



DEPARTMENT OF  
ENERGY, MINES AND RESOURCES  
OTTAWA

*MINES BRANCH*

SCIENTIFIC AND TECHNICAL PAPERS

PUBLISHED BY THE STAFF IN 1973

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## FOREWORD

This Information Circular is the eleventh annual review of the scientific and technical papers published by the staff of the Mines Branch.

Section 1 gives the titles and abstracts of papers published during 1973 in the Mines Branch Series (Monographs, Research Reports, Technical Bulletins, Information Circulars and Reprint Series). These publications are available from Information Canada, 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 1973 by the Mines Branch staff. The periodicals containing these papers are available in many technical libraries.

Section 3 contains a list of the 1973 titles available in the Investigation Report Series and also the titles from previous years that have now been released for general distribution. This series includes the results of investigations done by the Mines Branch at the request of industry, of other government agencies, and 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 this Information Circular are available for reference, in the divisions concerned, but in most cases there are no copies remaining 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 provide the reader with a more complete view of the work of the Mines Branch.

D. F. Coates,  
Director

## AVANT-PROPOS

Cette circulaire d'information est la onzième revue annuelle des rapports scientifiques et techniques publiés par le personnel de la Direction des mines.

La Section 1 indique les titres et les résumés des rapports publiés en 1973 dans la Série de la Direction des mines (les Monographes, les Rapports de recherche, les Bulletins techniques les Circulaire d'information et la Série de deuxième édition). Ces publications sont disponibles à Information Canada, Ottawa aux prix indiqués et peuvent être commandées par le numéro du Catalogue donné pour chaque publication (les publications avant 1962 sont cataloguées dans "Canadian Government Sectional Catalogue", No. 12, juillet 1962).

La Section 2 indique les titres de tous les rapports publiés dans les revues scientifiques et techniques en 1973 par le personnel de la Direction des mines. Les périodiques qui contiennent ces rapports sont disponibles dans plusieurs bibliothèques techniques.

La Section 3 contient une liste des titres de 1973 disponibles dans la Série des Rapports d'investigation ainsi que les titres des années précédentes qui ont été maintenant mis en circulation pour distribution générale. Cette série comprend les résultats des études faites par la Direction des mines à la demande de l'industrie et d'autres agences gouvernementales, et des études initiées par la Direction des mines sur les matériaux et les procédés spécifiques. Plusieurs Rapports d'investigation ne sont pas disponibles parce qu'ils sont soit confidentiels soit d'un intérêt très limité. Ceux qui sont catalogués dans la Circulaire d'information sont disponibles comme référence dans les divisions intéressées, mais dans la plupart des cas, il n'y a pas de copies qui restent pour distribution. Cependant, on prévoit que même cette disponibilité limitée sera d'une valeur pour plusieurs individus ou sociétés avec des intérêts spécifiques et aidera à empêcher des reproductions inutiles d'études déjà faites par la Direction.

J'espère que cet index supplémentaire donnera au lecteur un aperçu plus complet du travail de la Direction des mines.

D. F. Coates,  
Directeur

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SECTION 1 - MINES BRANCH SERIES

RESEARCH REPORTS

R - 238 Crystal Growth Part IV: The Arsenides & Sulpharsenides of Cobalt, Iron and Nickel  
by L. G. Ripley\*

This report deals with an applied research project to explore the preparation and the growing of single crystals of sixteen arsenides and sulpharsenides of cobalt, iron, and nickel. A significant start has been made in the understanding of the growth problems presented by this group of compounds, but much more research needs to be done.

The prime growth procedure was the chemical vapour transport using iodine as the carrier. Good single crystals of safflorite ( $\text{CoAs}_2$ ), loellingite ( $\text{FeAs}_2$ ), skutterudite ( $\text{CoAs}_{3-x}$ ), and cobaltite ( $\text{CoAsS}$ ) were obtained by this procedure; the first two listed were in the millimetre size range. Three other growth procedures were tried: (1) the modified "melt-and-anneal" method, which was partially successful in the preparation of langisite ( $\text{Co}_{0.8}\text{Ni}_{0.2}\text{As}$ ); (2) the vapour transport method; and (3) the flux growth method. The last two methods were not successful in the cases to which they were applied.

