and operation of an apparatus with which cone-softening temperatures can be determined are described. The temperature of the furnace, which contains the cone, is controlled and can be recorded. The silhouette of the cone can be photographed with a standard grid as background, so that its extent of deformation can be determined quantitatively. The apparatus is built from components that can also be used in other combinations for other purposes.

L'auteur décrit la construction et le fonctionnement d'un appareil qui sert à déterminer les températures de détrempe des micro-cônes. La température du four qui contient le cône est contrôlée et peut être enregistrée. On peut photographier la silhouette du cône en se servant d'un quadrillage régulier, de sorte que le degré de déformation peut être déterminé quantitativement. L'appareil est fait de pièces qui peuvent aussi être utilisées dans d'autres montages servant à d'autres fins.

\*Research Scientist, Physical Chemistry Section, Mineral Sciences Division.

Price: 75 cents

Cat. No. M34-20/89

TB 92 The Construction, Operation and Performance of an Equipment for Differential Thermal Analysis

Richard H. Lake\*, August 1967, 49 pages, Illustrations, Figures.

A description is given of an equipment for use in differential thermal analysis. The equipment, which was designed and built in the Mines Branch, is capable of operating at high sensitivity and stability at temperatures up to 1600°C in air or in any controlled atmosphere at 1 atm. pressure, or in vacuum up to 1250°C. Details are given of the engineering specifications of the components and of precautions to be taken in order to obtain satisfactory operation. Typical DTA curves, showing the types of result that can be obtained with the equipment, are included. Possible sources of supply of the various components are quoted.

L'auteur donne une description d'un appareillage utilisé dans l'analyse thermique différentielle. L'appareillage, qui a été conçu et fabriqué à la Direction des mines, possède une haute sensibilité et une grande stabilité de fonctionnement à des températures allant jusqu'à 1600°C dans l'air ou dans toute atmosphère contrôlée à la pression d'une atmosphère, ou sous vide jusqu'à 1250°C. L'auteur donne des détails sur les prescriptions techniques des composantes et sur les précautions à prendre pour assurer un fonctionnement satisfaisant. Des courbes typiques d'analyse thermique différentielle sont jointes à l'ouvrage pour indiquer les genres de résultats qui peuvent être obtenus avec l'appareillage. L'auteur indique aussi les diverses sources d'approvisionnement pour les diverses composantes.

\*Technical Officer, Physical Chemistry Section, Mineral Sciences Division.

Price: 75 cents

Cat. No. M34-20/92

TB 93 Determination of Cobalt and Zinc in Nickel Metal by Atomic-Absorption Spectrophotometry After Separation by Simultaneous Chloroform Extraction of their Thiocyanate-Diantipyrylmethane Complexes

Elsie M. Donaldson\* and Vera H. E. Rolko\*\*, August 1967, 20 pages, Tables.

An atomic-absorption spectrophotometric method for determining cobalt and zinc in the range 0.0005 to 0.10% in nickel metal is described. After sample dissolution, cobalt and zinc are separated from the matrix element by simultaneous chloroform extraction of their thiocyanate-diantipyrylmethane ion-association complexes from a citric acid medium at pH 3.25. Interference from copper and various elements (i.e. titanium, vanadium, molybdenum, tungsten, etc.) is eliminated with thiourea and ammonium fluoride, respectively. Cadmium, iron and chromium also interfere under the chosen experimental conditions, but the amounts of these impurities present in nickel metal are so low that their interference effects are negligible. Other impurities do not interfere in the proposed method.

Les auteurs décrivent une méthode de dosage du cobalt et du zinc pour les teneurs allant de 0.0005 à 0.10% dans le nickel métal par spectrophotométrie d'absorption atomique. Après dissolution de l'échantillon, le cobalt et le zinc sont séparés du nickel par une extraction simultanée au chloroforme de leurs complexes d'associations ioniques thiocyanate et diantipyrylméthane à partir d'un milieu d'acide citrique à pH 3.25. L'interférence causée par le cuivre et divers éléments (i.e. le titane, le vanadium, le molybdène, le tungstène, etc.) est respectivement éliminée par la thiourée et le fluorure d'ammonium. Le cadmium, le fer et le chrome gênent également dans les conditions expérimentales choisies, mais les quantités de ces impuretés, présentes dans le nickel métal, sont si faibles que leur influence est négligeable. Les autres impuretés ne gênent pas dans le dosage proposé.

\*Research Scientist, and \*\*Scientific Officer, Analytical Chemistry Section, Mineral Sciences Division.

Price: 50 cents

Cat. No. M34-20/93

TB 94 Operating Characteristics of a Vibrating Mill

F. H. Hartman\* and R. A. Wyman\*\*, August 1967, 29 pages, Tables, Illustrations.

Variations in the operation of a vibrating mill were examined experimentally, and the various factors were related to the surface area of product as determined by the Lea and Nurse air-permeability apparatus. It was found that the product became finer as feed rate was decreased, or as amplitude and frequency were increased. The finest products were obtained when media of fused alumina cylinders, 1/2 by 1/2-inch, were used. These products contained approximately 70 per cent minus 10-micron material. Plus 325-mesh particles in various amounts were present in all products.

Cette étude expérimentale a porté sur les variations dans le fonctionnement d'un moulin vibreur; les divers facteurs qui l'influencent ont été étudiés en fonction de la surface de contact du produit fini, telle que déterminée par l'appareil Lea and Nurse de mesure de perméabilité à l'air. L'étude a démontré que la granulométrie du produit diminuait directement en fonction de la réduction de la vitesse d'alimentation ou de l'augmentation de l'amplitude et de la fréquence de vibration. Les particules les plus fines ont été obtenues en utilisant des cylindres d'alumine fondue (1/2 p x 1/2 p). Ces produits fins contenaient environ 70 p. 100 de particules d'un diamètre inférieur à 10 microns. Dans tous les produits finis, on a trouvé en quantité variable des particules ne traversant pas le tamis de 325 mailles.

\*Research Scientist, and \*\*Head, Industrial Minerals Milling Section, Mineral Processing Division.

Price: 75 cents

Cat. No. M34-20/94

TB 95 Material-Transporting Characteristics of Selected Vibrating Equipment

R. A. Wyman\*, November 1967, 44 pages, Tables, Illustrations.

In order to provide for the performance of completely integrated pilot-plant operations, and to facilitate bulk-materials handling in the Industrial Minerals Milling Section of the Mineral Processing Division, a study was made of transporting and feeding machines that would provide the necessary characteristics of versatility, mobility, accuracy and ease of cleaning. Vibrating equipment came closest to filling all of these requirements, and the Section acquired a conveyor unit, a short elevator and two types of feeder, to allow for study of material movement by this means.

Experimental work indicated that the machines selected had a broad range of application to the movement of bulk minerals and rocks, would be appropriate for connecting links between processing units, and were reliable, easy to maintain, and easy to clean. Capacities and operating characteristics are outlined.

Within the confines of an experimental processing plant, requiring changes for each investigation undertaken, the mobility of such units makes them very useful tools. They present a neat appearance and are readily stored when not in service. Although presenting drawbacks in some areas of performance, the over-all practicality of these units for the purposes required was clearly demonstrated.

En prévision de la mise en oeuvre d'opérations industrielles complètement intégrées, et pour accélérer la manutention des matériaux en vrac dans la Section de broyage des minéraux industriels de la Division du traitement des minéraux, on a entrepris une étude portant sur les machines de transport et d'alimentation dotées des caractéristiques suivantes: souplesse, mobilité, précision et facilité de nettoyage. Les appareils vibratoires de transport ont donné les meilleurs résultats et la Section a acheté un convoyeur, un élévateur court et deux dispositifs d'alimentation qui ont servi à l'étude du transport des matériaux par ce moyen.

Les expériences ont démontré que les machines choisies avaient de nombreuses applications pour le transport en vrac des minéraux et des roches; on pourrait aussi les utiliser pour relier entre eux les différents ateliers de traitement d'une usine. Ces machines sont sûres, faciles à entretenir et à nettoyer. On trouvera dans cette étude des chiffres sur la capacité et les caractéristiques de fonctionnement.

La mobilité de ces machines les rend particulièrement utiles dans une usine de traitement expérimentale, où les conditions d'utilisation changent avec chaque expérience. D'apparence agréable, on peut les ranger facilement lorsqu'on n'en a pas besoin. Ces machines, bien que présentant quelques inconvénients à certains égards, ont quand même démontré sans conteste leur utilité pour les fins recherchées.

\*Head, Industrial Minerals Milling Section, Mineral Processing Division.

Price: 75 cents

Cat. No. M34-20/95

TB 96 Column Flotation of Uranium from Elliot Lake Ore

W. R. Honeywell\*, December 1967, 15 pages, Tables.

This report describes investigations using the column flotation cell on an Elliot Lake ore sample. Results obtained from conducting exploratory tests followed by a statistically designed series of tests involving six operating variables using a two-inch-diameter column cell are given.

On de-slimes uranium ore, a recovery of 90 per cent with a concentration ratio of 3.0 was obtained. These results are similar to those obtained using conventional cells in previous studies. On unde-slimes ore, recoveries in the order of 80 per cent, and concentration ratios ranging from 4.7 to 8.3 were made. These concentration ratios are higher than can be obtained by conventional cells, but the recoveries are lower.

L'auteur décrit les recherches sur l'usage de la cellule de flottation en colonne dans le traitement d'un échantillon de minerai en provenance d'Elliot Lake. Il donne les résultats obtenus d'essais d'exploration suivis d'une série de tests comportant six variables de fonctionnement, par l'emploi d'une cellule en forme de colonne de deux pouces de diamètre.

On a obtenu une récupération de 90 p. 100 en utilisant du minerai d'uranium lavé; le rapport de concentration était de 3:0. Ces résultats sont semblables à ceux qui ont été obtenus en utilisant des cellules ordinaires au cours d'expériences antérieures. On a obtenu des récupérations de l'ordre de 80 p. 100 en utilisant du minerai non lavé et les rapports de concentration variaient entre 4:7 et 8:3. Ces rapports sont plus élevés que ceux que l'on peut obtenir à l'aide des cellules ordinaires, mais les pourcentages de récupération sont moins élevés.

\*Research Scientist, Hydrometallurgy Section, Extraction Metallurgy Division.

Price: 50 cents

Cat. No. M34-20/96

## INFORMATION CIRCULARS

IC 186 Copper-Zirconium Alloys (A Literature Survey)

J. L. Dion\* and R. Thomson\*\*, November 1966, 30 pages, Tables, Figures.

A review of work on high-conductivity copper-zirconium alloys is presented, covering such topics as the phase diagram, melting procedures, fabrication, heat treatment, properties and applications. Comparative reference is made to other high-conductivity alloys. The further development of copper-zirconium alloys includes the addition of third elements such as chromium, arsenic and hafnium.

Les auteurs passent en revue les recherches effectuées sur les cupro-zirconiums à haute conductibilité électrique, touchant aux sujets suivants: diagramme d'équilibre, procédés de fusion, fabrication, traitement thermique, propriétés et usages. Ils comparent le cupro-zirconium à d'autres alliages à haute conductibilité électrique. D'autres essais sur les cupro-zirconiums comportent l'addition de tiers éléments comme le chrome, l'arsenic et le hafnium.

\*Scientific Officer and \*\*Research Scientist, Non-Ferrous Metals Section, Physical Metallurgy Division.

Price: 75 cents

Cat. No. M38-3/186

IC 187 Bibliography of High-Temperature Condensed States Research Published in Canada. October-December, 1966

Norman F. H. Bright\*, January 1967, 12 pages.

This report contains bibliographic information concerning research work on high-temperature condensed states published in Canadian journals from October 1 to December 31, 1966.

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, 1966.

\*Head, Physical Chemistry Section, Mineral Sciences Division.

Price: 50 cents

Cat. No. M38-3/187

IC 188 A Review of DMIC Memorandum 215, "Titanium, 1966" (September 1, 1966)

H. V. Kinsey\*, February 1967, 20 pages.

The publication under review, "Titanium, 1966" (issued on September 1, 1966, as Memorandum 215 by the Defense Metals Information Center, Battelle Memorial Institute, Columbus 1, Ohio), is a collection of fourteen lectures that were presented at a Titanium Symposium held at Hawthorne, Calif., on March 28-29, 1966, under the sponsorship of the Norair Division of the Northrop Corporation.

The primary objective of the symposium was to provide technical personnel of diversified disciplines with a working knowledge of titanium technology. The papers were designed to be of value to a non-metallurgical technical audience as well as to those familiar with titanium technology. The secondary objective was to emphasize the need for the utilization of all required support technologies, such as materials, manufacturing, quality control, and so forth, early in the conceptual design state rather than piece-meal after the design has been formalized.



La publication à l'étude, "Titanium, 1966" (publiée le 1<sup>er</sup> septembre 1966, à titre de Mémoire 215 par le Defense Metals Information Center, Battelle Memorial Institute, Columbus 1, Ohio), réunit quatorze conférences qui ont été données à un symposium sur le titane, tenu à Hawthorne (Calif.) les 28 et 29 mars 1966, sous les auspices de la division Norair de la Northrop Corporation.

Le premier objectif de ce symposium a été de donner au personnel technique de différentes disciplines une connaissance pratique de la technologie du titane. Les exposés ont été publiés à l'intention des techniciens des disciplines non métalliques, tout autant que de ceux qui connaissent la technologie du titane. Le second objectif consiste à souligner le besoin d'utiliser toutes les techniques auxiliaires requises (techniques de matériaux, de la fabrication, du contrôle de la qualité, etc.) dès le début de la conception et du dessin des plans, plutôt que d'y recourir au fur et à mesure après que les plans soient définitifs.

\*Head, Refractory Metals Section, Physical Metallurgy Division.

Price: 50 cents

Cat. No. M38-3/188

IC 189 An Introduction to the PDP-8 Computer, Its Operation and Programming

C. A. Josling\*, April 1967, 27 pages, Figures.

A description of the functioning and programming of a small computer (Digital PDP-8) which may be used to control experiments (on-line) is given in this circular.

In part one the principal components and their operation are discussed. Special features that enable it to be used on-line are described. The arrangement of the memory into pages is explained.

Part two deals with the programming of the computer in a symbolic language known as "PAL" or program assembly language. A sample program which adds two numbers together is given. It is assumed that the reader has no previous knowledge of computers.

Cette circulaire décrit le fonctionnement et la programmation d'un petit ordinateur (Digital PDP-8) qui peut être employé pour contrôler des expériences.

Dans la première partie, on discute des principales composantes et de leurs opérations. On décrit également des caractéristiques spéciales qui permettent de l'employer "sur ligne" (on-line). On explique aussi l'arrangement de la mémoire en pages.

Dans la deuxième partie, on traite de la programmation de l'ordinateur dans un langage symbolique connu sous le nom de "PAL". On donne l'addition de deux nombres comme exemple de programmation. L'auteur suppose que le lecteur n'a pas de connaissances préalables des ordinateurs.

\*Technician, Mineral Physics Section, Mineral Sciences Division.

Price: 75 cents

Cat. No. M38-3/189

IC 190 Bibliography of High-Temperature Condensed States Research Published in Canada, January-March, 1967

Norman F.H. Bright\*, April 1967, 12 pages,

This report contains bibliographic information concerning research work on high-temperature condensed states published in Canadian journals from January 1 to March 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 de janvier 1 à mars 31, 1967.

\*Head, Physical Chemistry Section, Mineral Sciences Division.

Price: 50 cents

Cat. No. M38-3/190

IC 191 Problems Associated with Determining the Tensile Strength of Concrete

V.M. Malhotra\*, August 1967, 72 pages, Tables, Figures.

This paper critically examines the various direct and indirect methods for determining the tensile strength of concrete. The direct methods considered are the classical uniaxial tension tests, the modified direct tension test due to Todd, and the very recent methods in which thick steel plates are glued by means of epoxies to the ends of concrete specimens, which are then broken in tension. The inherent problems of parasitic stresses due to clamping and misalignment in these tests are outlined and discussed.

The indirect methods examined vary from bending tests, first proposed around 1904, to the cylinder and cube-splitting tension tests, advanced in 1940 and 1960 respectively, and the ring tensile test proposed in 1965. The errors introduced in these tests due to the assumptions based upon the Hooke's Law of Linear Stress-Strain Proportionality are outlined, and an attempt has been made to correct the strength values obtained in these tests to derive the "true" tensile strength of the concrete.

The reproducibility of the strength-test results for the various methods is given, and relationships have been attempted between the different types of strength.

The advantages and disadvantages of both direct and indirect tension test methods are given. The most common methods are illustrated by photographs or line drawings and over 100 pertinent references are listed.

L'auteur fait un examen critique des diverses méthodes directes et indirectes de détermination de la résistance du béton à la traction. Les méthodes directes étudiées sont les essais conventionnels de traction uniaxiale, l'essai modifié de traction directe de Todd, et les méthodes très récentes qui consistent à coller d'épaisses plaques d'acier à l'aide de résines époxydes aux extrémités des éprouvettes de béton qui sont alors brisés sous la traction. Les problèmes inhérents des contraintes parasitaires causées par le serrage et le mauvais alignement dans ces essais sont exposés et examinés avec soin.

L'auteur fait aussi l'examen de diverses méthodes indirectes: essais de flexion, d'abord proposés en 1904; essais de traction par rupture de cylindres et de cubes, proposés en 1940 et 1960 respectivement, et l'essai de traction sur anneau proposé en 1965. Les erreurs introduites dans ces essais à cause des hypothèses fondées sur la loi de Hooke sur la proportionnalité linéaire entre l'effort et la déformation sont exposées et l'auteur tente de corriger les valeurs de résistance obtenues dans ces essais afin d'en dériver la résistance "réelle" du béton à la traction.

L'auteur indique les possibilités de reproduire les résultats des essais de résistance obtenus par les diverses méthodes et tente d'établir les relations entre les différents types de résistance.

Il expose les avantages et les désavantages des méthodes d'essais de traction directes et indirectes, et illustre à l'aide de photos ou de graphiques les méthodes les plus courantes, en énumérant plus de 100 références pertinentes.

\*Research Scientist, Construction Materials Section, Mineral Processing Division.

Price: \$1.00

Cat. No. M38-3/191

IC 192 The Mineral Physics Section, Mineral Sciences Division, Mines Branch, 1963-1967

J. D. Keys\*, August 1967, 33 pages, Figures, Illustrations.

The work of the Mineral Physics Section of the Mineral Sciences Division, Mines Branch, between 1963 and 1967 is reviewed. The transition which took place in the Section's activities during this period -- from instrumentation and radiotracer studies to the Section's undertaking a significant role in the Divisional sulphide program -- is discussed. An account of current research investigations is given, together with a detailed bibliography.

L'auteur passe en revue le travail accompli entre 1963 et 1967 par la Section de la physique minérale, de la Division des sciences minérales, Direction des mines. Il traite de la transition qui s'est produite dans les activités de la Section au cours de cette période: des études de traceurs radioactifs et d'instruments, au programme de travaux sur les sulfures de la Division, dans lequel elle joue un rôle important. Il traite de la recherche courante et donne une bibliographie détaillée.

\*Head, Mineral Physics Section, Mineral Sciences Division.

Price: 75 cents

Cat. No. M38-3/192

IC 193 Analyses of Coal and Coke During 1966

W. J. Montgomery\* and G. C. Behnke\*\*, July 1967, 25 pages, Tables.

The Solid Fuels Laboratory of the Fuels and Mining Practice Division 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 seventh of an annual series, tabulates the analyses of coal and coke samples analysed by the Division during 1966.<sup>1</sup>

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

1. There were no commercial samples of coke analysed during 1966.

Le Laboratoire des combustibles solides, à la Division des combustibles et du génie minier, 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 septième d'une série qui doit paraître annuellement, traite des analyses d'échantillons de houille et de coke analysés par la Division au cours de 1966.<sup>1</sup>

Il faut bien se rappeler que, sauf pour les échantillons prélevés par ses propres fonctionnaires, la Division 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 recus" et "à sec". Pour les fins de référence, les analyses sont classées par province et par état.

1. Aucun échantillon de coke commercial n'a été analysé par la Division en 1966.

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

Price: 50 cents

Cat. No. M38-3/193

IC 194 Bibliography of High-Temperature Condensed States Research Published in Canada, April-June, 1967

Norman F.H. Bright\*, July 1967, 11 pages,

This report contains bibliographic information concerning research work on high-temperature condensed states published in Canadian journals from April 1 to June 30, 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'avril 1 à juin 30, 1967.

\*Head, Physical Chemistry Section, Mineral Sciences Division.

Price: 50 cents

Cat. No. M38-3/194

IC 196 Traduction du Contenu, des Titres des Schemas, de L'Appendice A, des Symboles et Abbreviations et du Glossaire de L'Appendice B du Mines Branch Monograph 874 'Rock Mechanics Principles'

D. F. Coates\*, Août 1967, 81 pages.

Comme la monographie "Rock Mechanics Principles" a suscité un vif intérêt dans les milieux universitaires de la province de Québec ainsi que de la part de groupes de recherches dans les pays latins d'outre-mer, il fut décidé de préparer un supplément à cette monographie dans le but d'aider ceux qui ont plus de facilité à lire le français que l'anglais.

Ce supplément a été rendu possible grâce au travail inlassable de Messieurs Vary et Everell et à la collaboration des professeurs Ladanyi et Gill, sans oublier le concours de M. P. E. Riverin, président de l'École Polytechnique et du professeur H. Monette du département des Mines et de la Métallurgie de l'Université Laval qui fut hautement apprécié.

\*Chef, Laboratoires de recherche en genie minier, Centre de recherche minier.

Price: \$1.25

Cat. No. M38-3/196F

IC 199 Bibliography of High-Temperature Condensed States Research Published in Canada, July-September, 1967

Norman F.H. Bright\*, October 1967, 13 pages.

This report contains bibliographic information concerning research work on high-temperature condensed states published in Canadian journals from July 1 to September 30, 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 de juillet 1 à septembre 30, 1967.

\*Head, Physical Chemistry Section, Mineral Sciences Division.