Dans ce rapport l'auteur traite d'un projet de recherche appliqué sur l'étude de la préparation et de la croissance des monocristaux de seize arséniures et sulfarséniures de cobalt, de fer et de nickel. L'auteur a fait un commencement significatif pour bien comprendre les problèmes de croissance présentés par ce groupe de composés mais il y a encore beaucoup plus de recherches qui doivent être faites.

Le premier procédé de croissance était le transport chimique en phase vapeur utilisant l'iode comme porteur. L'auteur a obtenu de bons monocristaux de safflorite ( $\text{CoAs}_2$ ), de loellingite ( $\text{FeAs}_2$ ), de skutterudite ( $\text{CoAs}_{3-x}$ ) et de cobaltine ( $\text{CoAsS}$ ) par ce procédé; les deux premiers monocristaux étaient dans la série de dimensions en millimètre. Il a essayé trois autres procédés de croissance: (1) la méthode modifiée de "fondre-et-recuire" qui était en partie une réussite dans la préparation de langisite ( $\text{Co}_{0.8}\text{Ni}_{0.2}\text{As}$ ); (2) la méthode de transport en phase vapeur; et (3) la croissance par la méthode des fondants. Les deux dernières méthodes n'étaient pas une réussite dans les cas auxquels elles étaient appliquées.

Price \$1.25

Catalogue No. M38-1/238

\*Research Scientist, Physical Chemistry Group, Mineral Sciences Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.



R - 254 The Derivation of Plume Dispersion Parameters from Measured Three-Dimensional Data  
by H. Whaley\*

It is well known that atmospheric diffusion models, however, sophisticated and rigorous they may be mathematically, can only be as accurate as the input data used for model calibration and verification. In this paper, the method of finite differences is used to determine both the plume rise and the standard deviations of plume spread from three-dimensional data acquired by aerial probing. Comparisons are also made with corresponding values estimated by accepted empirical methods.

The derivation of reliable values for critical plume dispersion parameters, that are applicable to a given geographic region, significantly improves the precision of computations for specifying stack heights, selecting plant sites, and predicting ground-level pollutant concentrations.

C'est bien connu que les modèles de diffusion atmosphérique malgré leur sophistication mathématique peuvent seulement être aussi précis que les données en entrée utilisées pour l'étalonnage et la vérification du modèle. Dans ce rapport, l'auteur utilise la méthode de différences finies pour déterminer la montée de panache et la dérivation normale de la dispersion de panache des données en trois dimensions acquises par la méthode de sonde aérienne. Il a aussi fait des comparaisons avec les valeurs correspondantes estimées par les méthodes empiriques acceptées.

La dérivation des valeurs fiables pour les paramètres critiques de dispersion de panache qui sont applicables à une région géographique spécifique, améliore significativement la précision des calculs pour la spécification de l'hauteur des cheminées, pour la sélection des sites d'usines et pour la prédiction des concentrations de la pollution au niveau du sol.

Price 75 cents

Catalogue No. M38-1/254

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\*Research Scientist, Canadian Combustion Research Laboratory, Fuels Research Centre, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

R - 255 Hydrogen-Atmosphere Galvanizing of Iron-Base Alloys  
by J. J. Sebisty\* and G. E. Ruddle\*

Series of iron-base alloys containing manganese, phosphorus and silicon were galvanized in a hydrogen-atmosphere apparatus over a range of time and temperature conditions.

Manganese in amounts of 0.17, 0.50 and 1.17% failed to exert any prominent effect on coating formation.

Phosphorus-containing alloys (0.01, 0.042, 0.069, and 1.1%P), exhibited relatively high galvanizing reactivity which was characterized by increasing unevenness in iron-zinc alloy growth with increasing phosphorus content and immersion time.

The reactivity of the silicon-containing alloys (0.03, 0.08, 0.21, 0.91 and 3.4% Si) generally followed established behaviour but with some significant anomalies. Most notable was a reaction rate inversion in going from the normal galvanizing temperature of 450°C (840°F) to 470°C (880°F). At this higher temperature, the coating microstructures were significantly altered towards thinner, more compact, iron-zinc alloy layers.

Les auteurs ont galvanisé des alliages à base de fer, contenant du manganèse, du phosphore et du silicium dans un appareil avec une atmosphère d'hydrogène, sous différentes conditions de temps et de température.

Des montants de manganèse de 0.17, 0.50, et 1.17% n'ont pas exercé d'effets importants sur la formation du revêtement.