Price: 50 cents

Cat. No. M38-3/199

## REPRINT SERIES

RS 27 Planning Slopes in Shale and Other Rocks

D. F. Coates\*. Conference Preprint 342 of ASCE Water Resources Engineering Conference/Denver, Colorado, May 16-20, 1966.

In rock slopes it is difficult to follow the traditional design procedures as there are no theoretical analyses that can be used for the determination of stresses. Only in the cases where rocks yield sufficiently to be analogous to soil can average stresses be used as implied by the slip circle analysis. Furthermore, with failure being a stochastic phenomenon (unlike the traditional assumption in soil mechanics where variability is ignored) and with the strength of rock samples being known to vary inversely with their volume, the prediction of effective strength in a rock slope will not be easy.

Of the various types of rock slope failures - rockfalls, rotational shear, plane shear and block flow - the possibility of the latter two occurring is generally of most concern to those planning excavated slopes. The difficulty in predicting a plane shear failure is in locating any critical extensive planes of weakness. The difficulty in predicting block-flow failure is that the mechanics involved are not understood.

In reviewing the properties of shales, it is found that they vary through the complete spectrum of rock properties from weak, yielding materials to strong, elastic, brittle materials. Viewed in this light it can be argued that a functional classification of the rock at the site would be more useful than a name based on genesis or composition. The peculiar properties of some shales of decrepitation and swelling on exposure might be considered simply as reactions affecting the long-term strength of the material. The case histories reviewed in the paper tend to support this orientation.

At the present time, it is suggested that for the planning of slopes in shales and other rocks, the practical procedure is to concentrate on monitoring deformation rather than analysing stress. In fact, it is thought that it may eventually be proved that deformation is a better parameter than stress for predicting and analysing the reaction of rock to both surface and underground excavations.

\*Head, Mining Research Laboratories, Mining Research Centre.

Price: 25 cents

Cat. No. M38-8/27

RS 28 Occurrence, Research and Control of Sudden Outbursts of Coal and Gas in Canada

T. H. Patching\* and J. C. Botham\*\*. Reprinted from International Congress on Problems of Sudden Outbursts of Gas and Rock, Leipzig, October 1966.

Sudden outbursts of gas and salt minerals have not occurred in Canada, but outbursts of coal and gas have been experienced in the Nanaimo district of Vancouver Island, the Coal Creek and Morrissey districts of Southeastern British Columbia, and the Canmore district in Alberta. At present mining in outburst-prone seams in Canada is done only at Canmore.

The coal in these three districts is of Cretaceous age and is of high- to low-volatile, bituminous rank. The seams in all cases have been disturbed by tectonic movements, and the coal is generally highly sheared and very friable.

A bord-and-pillar method mining is generally used in the mountainous areas of Western Canada. Development headings are driven to divide the coal into rectangular pillars which may be extracted later. Almost all outbursts have occurred while driving development headings at depths of over 700 feet. In almost all cases they have been initiated by a blow or shock, and often there was no preliminary warning except that the coal seemed to be "alive".

Outbursts were first experienced in Canmore in 1944. Shortly thereafter several programs of study were initiated into their control and causes. These studies involved participation of the

mining company, provincial mine inspectors, the federal Department of Mines and Technical Surveys, and university personnel.

Shock blasting techniques have been tested and introduced at Canmore in the dangerous seams. This practice has prevented outbursts from occurring during the working periods but has apparently increased the overall frequency of outbursts, and it interferes with the most efficient working of the seams, especially with present trends to increase mechanization of coal production.

Other field and laboratory investigations are briefly reviewed in the following. A study of the structural geology of coal seams which were subject to outbursts was made. This study noted that outbursts were not characteristically associated with faults. Detailed mapping of outburst areas was carried out to record their characteristics. Convergence studies showed no unusual rates of closure prior to an outburst although sudden closure did occur at the time of an outburst.

A study of coal strengths (based on an impact test) found no evidence of unusual weakness in the immediate vicinity of outbursts. Tests suggest that the degree of shearing of coal can be indicated by the size distribution after crushing.

Measurements of the electrical resistivity of the coal ahead of an advancing face were made, but no correlation could be found between resistivity and outbursts.

Gas from the Canmore seams is mainly of methane. Only very low gas pressures have been observed from 'in situ' measurements, probably because of leakage around the seals. Up to 400 cubic feet of gas per ton of coal has been found in samples from boreholes. Samples from outbursting seams generally show high gas-emission rates.

Sorption isotherms have been determined for a variety of coals and show the apparent relationship of sorption capacity to rank. Sorptive capacity isotherms of outbursting coal from Canmore showed that saturation was readily attained in coarse and fine sizes, but this was not possible with a non-outbursting coal from Springhill, N. S.

Laboratory studies have confirmed that permeability is mainly due to fractures and is sharply reduced by confining pressures.

Laboratory studies were made to show that miniature outbursts could be created by the sudden release of gas from coal.

\*Professor of Mining and Metallurgy, University of Alberta\*\*Research Scientist, Carbonization Section, Fuels Research Centre.

Price: 25 cents

Cat.No. M38-8/28

RS 29 Occurrence, Étude et Contrôle des Dégagements Instantanés de Charbon et Gaz au Canada

T.H. Patching\* et J.C. Botham\*\*. Conférence présentée au Congrès International sur des problèmes des dégagements instantanés de gaz et roche, octobre 13-18, 1966, Leipzig.

Aucun dégagement instantané de gaz et minéraux salins ne s'est produit au Canada, mais des dégagements instantanés de charbon et gaz ont été observés dans le district de Nanaimo sur l'île de Vancouver, dans les districts de Coal Creek et de Morrissey au sud-est de la Colombie Britannique, et dans la région de Canmore en Alberta. A présent l'exploitation dans des couches sujettes aux dégagements instantanés se fait seulement à Canmore.

Le charbon dans ces trois districts est de l'âge Crétacé et sa classification de charbon bitumineux va des hautes teneurs aux basses teneurs en matière volatile. Les couches dans tous les cas ont été affectées par des mouvements tectoniques, et le charbon est généralement fortement cisailé et très friable.

Le charbon est généralement exploité dans les régions montagneuses de l'ouest du Canada par une méthode de chambres et piliers. Des chantiers de traçage avancent dans le charbon pour le diviser en piliers rectangulaires qu'on peut extraire ensuite. Presque tous les dégagements instantanés se sont produits pendant l'avancement des chantiers de traçage à des profondeurs de plus de 700 pieds. Les dégagements instantanés se sont produits souvent sans aucun indice précurseur sauf que le charbon paraissait être "en vie"; ils étaient presque toujours initiés par un coup, choc ou secousse.

Les dégagements instantanés furent observés pour la première fois à Canmore en 1944. Peu de temps après plusieurs programmes d'études furent instaurés pour étudier leur réduction et leurs causes. Ces études impliquèrent la participation de la compagnie minière, des inspecteurs provinciaux des mines, du ministère fédéral des mines et relevés techniques, ainsi que du personnel universitaire.

La méthode des tirs d'ébranlement fut mise à l'épreuve et introduite à Canmore dans les couches dangereuses. Cette pratique a empêché les dégagements instantanés de se produire durant les périodes de travail, mais apparemment a augmenté la fréquence globale de dégagements instantanés, et elle gênait l'exploitation la plus efficace des couches, surtout avec la tendance actuelle d'augmenter la mécanisation de la production du charbon.

D'autres investigations sur place et au laboratoire sont passées en revue brièvement dans ce qui suit:

Une étude de la géologie de structure des couches de charbon, sujettes aux dégagements instantanés, a noté que les dégagements instantanés n'étaient pas associés d'une manière caractéristique aux failles.

Une cartographie détaillée a été faite dans les régions, où des dégagements instantanés se produisaient, pour enregistrer leurs caractéristiques.

Des études de convergence ne montrèrent aucune vitesse insolite de fermeture avant un dégagement instantané, quoique une fermeture soudaine s'est en fait produite au moment d'un dégagement instantané.

Un examen des résistances du charbon (basé sur l'essai au choc) ne découvrit aucune preuve de faiblesse inusitée au voisinage immédiat des dégagements instantanés. L'expérience d'essais suggère que le degré de cisaillement du charbon peut être indiqué par la distribution granulométrique après écrasement.

Des mesures de la résistivité électrique du charbon en avant d'un front d'avancement furent faites, mais aucune corrélation ne put être trouvée entre la résistivité et les dégagements instantanés.

Le gaz des couches de Canmore se révéla être principalement du méthane. Des mesures de pression de gaz *in situ* n'indiquèrent que de très basses pressions, probablement à cause de fuites autour des scelllements. Jusqu'à 400 pieds cubes de gaz par tonne de charbon furent trouvés dans des échantillons pris dans des trous de sonde. Généralement les échantillons des couches sujettes au dégagement instantané montrèrent de grandes vitesses d'émission de gaz.

Des isothermes d'adsorption ont été déterminées pour une grande variété de charbons et montrèrent la relation apparente entre la capacité d'adsorption et la catégorie de classification. Les isothermes de capacité d'adsorption d'un charbon de Canmore sujet au dégagement instantané montrèrent que la saturation était facilement atteinte pour les grosses et fines dimensions, mais ceci n'était pas possible avec un charbon de Springhill, N. S. n'étant pas sujet au dégagement instantané.

Des études de laboratoire ont confirmé que la perméabilité est due principalement aux fissures et est réduite sévèrement par des pressions enveloppantes.

Des études de laboratoire ont été faites pour démontrer que les dégagements instantanés miniatures pouvaient être créés par une libération soudaine de gaz du charbon.

\*Professeur d'exploitation des mines, Université d'Alberta, Canada, \*\*Chercheur scientifique, Centre de recherche minier.

RS 30 Additives Prevent Low-Carbon-Steel Corrosion in Sulfurous Acid

W. McLeod\* and R.R. Rogers\*\*. Reprinted from Materials Protection, Vol. 5, (12), 28-29, (1966).

Mild steel in contact with an aqueous solution of sulfurous acid can be protected from corrosion by the use of an inhibitor consisting of ammonium oxalate and hexamine. The experimental results leading to this discovery are described in this article.

\*Senior Scientific Officer and \*\*Head of Pyrometallurgy and Corrosion Section, Extraction Metallurgy Division.

Price: 25 cents

Cat.No. M38-8/30

RS 31 Use of 'On-Line' Computer for Mossbauer Experiments

R.H. Goodman\* and J.E. Richardson\*\*. Reprinted from The Review of Scientific Instruments, Vol. 37, (3), 283-286, (1966).

The application of a small general purpose computer as an "on-line" data-acquisition device for Mössbauer effect experiments is described. A method of conversion from analog to digital information and outline of the computer program are given. The performance of the system is demonstrated by a Mössbauer spectrum of iron sulphide (pyrite). The extension of these techniques to other experiments is briefly considered.

\*Research Scientist, Mineral Physics Section, Mineral Sciences Division; \*\*Digital Equipment of Canada, Carleton Place, Ontario, Canada.

Price: 25 cents

Cat.No. M38-8/31

RS 32 The Effects of Some Variations in Fabrication Procedure on the Properties of Lead Zirconate-Titanate Ceramics made from Spray-Dried, Co-Precipitated Powders

A.H. Webster\*, T.B. Weston\*\* and V.M. McNamara\*\*\*. Reprinted from the Journal of the Canadian Ceramic Society, Vol. 35, 60-68, (1966).

Lead zirconate-titanate piezoelectric ceramic disks were prepared from spray-dried, co-precipitated powders by cold-pressing and sintering. The effects of several processing variables on the electromechanical properties of the ceramics were determined. It was found that satisfactory samples could be fabricated from the spray-dried powders without milling, and that the forming pressure could be varied over a considerable range with little effect on the final properties. Disks sintered in oxygen showed only a slight improvement in properties over those sintered in air. In general, an increase in planar coupling factor could be achieved by increasing the sintering temperature or sintering time, but some decrease in dielectric constant was observed at the highest temperatures and longest times. Precipitates with a slight excess or deficiency of lead oxide tended toward stoichiometry with respect to lead oxide during sintering under appropriate conditions.

\*Research Scientist, Physical Chemistry Section, Mineral Sciences Division, \*\*Research Scientist, Ceramics Section, Mineral Processing Division, \*\*\*Senior Scientific Officer, Hydrometallurgy Section, Extraction Metallurgy Division.

Price: 25 cents

Cat.No. M38-8/32



RS 33 Experimental Alloy Analysis by X-Ray Spectroscopy

D. J. Reed\*. Reprinted from the Canadian Spectroscopy, Vol. 12,(1), 6-9, (1967).

The lack of standards for non-routine X-ray spectrography has resulted in the use of synthetic standards for the determination of minor constituents in experimental alloys at the Mineral Sciences Division of the Mines Branch. For mild steels secondary Mines Branch standards have been developed with the aid of these synthetic standards.

For major constituents the use of solutions dried on filter papers has produced some unexpected results. Major elements in an alloy have been determined from ratios obtained under conditions of equivalent excitation when only a single standard was at hand.

Computer techniques have been examined for the determination of both major and minor constituents when suitable standards were available.

Par suite du manque d'échantillons étalons pour certaines analyses spéciales par spectrométrie des rayons-X, il en est résulté un usage croissant d'étalons synthétiques pour la détermination des constituants mineurs dans les alliages expérimentaux. Dans nos laboratoires, ces étalons synthétiques ont servi à la préparation d'étalons secondaires pour l'analyse des aciers doux.

Pour les constituants majeurs, l'emploi de solutions évaporées sur papier-filtre a donné des résultats imprévus. Les éléments majeurs d'un alliage ont été déterminés à partir de rapports obtenus sous des conditions d'excitation semblables à celles utilisées lorsqu'un seul étalon était disponible. On a examiné des techniques à base d'ordinateurs pour la détermination des constituants majeurs et mineurs quand il existe un nombre convenable d'étalons.

\*Research Scientist, Analytical Chemistry Subdivision, Mineral Sciences Division.

Price: 25 cents

Cat.No. M38-8/33

RS 34 A Process for Preparing Tungstic Trioxide of High Purity from a Canadian Scheelite Concentrate

J. A. Vezina\* and W. A. Gow\*\*. Reprinted from the Canadian Mining and Metallurgical Bulletin, Vol. 59 (656), 1418-1422, (1966).

A new process for treating scheelite for the production of tungstic trioxide is described. The novelty of the process resides in that an ion-exchanger is used to convert sodium tungstate to either ammonium tungstate or tungstic acid.

The process consists of a conventional hydrochloric acid leach of the scheelite concentrate, and the dissolution of the impure tungstic acid thus produced with sodium hydroxide at pH 8. The sodium tungstate solution is clarified and passed through a column of Dowex 50W x 8 ion-exchange resin to exchange the sodium ions for either hydrogen or ammonium ions, both being suitable. The tungsten-bearing column effluent is evaporated to crystallize the tungsten as ammonium tungstate; the crystals are washed with nitric acid and water and decomposed by heat to produce tungstic trioxide of high purity.

Ninety-six per cent of the tungsten in the concentrate may be recovered as tungstic trioxide ( $WO_3$ ), and the reagents consumed are 0.7 g HCl, 0.41 g NaOH and either 1.73 g  $NH_4Cl$  or 225 g HCl per gram of tungsten.

\*Senior Scientific Officer, \*\*Head, Hydrometallurgy Section, Extraction Metallurgy Division.

Price: 25 cents

Cat.No. M38-8/34

RS 35 The Effect of Stress Concentrations on the Stability of Tunnels

D. F. Coates\*, Reprinted from Proceedings of the First Congress of the International Society of Rock Mechanics, Vol. 11, 1966, Laboratorio Nacional de Engenharia Civil, Lisbon, Portugal.

The stress concentrations around an underground opening may theoretically exceed the strength of the rock mass. Deviations of the actual rock properties from those of homogeneity and perfect elasticity can, however, modify the theoretical stress distributions considerably. In addition, the known variation of the strength of rocks with the volume of the rock makes the predictability of failure due to stress concentration questionable. Several experiments have been conducted which show that failure due to compressive stress concentrations can be predicted under favourable circumstances quite accurately. However, considering failure as a stochastic phenomenon, predictions should be in terms of a probability of failure rather than a certainty. As a result of these experiments, it can be seen that the main requirements to improve the correspondence between experimental results and predicted results is to have better methods for determining the mechanical properties of rock masses.

Les concentrations des contraintes autour d'une galerie peuvent être théoriquement plus grandes que la résistance du massif. Quand le massif n'est pas parfaitement homogène et élastique, les concentrations des contraintes d'après les théories peuvent être modifiées considérablement. Aussi, la variation de la résistance des roches qui est bien connue, rend les prédictions difficiles. Quelques expériences ont été entreprises qui montrent que la rupture en compression peut être prédite dans des circonstances favorables avec pas mal de précision. Pourtant acceptant que la rupture est probable, les prédictions doivent être considérés comme probables au lieu d'être supposées certaines. Les expériences montrent surtout qu'il est très important d'améliorer les méthodes pour déterminer les propriétés mécaniques du massif.

\*Head, Mining Research Centre.

Price: 25 cents

Cat.No. M38-8/35

RS 36 The Analysis of the Viscous Property of Rocks for Classification

R. C. Parsons\* and D. G. F. Hedley\*\* Reprinted from International Journal of Rock Mechanics and Mining Sciences, Vol. 3, 325-335, Pergamon Press Ltd., (1966).

The time-dependent deformation of geological materials can be thought of in terms of classical rheological models. The viscous component though usually present, may not be of sufficient magnitude to measure over the limited time spans available. For rock classification purposes, several specimens from each of twenty different rock types have been tested in uniaxial compression to determine the magnitude of the viscous component. Several methods of evaluating the results to determine the magnitude of the viscous coefficients are discussed and compared. Two basic methods use extrapolation or the shape of the time-deformation curves.

It is found that for the great majority of the rock types tested, the semi-log relationship, log time vs. strain, closely fits the data. Extrapolation to the region of 200 min gives a realistic value of the strain rate. The strain rate of 2 in/in/hr appears to be a practical value for the division between elastic and viscous behaviour of the rock substance.

\*Scientific Officer, Rock Mechanics Laboratory and \*\*Post-doctorate Research Fellow, Elliot Lake Laboratory, Mining Research Centre.

Price: 25 cents

Cat.No. M38-8/36

RS 37 Control of Oil-Ash Slagging by an Additive

G. K. Lee\* and E. R. Mitchell\*\*, Reprinted from Pulp and Paper Magazine of Canada, Technical Section, Vol. 68, C Convention, (1967).

Conventional cleaning methods were found to be inadequate for removing slag deposits from high-temperature heat-transfer surfaces of oil-fired boilers. The research project described in this paper first established that minute interconnecting voids in slag deposits were sufficiently large to allow penetration by water treated with a suitable surfactant. From this was developed a practical water-washing procedure that has been adopted as routine maintenance in certain marine boilers.

Subsequently, fundamental combustion studies established that the mechanism of deposition for indigenous oil-ash constituents is primarily one of molecular diffusion. This finding indicates that new and radical burner and boiler design concepts are needed to overcome operational problems when untreated high-vanadium fuel oils are burned.

Also described is a program of research on additives to fuel oil to alleviate the superheater slagging problem. This includes the evaluation of many additive materials in a laboratory combustion rig and the development of a particular magnesia-alumina formulation that has promise as a practical and effective additive.

Several large power-utility boilers are now operating regularly on additive formulations developed through this research program, and preliminary reports indicate a high degree of success.

\*Research Scientist and \*\*Head, Canadian Combustion Research Laboratory, Fuels Research Centre.

Price: 25 cents

Cat.No. M38-8/37

RS 38 1. Pull Tests as a Measure of Roof-Bolt Efficiency and of Roof-Bolt Design

T. S. Cochrane\* and F. Grant\*\*. Reprinted from The Canadian Mining and Metallurgical Bulletin, Vol. 56, (620), 877-879, (1963).

Various practical tests have been tried in the mining industry to determine the support properties of mine roof bolts. Such tests include torsion wrench readings, hammer-blow tests and the use of plates with built-in tension indicators. This paper gives some details of pull tests with a hydraulic jack, as carried out in coal mines of western Canada.

\*Head, Elliot Lake Laboratory and \*\*Scientific Officer, Mining Research Section, Mining Research Centre.

2. Roof-Bolt Anchorage at Michel Colliery

L. M. Dwarokin\*. Reprinted from The Canadian Mining and Metallurgical Bulletin, Vol. 56, (620), 880-884, (1963).

The use of roof bolting gave promise of substantial economic benefits to Continuous Miner operations at Michel Colliery. As the first step in the adoption of bolting, 142 anchorage tests, employing six types of anchor shells, were made in three mines. Significant differences were found in the anchorage capabilities of the various shells and the various roof rocks.

\*Chief Engineer, Crow's Nest Industries Limited, Fernie, B. C..

3. Roof-Bolting Practices, Dominion Coal Company Limited, Sydney, N. S.

Donald MacFadgen\*. Reprinted from The Canadian Mining and Metallurgical Bulletin, Vol. 56, (620), 885-886, (1963).

Since 1950, 164 miles of levels and rooms have been roof-bolted in the collieries of the Dominion Coal Company. Roof bolting is an efficient and economic method of support where heavy timber sets or steel booms are necessary for temporary roof support, or where conventional

methods of support interfere with the passage of mechanical mining equipment.

This paper discusses present roof-bolting practices and special bolting applications.

\*Dominion Steel and Coal Corporation, Ltd., Sydney, Nova Scotia.

#### 4. Discussion - Forum on Roof Bolting

T.S. Cochrane\*, F. Grant\*\*, D.F. Coates\*\*\*, H.P. Boucher\*\*\*\*, T.G. Callcott\*\*\*\*\*, G.N. G.N. Forrester\*\*\*\*\*, L. Dwarkin\*\*\*\*\*. Reprinted from The Canadian Mining and Metallurgical Bulletin, Vol. 56, (620), 887, (1963).

\*Head, Elliot Lake Laboratory, \*\*Scientific Officer, Mining Research Section and \*\*\*Chief, Mining Research Centre, \*\*\*\*International Nickel Company Limited, Thompson, Manitoba, \*\*\*\*\*Broken Hill Proprietary Company, Australia, \*\*\*\*\*Steel Company of Canada, Hamilton, Ontario, \*\*\*\*\*Chief Engineer, Crow's Nest Industries Limited, Fernie, B.C.