Les alliages contenant du phosphore (0.01, 0.042, 0.069 et 1.1%P) ont montré une réactivité relativement élevée de galvanisation qui était caractérisée par une inégalité croissante dans le développement de l'alliage fer-zinc avec une teneur en phosphore et une période d'immersion grandissantes.

La réactivité des alliages contenant du silicium (0.03, 0.08, 0.21, 0.91 et 3.4%Si) a généralement suivi le procédé établi mais avec quelques anomalies significatives. L'anomalie la plus remarquable a été l'inversion de la vitesse de réaction en allant de 450°C (la température normale de galvanisation) à 470°C. À 470°C les microstructures du revêtement ont été changées significativement pour donner des couches d'alliage fer-zinc plus minces et plus compactes.

Price 75 cents

Catalogue No. M38-1/255

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\*Research Scientist, Non-Ferrous Metals Section, Physical Metallurgy Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

R - 256 The Hydrocracking of Residual Oils and Tars Part 3: The Effect of Mineral Matter on the Thermal and Catalytic Hydrocracking of Athabasca Bitumen  
by P. S. Soutar,\* E. C. McColgan\* and B. I. Parsons\*\*

The report describes a bench-scale investigation of the effect of the concentration of residual clay and silt on the thermal and catalytic hydrocracking of bitumen separated from the Athabasca tar sands. The experiments were done in the liquid phase in a bottom-feed, continuous-flow apparatus at 1000 and 2000 psi, at liquid hourly space velocities of 1.05 and 2.1 with bitumen feed stocks containing 0.9% and 3.8% mineral matter. In the thermal hydrocracking process, the maximum conversion attainable and the yield of liquid distillate product were measurably higher with the bitumen containing the greater amount of mineral matter. The primary effect of the mineral matter is to suppress the coking and fouling reactions which limit the maximum operating temperature. The results indicate no significant catalytic activity attributable to the mineral matter for either the hydrocracking reaction or for desulphurization. In the catalytic process the residual clay and silt tended to foul the catalyst surfaces and the higher-mineral feed stock was found to be less reactive in every respect.

Dans ce rapport, les auteurs décrivent une recherche faite au laboratoire sur l'effet de la concentration d'argile et de limon résiduels sur l'hydrocraquage thermique et catalytique de bitume séparé des Sables asphaltiques d'athabasca. Ils ont fait des expériences à la phase liquide utilisant un appareil d'écoulement continu avec un réacteur d'alimentation par le bas à 1000 et 2000 psi aux vitesses spatiales liquides par heure de 1.05 et 2.1 avec des stocks d'alimentation de bitume contenant de la matière minérales de 0.9% et 3.8%. Dans le procédé d'hydrocraquage thermique, la conversion maximum accessible et le rendement du produit de distillat liquide étaient plus élevés avec le bitume contenant le plus grand montant de matière minérales. Le premier effet de la matière minérale est de supprimer les réactions de cokéfaction et d'encrassement qui limitent la température maximum de fonctionnement. Les résultats indiquent qu'il n'y a pas d'activité catalytique significative attribuable à la matière minérale soit pour la réaction d'hydrocraquage soit pour la désulfuration. Dans le procédé catalytique, les auteurs ont trouvé que l'argile et le limon résiduels tendaient à encrasser les surfaces catalytiques et que le stock d'alimentation de minéraux élevés était moins réactif à tous les points de vue.

Price 50 cents

Catalogue No. M38-1/256

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\*Technicians and \*\*Research Scientist, Fuels Research Centre, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

R - 258 Study of Surface Treatment Effects in Galvanizing Iron Single Crystals  
by G. E. Ruddle\* and J. J. Sebisty\*

Single crystals of iron with basic low-index surface orientations were given various pretreatments to produce a range of surface roughness and hardness conditions and then galvanized in pure zinc in a purified hydrogen atmosphere.

Significantly different reaction effects previously found on electropolished (110), (100) and (111) surfaces of commercial single crystals were confirmed in tests involving pretreatment by thermal faceting and mechanical polishing. A relationship between galvanizing reactivity and crystallographic orientation of the iron surface was thereby more conclusively established.

Increasing the roughness of the crystal surfaces by grit blasting, and to a lesser extent by chemical etching, significantly reduced the dependence of the reactivity on crystallographic orientation. Fine surface irregularities and larger-scale unevenness, especially as produced by grit blasting, in combination with the growth habit of the iron-zinc alloy layers, were the predominant factors determining the galvanizing behaviour.