#### 5. Roof-Bolting Effectiveness at Michel

D.F. Coates\* and L.M. Dwarkin\*\*, Reprinted from The Canadian Mining and Metallurgical Bulletin, Vol. 60, (659), 297-302, (1967).

Crows Nest Industries Limited adopted roof bolting in 1963 to improve roof control and to extend continuous-miner utilization in one mine. Bolting was held back because anchorage tests gave inconsistent results. The time lapse between mining and bolting was suspected as a cause, and so a test entry was driven and sections of it were bolted as part of the work cycle in addition to the normal timbering. This paper presents the results of the instrumentation of test entries and discusses the utilization of the results to improve mining procedure.

\*Chief, Mining Research Centre; \*\*Chief Engineer, Crow's Nest Industries Ltd., Fernie, B.C..

Price: 25 cents

Cat.No. M38-8/38

#### RS 39 Practical Problems in Particle Size and Surface Area Measurements

A.A. Winer\* and I.F. Wright\*\*, Reprinted from the Journal of the Canadian Ceramic Society, Vol. 35, 68-75, (1966).

Different techniques for particle size measurement employ different physical principles, and therefore may well show different results. Some methods used in practice are compared and discussed.

Variations in the test results may also be due to material characteristics, such as porosity, surface activity and the tendency of some finely divided powders to agglomerate. These may require additional analytical techniques, such as surface area measurement by gas adsorption. A relatively simple and rapid surface area technique is discussed.

\*Research Scientist, Non-Metallics Minerals Section, \*\*Head, Special Ceramics Section, Mineral Processing Division.

Price: 25 cents

Cat.No. M38-8/39

RS 40 1. The Effect of Thin Anodic Oxide Films on the Fatigue Behaviour of an Aluminium Alloy

E. G. Eeles\*, Reprinted from the Journal of the Institute of Metals, Vol. 95, 156-157 (1967).

Fatigue tests on anodised samples of 57S aluminium alloy showed that environment-induced variations in the fatigue behaviour were related to changes in the base or barrier layer of the oxide film.

\*Research Scientist, Engineering Physics Section, Physical Metallurgy Division.

2. The Relation of Humidity to the Fatigue Endurance of an Aluminium Alloy

E. G. Eeles\* and R. C. A. Thurston\*\*, Reprinted from the Journal of the Institute of Metals, Vol. 95, 156-157 and 111-115, (1967).

Fatigue tests on a commercial aluminium-magnesium-chromium alloy have shown that considerable changes in endurance are found with changes in the test environment and the environmental history of the test-pieces. It is suggested that variations in the surface oxide film are responsible.

\*Research Scientist, Senior Scientific Officer and \*\*Head, Engineering Physics Section, Physical Metallurgy Division.

Price: 25 cents

Cat.No. M38-8/40

RS 41 Paper 4. Effect of Fuel Characteristics and Excess Combustion Air on Sulphuric Acid Formation in a Pulverized-Coal-Fired Boiler

G. K. Lee\*, F. D. Friedrich\*\* and E. R. Mitchell\*\*\*, Presented at the Symposium on the Science and Technology of Coal, Ottawa, Canada, March 31, 1967.

This paper describes part of a continuing research programme aimed at establishing the influence of various factors on the corrosion potential of boiler flue gases. These factors include the sulphur content of coal, the cation content of coal ash and excess combustion air. From the experiments which were conducted in a pilot-scale research boiler with coals containing 6 and 7 per cent sulphur it has been established that  $SO_3$  concentrations, acid dew-point, rate of acid build-up and neutralization of acid by fly ash all influence corrosion potential: the method for determining the last parameter is described in detail. The findings, so far, strongly suggest that equilibrium data relating only acid concentration and theoretical acid dew-point cannot be applied to the corrosion rate under dynamic boiler conditions where flue-gas constituents such as  $SO_3$ ,  $H_2O$  and fly ash are continually deposited from the gas stream. As could be expected corrosion potential is minimal or non-existent at less than 1 per cent oxygen in the flue gas but high above 3 per cent oxygen.

\*Research Scientist, \*\*Senior Scientific Officer and \*\*\*Head, Canadian Combustion Research Laboratory, Fuels Research Centre.

Price: 25 cents

Cat.No. M38-8/41

RS 42 Development of a Model Vibrating-Grate Stoker for Strongly Caking Coals

F. D. Friedrich\*, Reprinted from the Journal of the Institute of Fuel, 102-110, March, (1965).

Research was undertaken to develop a stoker capable of satisfactory performance with strongly caking, low-ash-fusion coals, and adaptable to packaged boiler systems, for a capacity range of 50 to 1000 lb of coal/hr. To obtain a simple, compact design, a combination of an air-cooled vibrating grate, with a plate feeder extending the full width of the grate, was chosen. The feasibility of the design was

demonstrated by experiments on a model stoker having a grate 1 ft wide and 2 ft long, housed in a refractory furnace. Grate-surface temperatures of up to 1200°F were recorded, and ash fused to the grate at average grate-heat-release rates of about 225000 Btu/ft<sup>2</sup> hr. However, experiments on a full-size air-cooled vibrating-grate stoker installation showed that, with a water-cooled furnace and about 160 per cent total air, grate-surface temperatures can be maintained below 500°F. Hence it should be possible to avoid the complication of water cooling the grate. A combination of experiments on the model stoker and full-sized vibrating-grate installations showed that a vibrating frequency of 1200 c.p.m. is substantially more effective than frequencies of 400 to 800 c.p.m. in breaking up coke formations from strongly caking coal. It was established that the optimum fuel-bed thickness for good performance with strongly caking coal is 3 to 4 in, and that a positive means of providing a uniform fuel bed must be provided. Zone control of primary combustion air is also necessary. Data are given from tests on the model stoker with lignite, a non-caking coal, and a strongly caking coal. Extrapolation of the results to the design of full-scale stokers is attempted.

\*Senior Scientific Officer, Combustion Engineering Section, Fuels Research Centre.

Price: 25 cents

Cat.No. M38-8/42

#### RS 43 Galvanizing of Low-Alloy High-Strength Steels

J. J. Sebisty\* and R. H. Palmer\*. Presented at 8th International Conference on Hot-Dip Galvanizing, London, 11 to 16 June 1967.

Laboratory studies have been made on the galvanizing behaviour of several grades of low-alloy high-strength steel sheet in iron-saturated lead-containing zinc baths otherwise alloyed with chromium, manganese, nickel and vanadium. Beneficial modifications in coating formation and structure revealed were primarily related to suppression of the iron-zinc reaction rate. This was reflected in levelling out of iron-zinc alloy irregularities in coatings on normal-activity steels and, at the opposite extreme, the characteristic linear attack of silicon-containing materials was drastically altered to a parabolic form. The bath addition of 0.1% V was found to be most effective and 0.2% Cr, 0.2% Ni and 0.5% Mn followed in that order. Within limits defined by the tests, use of such additions appears to offer improved control of the coating process in galvanizing of this class of steels.

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

Price: 25 cents

Cat.No. M38-8/43

#### RS 44 Ore Deposits of the Cobalt Area

W. Petruk\*, Reprinted from Guidebook, Geological Association of Canada, Field Trip-Eastern Ontario and Western Quebec, August-September, 123-136, (1967).

The Cobalt area is underlain by Keewatin volcanic and sedimentary rocks, pre-Algoman intrusive rocks, Algoman granite, Huronian sediments, Nipissing diabase, and late Keweenawian diabase dykes. Silver deposits occur as individual veins and clusters of veins in Keewatin rocks, pre-Algoman lamprophyre dykes, Huronian sediments, and Nipissing diabase. The veins are generally nearly vertical and are up to several hundred feet in vertical and horizontal extent. They are composed of carbonate minerals and contain shoots of silver ore, cobalt arsenides, and nickel arsenides. The silver ore shoots contain up to 8,000 ounces silver per ton of vein material. The silver in them is present as masses, veinlets and separate grains. The masses and separate grains occur in arsenides, carbonate veins and adjacent wall rock; the veinlets occur in fractures in the veins and wall rock, and along the boundaries between the veins and wall rock.

\*Research Scientist, Mineralogy Section, Mineral Sciences Division.

Price: 25 cents

Cat.No. M38-8/44

RS 45 Formation of Oil Ash Deposits on Boiler Surfaces and Control by an Additive

G. K. Lee\*, E. R. Mitchell\*\*, R. G. Grimsey\*\*\* and Lt. Commander D. H. Benn\*\*\*\*, Reprinted from American Power Conference, Vol. XXVIII, 613-631, (1966).

In a continuing combustion research program the mechanism of fuel-oil-ash deposition has been elucidated. This mechanism together with an extensive knowledge of the physico-chemical properties of high-vanadium-, sulphur-, and sodium-bearing ash deposits led to the development of a research, non-proprietary, additive formulation for controlling slag formation on superheater tubes.

\*Senior Scientific Officer and \*\*Head, Combustion Research Laboratory, Fuels Research Centre; \*\*\*Staff Officer, Fuels and Lubricants, and \*\*\*\* Staff Officer, Boilers, Royal Canadian Navy.

Price: 25 cents

Cat.No. M38-8/45

RS 46 Use of "On Line" Computer For Mössbauer Experiments

R. H. Goodman\* and J. E. Richardson\*\*. Reprinted from The Review of Scientific Instruments, Vol. 37, (3), 283-286, (1966).

The application of a small general-purpose computer as an "on line" data acquisition device for Mössbauer-effect experiments is described. A method of conversion from analog to digital information and an outline of the computer program are given. The performance of the system is demonstrated by a Mössbauer spectrum of iron sulphide (pyrite). The extension of these techniques to other experiments is briefly considered.

\*Research Scientist, Mineral Physics Section, Mineral Sciences Division; \*\*Digital Equipment of Canada, Carleton Place, Ontario.

Price: 25 cents

Cat.No. M38-8/46

RS 47 Kinetic and Thermodynamic Data from Effluent-Gas Analysis

T. R. Ingraham\*, Reprinted from the Proceedings of the Second Toronto Symposium on Thermal Analysis, Toronto Section, Chemical Institute of Canada, February 27, (1967).

The basic principles of gas analysis are reviewed and applied to the analysis of single gases for the purpose of determining both thermodynamic and kinetic properties of materials. A new method is described for determining activation energies from a single run during which the temperature is increased at a uniform rate.

\*Head, Research Section, Extraction Metallurgy Division.

Price: 25 cents

Cat.No. M38-8/47

RS 48 The Small Computer in the Laboratory: Its On-Line Application

R. H. Goodman\* and C. A. Josling\*\*. Presented at Computer Centre Seminar, University of Saskatchewan, February, (1967).

Small, low-cost computers are now available for on-line applications of control and data acquisition, their use for data processing being limited. Criteria are discussed for the evaluation of on-line computer performance using the formula  $P = \frac{(WL - 7) MS}{ADD}$ : WL = word length, MS = memory

size and ADD = add time; data are also given for a variety of computers on cost as a function of performance (P in the previous formula). The general features of a computer suitable for on-line experiments are: the availability of accumulator input-output lines, an interrupt facility and a direct access to memory channel. The various types of experimental data that are normally encountered may be classified into (1) visual information, (2) readings of dials, meters, etc., and (3) counting of individual, random or sequential events. Different types of interfacing are described for the computer and the experiment being performed for each of the three classes of experiment.

\*Research Scientist and \*\*Technician, Mineral Physics Section, Mineral Sciences Division.

Price: 25 cents

Cat.No. M38-8/48

RS 49 An Investigation of the Surface of Chrysotile Asbestos Fibre

A. A. Winer\* and L. L. Sirois\*\*, Presented at the Conference of Metallurgists at Queen's University, Kingston, August 27-30, 1967.

Samples of asbestos fibres from Canada and the United States as well as nemalite (a fibrous variety of brucite) from one of the asbestos deposits in Quebec were investigated using electrophoresis. Results obtained by this method were compared with those obtained by chemical analysis, surface area (gas adsorption) and by potentiometric titration. Scanning-electron and transmission-electron micrographs of a Canadian and United States chrysotile fibre were compared. Solutions containing approximately 50 ppm of asbestos were introduced in an electrophoretic apparatus and their electrophoretic mobilities were determined. Curves of mobility, related to zeta potential, were obtained by varying the pH of a  $10^{-3}$ N potassium chloride solution with hydrochloric acid and sodium hydroxide. The surface charge of one asbestos sample was also determined by using a suspension in KCl and titrating with  $\text{HClO}_4$  and KOH. The zero point of charge (ZPC) obtained by this method compares favourably with that obtained by electrophoresis. Surface-area determinations by gas adsorption did not appear to correlate with zeta-potential measurements and the other data. The results of the spectroscopic analysis appeared to correlate with those obtained by electrophoresis.

Processing the fibre appears to alter its zeta potential, possibly because of removal of some of the associated minerals. The Canadian and United States fibre appear to have become more similar after processing, as evidenced by their zeta potential or their electrophoretic mobility. Perhaps zeta-potential measurements can be used to predict fibre behaviour at any processing stage or in the final product. Mobility curves should be plotted in detail to ascertain that all inflection points have been included. Future work will include the automating of the potentiometric titration method for the determination of zeta potential.

\*Research Scientist, Non-Metallic Minerals Section, and \*\*Research Scientist and Head, Metallic Minerals Research Laboratory, Mineral Processing Division.

Price: 25 cents

Cat.No. M38-8/49

RS 50 Research in Improved Methods of Rock Breakage

L. B. Geller\*, Reprinted from Transactions/Section A of the Institution of Mining and Metallurgy, Vol. 76, pp. A105-A124, 1967.

In planning research to improve methods of rock breakage one of the most difficult problems is that of deciding which of the almost endless aspects one should tackle first. In an effort to assist such a decision a critical review is offered of past results in both fundamental research and practical applications. Excavation, as well as crushing and grinding, is covered. Certain areas which seem to represent appropriate points of departure in a continuing search for improved methods of rock breakage are suggested as being worthy of investigation both at the fundamental and applied levels.

\*Research Scientist, Combustion Engineering Section, Fuels Research Centre.

Price: 25 cents

Cat.No. M38-8/50



RS 51 Elimination of the Dispersion Effect in the Analysis of Diffraction Line Profiles

C. Mitchell\* and P.M. De Wolfe\*\*, Reprinted from Acta Crystallographica, Vol. 22, Part 3, (10), 325-328, (1967).

The scattering distribution of X-rays, free from experimental aberration and spectral broadening, from a set of planes in a single crystal or polycrystalline specimen, can be analysed to measure coherent domain size and lattice distortion. The distortion due to cold work, the density of stacking faults, and the distribution of solute atoms can be determined from the interference function.

The paper describes a method of unfolding the spectral wavelength distribution from the X-ray diffraction line profile to give the interference distribution free of dispersion error. The scattering distribution corrected for instrumental aberrations is transformed to a scale  $\ln(\sin\theta/\sin\hat{\theta})$ , where  $\theta$  is the Bragg angle, and corrected for  $\theta$  dependence. The characteristic wavelength distribution  $L(\lambda)$  is transformed to the scale  $\ln(\lambda/\hat{\lambda})$  and mapped as a function  $M(\lambda) = (\lambda/\hat{\lambda})^3 L(\lambda)$  where  $\hat{\theta}$  and  $\hat{\lambda}$  are reference values. Fourier unfolding gives the interference distribution on the scale  $\ln(\rho/\hat{\rho})$  where  $\rho$  is the reciprocal lattice spacing.

\*Research Scientist, Metal Physics Section, Physical Metallurgy Division; \*\*Laboratorium voor Technische Natuurkunde, Lorentzweg 1, Delft, The Netherlands.

Price: 25 cents

Cat.No. M38-8/51

RS 52 Variations in Properties with Composition in Lead Zirconate-Titanate Ceramics

T. B. Weston\*, A. H. Webster\*\* and V. M. McNamara\*\*\*, Reprinted from Canadian Ceramic Society Journal, Vol. 36, 15-20, (1967).

Lead zirconate-lead titanate ceramics, covering the compositional range 40 to 70 mole per cent lead zirconate, were prepared by cold-pressing and sintering from co-precipitated powders. For these ceramics the maxima in the values of dielectric constant and electromechanical coupling factor that occur at the rhombohedral-tetragonal boundary were found to be higher and sharper than previously reported for unmodified lead zirconate-titanate. Dielectric and mechanical losses were lower in the tetragonal than in the rhombohedral phase. Determination of the variations in properties with temperature confirmed the previously reported shift in the phase boundary toward higher zirconate compositions with increasing temperature. It was found that changes in electromechanical properties resulting from loss of lead oxide could be explained on the basis of the formation of a more titanate-rich solid solution, accompanied by the precipitation of zirconia.

\*Research Scientist, Ceramic Section, Mineral Processing Division, \*\*Research Scientist, Physical Chemistry Section, Mineral Sciences Division, \*\*\*Senior Scientific Officer, Hydrometallurgy Section, Extraction Metallurgy Division.

Price: 25 cents

Cat.No. M38-8/52

RS 53 Evaluation of Iron Oxides For Ferrite Manufacture

D. V. Ratnam\*, G. A. Ingham\*, Norman F. H. Bright\*\*, Richard H. Lake\*\*\*, and John F. Rowland\*\*\*\*. Reprinted from Canadian Ceramic Society Journal, Vol. 36, 20-24 (1967).

Iron oxides intended for use in ferrite manufacture are described in terms of physical properties such as surface area, particle size and shape, and tap density. Results are presented of a study of the barium hexaferrite formation reaction, using X-ray diffraction, differential thermal and thermogravimetric analyses and, based thereon, the possibility of including a reactivity parameter in the description of an iron oxide is suggested.

\*Northern Pigment Company Ltd., New Toronto, Ontario, \*\*Head, \*\*\*Technical Officer and \*\*\*\* Research Scientist, Physical Chemistry Section, Mineral Sciences Division.

Price: 25 cents

Cat.No. M38-8/53

RS 54 Diffusion of External Methane Atmospheres Through Gaps of Various Sizes and Widths into Enclosures of Different Volumes and the Effect of Greased Joints

E. D. Dainty\* and G. K. Brown\*\*, Presented to 12th International Conference of Mine-Safety Research Establishments, Dortmund, September 1967.

Fifty per cent methane-air mixtures were prepared in a cubical case containing a cylinder which was divided in half by a joint at a right angle to the longitudinal axis. The gap, joint width and internal volume were varied to determine their effects on the diffusion rate of the external mixture into the cylinder.

The experimental results agreed well with those calculated using the following simplified logarithmic diffusion equation:

$$C_i = C_o \left( \frac{e^{xt} - 1}{e^{xt}} \right)$$

where  $C_i$  and  $C_o$  are the inside and outside methane concentrations,  $x$  is a function of the gap geometry, internal enclosure volume and the diffusion coefficient, and  $t$  is the elapsed time from the start of the diffusion process.

The application of grease on the gap surface in sufficient quantities stopped the diffusion process, and the effects on the grease seal of internal pressures simulating pressure changes due to thermal cycling of electrical equipment, were briefly studied. The results showed that the seal was effective for pressures greater than those considered possible during thermal cycling.

\*Research Scientist and \*\*Head, Electrical Equipment Certification Section, Fuels Research Centre.

Price: 25 cents

Cat.No. M38-8/54

*SECTION 2 - PAPERS PUBLISHED IN PERIODICALS*

## MINERAL PROCESSING DIVISION

- "Optimizing Mill Circuit - Pre-Control Studies", by D. E. Pickett. Proceedings of the Fourth Annual Meeting of the Canadian Gold Metallurgists held at Mines Branch, Department of Energy, Mines and Resources, Ottawa, 43-45, January, (1967).
- "Milling and Process Metallurgy - Technical Advances in Canada", by D. E. Pickett. Canadian Mining Journal, February, (1967).
- "Industrial Minerals", by R.K. Collings. Canadian Mining Journal, February, (1967).
- "Asbestos", by H. M. Woodrooffe, Canadian Mining Journal, February, (1967).
- "Potash", by C.M. Bartley, Canadian Mining Journal, February, (1967).
- "Accelerated Method of Predicting the 28-Day Compressive Strength of Lightweight Concrete", by H. S. Wilson, N.G. Zoldners and V.M. Malhotra. Proceedings, RILEM Symposium on Testing and Design Methods of Lightweight Aggregate Concretes, held at the Hungarian Academy of Sciences, Budapest, March, (1967).
- "Comparison of Ring-Tensile Strength of Concrete With Compressive, Flexural and Splitting-Tensile Strengths", by V.M. Malhotra and N.G. Zoldners. ASTM Journal of Materials, 2, (1), 160-199, January-March issue, (1967).
- "Applications of Digital Computer in the Quality Control of Concrete", by V.M. Malhotra. Symposium of American Concrete Institute, Special Publication SP-16, 9-22, March, (1967).
- "Beneficiation of Low-Grade Tin Ores by Flotation", by R. W. Bruce and B. Yaksic. Transactions of the Canadian Mining and Metallurgical Bulletin, Vol. LXX, 49-53, (1967).
- "Study of the Adsorption of Dodecylammonium Chloride on a Labradorite", by T. Takamori and L. L. Sirois. Journal, Mining and Metallurgical Institute of Japan, 83, (945), 19-24, (1967).
- "Effect of High Temperature on Concrete Made With Anorthosite Aggregate and Aluminous Cement", by N.G. Zoldners and V.M. Malhotra. Engineering Journal, 50, (6), 32-38, (1967).
- "Variations in Properties with Composition in Lead Zirconate - Titanate Ceramics", by T. B. Weston, A.H. Webster, and V.M. McNamara. Journal, Canadian Ceramic Society, 36, 15-20, (1967).
- "Effect of PbO Deficiency on the Piezoelectric Properties of Lead Zirconate - Titanate Ceramics", by A. H. Webster, T. B. Weston and Norman F. H. Bright. Journal, American Ceramic Society, 50, 490-91, (1967).
- "Sulphur", by C.M. Bartley. Western Miner, March, (1967).
- "Non-Destructive Methods of Testing Concrete", by V.M. Malhotra. Canadian Pit and Quarry, 8, Part I, (?), 26-39, February, (1967); Part II, (4), 54-56, April, (1967); Part III, (5), 47, May, (1967).
- "A Century of Cement in Canada", by N.G. Zoldners. Canadian Pit and Quarry, 8, 30-32, May, (1967).
- "Problems Associated with Determining the Tensile Strength of Concrete", by V.M. Malhotra. Transactions, Engineering Institute of Canada, (67), Civil Division 9, 23, July, (1967).
- "Filtration Fundamentals", by N. Nemeth. Canadian Mining and Metallurgical Bulletin, August, (1967).
- "Non-Destructive Testing of Concrete", by V.M. Malhotra. Cement and Concrete Journal, New Delhi: Part I, April-June; Part II, July-September; Part III, October-December, (1967).
- "Durability of Concrete", by N.G. Zoldners. Canadian Pit and Quarry, 8, Part I, 34-36, October, (1967); Part II, 30-32, December, (1967).

"Ceramics in a Changing World. Part I: Glass, Clay Products and Ceramic-Metal Systems", by J.G. Brady. Canadian Mining and Metallurgical Bulletin, 60, (668), 1397-1402, December, (1967).

## EXTRACTION METALLURGY DIVISION

"Kinetics and Thermodynamic Data from Effluent-Gas Analysis", T.R. Ingraham. Proceedings of Second Toronto Symposium on Thermal Analysis, 21-36, (1967).

"Kinetics of Silver Cementation on Copper in Perchloric Acid and in Alkaline Cyanide Solutions", E. A. von Hahn and T.R. Ingraham. Transactions, Metals Society, AIME, 239, 1895-1900, (1967).

"Roasting in Extractive Metallurgy - A Thermodynamic and Kinetic Review", T.R. Ingraham and R.C. Kerby. Canadian Metallurgical Quarterly, 6, 89-119, (1967).

"Thermodynamic Properties of Indium Oxide", K. Hochgeschwender and T.R. Ingraham. Canadian Metallurgical Quarterly, 6, 293-300, (1967).

"Thermodynamics of the Chlorination of Manganese, Lead and Zinc Sulphides", R.F. Pilgrim and T.R. Ingraham. Canadian Metallurgical Quarterly, 6, 333-346, (1967).

"Kinetics of Dissolution of Synthetic Digenite and Chalcocite in Aqueous Acidic Ferric Sulphate Solutions", G. Thomas, T.R. Ingraham and R. J.C. MacDonald. Canadian Metallurgical Quarterly, 6, 261-281, (1967).

"Kinetics of the Thermal Decomposition of Zinc Sulphate and Zinc Oxysulphate", T.R. Ingraham and P. Marier. Canadian Metallurgical Quarterly, 6, 249-261, (1967).

"Variations in Properties with Composition in Lead Zirconate - Titanate Ceramics", T.B. Weston, A.H. Webster and V.M. McNamara. Journal, Canadian Ceramic Society, 36, 15-20, (1967).

"Brief Review of Bacterial Leaching in the Canadian Mining Industry", H.W. Smith. The Canadian Scientist, 1, 22-23, Winter Issue, (1967-1968).

"Improved Electroplating Methods and Their Use in Combatting Hydrogen Embrittlement", W. Dingley, J. Bednar and R.R. Rogers. Metal Finishing Journal, 65 (2), 44-48, February (1967).

## MINERAL SCIENCES DIVISION

"On the Bonding in Bismuth Telluride", J.D. Keys and H.P. Dibbs. Physica Status Solidi, 19, K 11, (1967).

"The Production and Homogeneity Testing of High-Purity Copper Standards", J.L. Dalton, R. Thomson, and A.H. Gillieson. Canadian Spectroscopy, 12, (1), 6-9, (1967).

"Experimental Alloy Analysis by X-ray Spectroscopy", (Mrs.) D.J. Reed. Canadian Spectroscopy, 12, (1), 6-9, (1967).

"Europium Tartronate and Malonate Ion Association in Water", P.G. Manning. Canadian Journal of Chemistry, 45, 1643, (1967).

"Cu(II) in Octahedral Sites in Sphalerite", P.G. Manning. Canadian Mineralogist, 8, 567, (1966).

"Absorption Spectra of Fe(III) in Octahedral Sites in Sphalerite", P.G. Manning. Canadian Mineralogist, 9, 57, (1967).

"A Study of the Bonding Properties of Sulphur in Bornite", P.G. Manning. Canadian Mineralogist, 9, 5, (1967).

- "The Effect of Surface Properties on Refractive-Index Determination by the Brewster Angle Method", J.D. Butterill and E. H. Nickel. *American Mineralogist*, 52, 1247-1250, (1967).
- "New Palladium Minerals from Noril'sk, Western Siberia", L. J. Cabri and R. J. Traill. *Canadian Mineralogist*, 8, 541-550, (1966).
- "A New Copper-Iron Sulfide", L. J. Cabri. *Economic Geology*, 62, 910-925, (1967).
- "Note on the Occurrence of Calaverite and Petzite in the Phantom Lode, Great Boulder Mine, Kalgoorlie", L. J. Cabri. *Proceedings, Australasian Institute of Mining and Metallurgy*, 222, 95, (1967).
- "X-ray Analysis of the Substrates of Aconitase: VII. The Structure of Lithium Ammonium Hydrogen Citrate", E. J. Gabe, J. P. Glusker, J. A. Minkin and A. L. Paterson. *Acta Crystallographica*, 21, 418, (1966).
- "Inorganic Research in Canada", R. D. Heyding, J. B. Taylor and N. F. H. Bright. *Chemistry in Canada*, 19 (6), 22-27, (1967).
- "Variations in Properties with Composition in Lead Zirconate-Titanate Ceramics", T. B. Weston, A. H. Webster and V. M. McNamara. *Journal, Canadian Ceramic Society*, 36, 15-20, (1967); incorporated in "Canadian Clay and Ceramics", 40, (4), (1967).
- "Evaluation of Iron Oxides for Ferrite Manufacture", D. V. Ratnam and G. A. Ingham (Northern Pigment Co. Ltd., New Toronto) and N. F. H. Bright, R. H. Lake and J. F. Rowland. *Journal, Canadian Ceramic Society*, 36, 2-24, (1967); incorporated in "Canadian Clay and Ceramics", 40, (4), (1967).
- "Effect of PbO Deficiency on the Piezoelectric Properties of Lead Zirconate-Titanate Ceramics", A. H. Webster, T. B. Weston and N. F. H. Bright. *Journal, American Ceramic Society*, 50, (9), 490-491, (1967).
- "Small Computers Aid Engineers", R. H. Goodman and C. A. Josling. *Electronics and Communication*, 30, May 1967.
- "A Multi-Spectrometer Mössbauer System Using an On-Line Computer", R. H. Goodman. *Proceedings, 2nd Symposium, Low-Energy X and Gamma Sources and Applications*, Editors: P. S. Baber and M. Gerrard; Oak Ridge National Laboratory - Isotopes Information Center, 10; Union Carbide, 23, 175-196, (1967).
- "Electrotransport in Single-crystal Bismuth Telluride", H. P. Dibbs and J. D. Keys. *Canadian Journal of Physics*, 45, 3945-3957, (1967).
- "Studies of Mineral Sulpho-Salts: XX. Berryite, a New Species", E. W. Nuffield and D. C. Harris. *Canadian Mineralogist*, 8, 407-413, (1966).
- "X-ray Spectrographic Analysis of Minute Mineral Samples", D. C. Harris and E. J. Brooker. *Canadian Mineralogist*, 8, 471-480, (1966).
- "Some Observations on Pharmacolite", D. C. Harris. *Canadian Mineralogist*, 8, 530-531, (1966).
- "Minerals from the Nepheline Syenite, Mont. St. Hilaire", G. Y. Chao, D. C. Harris, A. W. Hornslow, J. A. Mandarino and G. Perrault. *Canadian Mineralogist*, 9, 109-123, (1967).
- N. B. The work reported on these last four papers was done by Dr. D. C. Harris at Royal Ontario Museum prior to joining the Mines Branch.
- "Correlation of Absorption Spectra and Structure of some Co(II)- and Ni(II)- 2, 2'-Biquinoline Complexes", G. Faye and J. L. Horwood. *Canadian Journal of Chemistry*, 45, 2336-2345, (1967).

"On a General Spectrochemical Method for the Direct Arcing of Liquid-Liquid Extraction Residues in a D. C. Arc", B. Nebesar. *Analytica Chimica Acta.*, 39, 301-307, (1967).

"D. C. Arc Spectrochemical Determination of Rhenium in Molybdenite Ore", B. Nebesar. *Analytica Chimica Acta.*, 39, 309-319, (1967).

"Chalcogenides of the Transition Elements, V: Crystal Structures of the di-Sulphides and di-Tellurides of Ruthenium and Osmium", Sutarno, Oswald Knop and K.I. G. Reid. *Canadian Journal of Chemistry*, 45, 1391-1400, (1967). (Based on work done by Dr. Sutarno at Nova Scotia Technical College, Halifax, before joining Mines Branch staff).

"Ore Deposits of the Cobalt Area", W. Petruk. Guidebook, Geology of Parts of Eastern Ontario and Western Quebec, 123-136, published by Geological Association of Canada, (1967).

"A Simple Vacuum Filtration Device Accommodating Tall Vessels", B. Nebesar. *Laboratory Practice*, 16, 727, (1967).

"A Stand for Pasteur Pipettes", B. Nebesar and L. Ninchich. *Laboratory Practice*, 16, 996, (1967).

## FUELS RESEARCH CENTRE

"Impact Test-Rotter Machine" and "Friction-Impact Test", D. A. B. Stevenson, J. A. Darling. *Canadian Section of Manual of Sensitiveness Tests*, TTCP Panel, 0-2 (Explosives), Working Group on Sensitivity, Canadian Armament Research and Development Establishment, Chapters 1 and 2, (1967).

"Formation of Oil Ash Deposits on Boiler Surfaces and Control by an Additive", G. K. Lee, E. R. Mitchell, R. G. Grimsey, D. H. Benn. *Proceedings American Power Conference*, Vol. XXVIII, 613-625, (1966).

"Effect of Fuel Characteristics and Excess Combustion Air on Sulphuric Acid Formation in a Pulverized-Coal-Fired Boiler", G. K. Lee, F. D. Friederich, E. R. Mitchell. *Journal of the Institute of Fuel*, Vol. XL, September, (1967).

## MINING RESEARCH CENTRE

"Roof-Bolting Effectiveness at Michel", D. F. Coates, L. M. Dwarkin. *The Canadian Mining and Metallurgical Bulletin*, 60, (659), March, (1967).

"Coupling and Stress Waves in Close Proximity to Surface Explosions", K. Sassa, D. F. Coates. *International Journal of Rock Mechanics and Mining Sciences*, 4, 229-243, (1967), Pergamon Press Ltd.

"Third Supplement to Bibliography of Canadian Contributions in the Field of Rock Mechanics (for January to December 1966)", D. F. Coates. *The Canadian Mining and Metallurgical Bulletin*, 60 (662), 655-656, (1967).

"Research in Improved Methods of Rock Breakage", L. B. Geller. *Transactions, Institution of Mining and Metallurgy*, 76, A105-A124, July, (1967).

"A Comparison of Two Methods for Measuring Stress in Rock", W. L. van Heerden and F. Grant. *International Journal of Rock Mechanics and Mining Sciences*, 4, 367-382, (1967), Pergamon Press Ltd., London.

## PHYSICAL METALLURGY DIVISION

"The Effect of Additions of Manganese, Vanadium and Chromium on the Activity of Oxygen in Molten Iron", J.K. Pargeter. Canadian Metallurgical Quarterly, 6, (1), 21-37, January-March, (1967).

"Research on Premium-Quality Light-Alloy Castings", J. W. Meier, Ontode (Budapest) 18(2), 39-45 and (3), 66-72 (Feb. and Mar. 1967), in Hungarian. (Official Exchange Paper from the American Foundrymen's Society to the 32nd International Foundry Congress, Warsaw, Poland, Sept. 12-18, (1965).

"Effect of Centrifugal Force on Solidification of Aluminum Alloys". Transactions, American Foundry Society, (1967); Modern Castings, 51, (4), 62-66, April, (1967).

"Corrosion Fatigue of Structural Metals in Mine-Shaft Waters", G. J. Biefer. Canadian Mining and Metallurgical Bulletin, 60, (662), 675-681, June, (1967).

"The Relation of Humidity to the Fatigue Endurance of an Aluminum Alloy", E. G. Eeles and R. C. A. Thurston. Journal, Institute of Metals, 95, 111-115, (1967).

"The Effect of Thin Anodic Oxide Films on the Fatigue Behaviour of an Aluminium Alloy", E. G. Eeles. Journal, Institute of Metals, 95, 156-157, (1967).

"Recovery and Recrystallization of Aluminum During Extrusion", W. A. Wong, H. J. McQueen and J. Jonas. Journal, Institute of Metals, 95, 129-137, (1967).

"Determination of the Distribution Coefficient and Diffusion Constants in Dilute Alloys of Thallium and Tin", K. G. Davis and P. Frysuk. Transactions, Metallurgical Society, AIME, 239, 1105-1106, (1967).

"Segregation and Inclusions in Zirconium-Containing Magnesium Casting Alloys", B. Lagowski, Transactions, American Foundrymen's Society, 75, 229-256, (1967); Modern Castings, 52, 87-114, August, (1967).

"Formation of Fatigue Striations in Face-Centered-Cubic Metals", D. Kuhlmann-Wilsdorf, E. E. Laufer and H. Nine, Journal of Applied Physics, 38, 896-898, (1967).

"Constitution of Niobium-Cobalt Alloys", J. K. Pargeter and W. Hume-Rothery, Journal of Less-Common Metals, 12, 366-374, (1967).

"Hot Working and Recrystallization of Face-Centered-Cubic Metals", H. J. McQueen, Proceedings, International Conference on Strength of Metals, Tokyo, Japan, 2-8 September, 1967.

"The Hot Tearing of Copper-Base Casting Alloys", A. Couture and J. O. Edwards, Cast Metals Research Journal, American Foundrymen's Society, 3, (2), 57-69, June (1967); Transactions, American Foundrymen's Society, 74, 709-721, (1966).

"The Mode of Solidification of Copper-Base Alloys", J. O. Edwards and A. Couture, Cast Metals Research Journal, American Foundrymen's Society, 3, (2), 70-79, (June, 1967); Transactions, American Foundrymen's Society, 74, 680-689, (1966).

"Isothermal Characteristics of a Low-Alloy Steel Using a Weld Thermal Cycle Simulator", D. G. Howden, Canadian Metallurgical Quarterly, 6(3), July-September, (1967).

"Wear of Engineering Materials", E. G. Eeles and S. L. Gertsman, Transactions, Canadian Institute of Mining and Metallurgy, 70, 210-215, (1967).



"Effect of Thermal Gradient and Other Factors on the Properties of Copper-Base Casting Alloys", J. O. Edwards and A. Couture. *Modern Castings*, 52, (6), 91-101, December, (1967); *Transactions, American Foundrymen's Society*, 75, 383-393, (1967).

"Elimination of the Dispersion Effect in the Analysis of Diffraction Line Profiles", C. M. Mitchell and P. M. de Wolff. *Acta Crystallographica*, 22, (3), 325-328, (1967).

"Surface Bubble Formation During Fatigue of an Aluminum Alloy", E. G. Eeles and R. C. A. Thurston, *Materials Research and Standards*, 7, (5), 193-194, (1967).

"Modernization - A Challenge to Canadian Foundries", S. L. Gertsman. *Canadian Metalworking/ Machine Production*, 30, (11), 33-39, (1967).

"Etching Steel to Determine Phosphorus Segregation", R. K. Buhr and F. Weinberg. *Journal, Iron and Steel Institute*, 205, 1161-1164, (1967).

*SECTION 3 - AVAILABLE INVESTIGATION REPORTS*

## MINERAL PROCESSING DIVISION

- IR 65-4 "Concentration of Magnesite from the Timmins Area, Ontario" (Project MP-IM-64-13), F.H. Hartman, January 1965.
- IR 66-3 "Beneficiation of Fluorite from Udaipur, India" Project (MP-IM-6408), F.H. Hartman, R.A. Wyman, January 1966.
- IR 66-9 "Nickeliferous Magnesite - Quartz Rock from Bale Verte, Newfoundland", James A. Soles, February 1966.
- IR 66-11 "Magnetic Concentration of Magnetically Roasted Ore from Steep Rock Iron Mines Limited, Atikokan, Ontario", G.W. Riley, January 1966.
- IR 66-24 "An Investigation of Metallurgical Problems at Preissac Molybdenite Mines Limited, Abitibi-East, Quebec", G.I. Mathieu, March 1966.
- IR 66-27 "Recovery of Carbon and Other Products from Fly Ash" (Project MP-IM-6501), F.H. Hartman, September 1966.
- IR 66-29 "Investigation of a Copper-Nickel Ore from Axis Lake Area of Northern Saskatchewan, for Placid Oil Company, Calgary, Alberta", G.I. Mathieu, March 1966.
- IR 66-30 "Evaluation of the Flotation Characteristics of a Copper-Gold-Silver Ore from Lucky Lake Mines, Usk, B.C.", G.I. Mathieu, March 1966.
- IR 66-34 "Beneficiation of Silica Sand from St. Canut, Quebec, Part 2", (Project MP-IM-6301), R.A. Wyman, March 1966.
- IR 66-37 "Pelletizing Expanded Perlite Fines", H.S. Wilson, March 1966.
- IR 66-51 "Petrography of Limestone Drill Core from St. Constant, Quebec", J.A. Soles, June 1966.
- IR 66-60 "Concentration of Copper-Nickel Ore from Lorraine Mining Co. Ltd., Belleterre Area, Quebec", A. Stemerowicz, March 1966.
- IR 66-62 "Pilot-Plant Investigation of Nickel-Copper Ore from the Strathcona Property of Falconbridge Nickel Mines Limited, Falconbridge, Ontario", A. Stemerowicz, July 1966.
- IR 66-63 "Pilot-Plant Investigation of a Cu-Pb-Zn Ore from Cupra Mines Limited, Stratford Centre, Quebec", T.F. Berry, July 1966.
- IR 66-64 "Work-Index Determination of Nordic Ore for Rio Algom Mines Limited, Elliot Lake, Ontario", T.F. Berry, July 1966.
- IR 66-80 "Examination of Lead Meta-Niobate Samples Submitted by Duplate Canada Limited Research Laboratories, Oshawa, Ontario", A.A. Winer, September 1966.
- IR 66-83 "Investigation of a Gold-Cobalt-Bismuth Ore from the Marion River Area for Precambrian Mining Services Limited, Yellowknife, N.W.T.", G.I. Mathieu, October 1966.
- IR 66-99 "Work-Index Determination of Silicified Porphyry Ore from East Malartic Mines Limited, Norrie, Quebec", T.F. Berry, December 1966.
- IR 66-100 "Tabling Tests on Barite-Fluorite Samples from Lake Ainslie, Nova Scotia", (Project MP-MIL-207), R.A. Wyman, November 1966.

- IR 67-6 "Assessment of Shales and Slates from New Brunswick for Lightweight Aggregate", H. S. Wilson, February 1967.
- IR 67-17 "Concentration of Magnetite Ore from Jaybee Landry Exploration and Mining Company Limited, Sudbury, Ontario", T. O. Llewellyn, March 1967.
- IR 67-27 "Laboratory and Pilot-Plant Investigation on Molybdenite-Bismuth Ores from Moly Hill Mining Corporation Limited, Rouyn, Quebec", G. I. Mathieu, May 1967.
- IR 67-28 "Mineralogical Examination of Sandstone and Siltstone, Thelon Formation (Proterozoic), Northwest Territories", R. S. Dean, May 1967.
- IR 67-50 "Investigation of a Gold-Silver Ore from the Lynn Lake Manitoba Property of Agassiz Mines Ltd.", G. I. Mathieu, July 1967.

### EXTRACTION METALLURGY DIVISION

- IR 67-1 "Application of Atomic-Absorption Spectrophotometry to Analysis of Mill Products from Metal Mining Operations. No. 2 McIntyre Porcupine Mines Ltd., Schumacher, Ont.", R. J. Guest, January 1967.
- IR 67-4 "The Use of Radioactive Tracers in Ion-Exchange Studies", A. J. Gilmore, January 1967.
- IR 67-5 "Melting SL-RN Pellets in a Combined Shaft-Electric Furnace", G. E. Viens, R. A. Campbell, G. N. Banks, G. V. Sirianni and R. L. Sachdeva, January 1967.
- IR 67-22 "Application of Atomic-Absorption Spectrophotometry to Analysis of Mill Products from Metal Mining Operations. 3. Cochenour Willans Gold Mines Limited, Cochenour, Ontario", R. J. Guest, May 1967.
- IR 67-24 "The Effect of Agitation in the Cyanidation of Gold Ores", B. H. Lucas and W. A. Gow, April 1967.

### MINERAL SCIENCES DIVISION

- IR 67-12 "Analysis of CAAS Copper Standards by Atomic-Absorption Spectrophotometry", J. C. Hole and D. J. Charette, January 1967.
- IR 67-23 "Ferrites: Part II. Investigation of the Co-Precipitation Method of Preparation of Permanent-Magnet-Type Ferrite Powders", Sutarno and W. S. Bowman, April 1967.
- IR 67-46 "Ferrites: Part III. Construction and Operation of a Magnetic Orienting Press for the Fabrication of Anisotropic Ferrite Magnets", Sutarno, W. S. Bowman, J. F. Tippins and G. E. Alexander, July 1967.
- IR 67-56 "Ferrites: Part I. Literature Survey on Permanent-Magnet-Type Ferrite Technology", Sutarno and W. A. Bowman, August 1967.
- IR 67-68 "Scintillation Counter Plateaus for X-Radiation of the Heavy Elements", (Mrs.) D. J. Reed, October 1967.

### PHYSICAL METALLURGY DIVISION

- IR 67-10 "Examination of Welded Joints in Sample from Hull of C. C. G. A. Sir Humphrey Gilbert", W. P. Campbell, March 1967.