Surface work-hardening by the mechanical polishing and grit-blasting pretreatments had no apparent effect on the galvanizing reaction.

Les auteurs ont tout d'abord donné de divers traitements préliminaires aux monocristaux de fer avec des orientations de surface de base à indices faibles afin de pouvoir produire des gammes de rudesse de surface et de dureté. Ensuite ils ont galvanisé ces monocristaux dans du zinc pur dans une atmosphère d'hydrogène purifié.

Ils ont pu confirmer les effets de réaction significativement différents trouvés auparavant sur les surfaces polies électrolytiquement des monocristaux commerciaux (110), (100) et (111) dans des essais qui impliquaient le traitement préliminaire par le facettage thermique et par le polissage mécanique. Ils ont pu donc établir, d'une manière plus concluante, une relation entre la réactivité de galvanisation et l'orientation cristallographique de la surface de fer.

Les auteurs ont trouvé que s'ils augmentaient la rudesse des surfaces de cristal par le grenailage, et de façon moins extrême c'est-à-dire par l'attaque chimique, ils pourraient réduire significativement la dépendance qu'il y a entre la réactivité et l'orientation cristallographique. Ils ont aussi trouvé que les petites irrégularités de surface et l'inégalité à une plus grande échelle, particulièrement produites par le grenailage, en combinaison avec la façon de croissance des couches d'alliage fer-zinc, étaient les facteurs prédominants qui ont déterminé le comportement de galvanisation.

Les auteurs montrent que l'érouissage par les traitements préliminaires de polissage mécanique et de grenailage n'ont pas eu d'effets apparents sur la réaction de galvanisation.

Price 75 cents

Catalogue No. M-38-1/258

\*Research Scientist, Non-Ferrous Metals Section, Physical Metallurgy Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

R - 259 Kinetics of Cobalt Cementation on Zinc  
by D. J. MacKinnon\*

Kinetics of cobalt cementation on zinc sheet from solutions of cobalt sulphate have been investigated with respect to temperature, stirring velocity, and acidity. The effect of buffered solutions on the reaction rate has also been determined. The rate of the cementation reaction was found to be strongly influenced by the presence of metallic ions other than cobalt in the solution. This effect is interpreted in terms of "alloy" formation, whereas the difficulties encountered in cementing cobalt in the absence of metallic ions is explained in terms of cobalt deposition overvoltage, hydrogen overvoltage, and inhibition by co-deposition of zinc.

L'auteur a étudié la cinétique de la cémentation de cobalt sur une feuille de zinc provenant des solutions de sulfate de cobalt du point de vue de la température, de la vitesse d'agitation et de l'acidité. Il a aussi déterminé l'effet des solutions tamponnées sur la vitesse de réaction. Il a trouvé que la vitesse de la réaction de cémentation était très influencée par la présence des ions métalliques autres que le cobalt dans la solution. L'auteur a interprété cet effet en fonction de la formation "d'alliage", tandis que les difficultés rencontrées dans la cémentation de cobalt, à l'absence des ions métalliques, ont été expliquées en fonction du survoltage du dépôt de cobalt, du survoltage associé à la libération d'hydrogène et de l'inhibition par dépôt simultané du zinc.

Price 75 cents

Catalogue No. M38-1/259

\* Research Scientist, Research Section, Extraction Metallurgy Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada. KIA 0G1.

R - 260 The Evaluation of Lithium Chloride-Coated Porous Silica for the Gas Chromatographic Separation of Petroleum Fractions  
by H. Sawatzky\*, A. E. George\* and G. T. Smiley\*\*

In this work gas solid chromatographic separation of petroleum hydrocarbons and sulphur compounds on column packings consisting of lithium chloride-coated diatomaceous silica and porous silica beads have been studied. The temperatures required for separating most of these compounds were not above those needed for equivalent gas liquid chromatographic separations, and the efficiencies were comparable. The dialkyl and alkylaryl sulphides had retention values much greater than polynuclear aromatic hydrocarbons of similar boiling points. The retention values are discussed in terms of specific and non-specific interactions in order to show how compounds of similar boiling points were separated according to type. A number of fractions with 20°C boiling ranges that had been collected during gas chromatographic simulated distillations of petroleum were rechromatographed on these inorganic column packings. Interpretations of the separation of oil constituents are made on the basis of the retention data of the pure compounds. These column packings are thermally stable, so they can be used for type separations of high-boiling materials with none of the contamination that could not be avoided in columns packed with relatively unstable highly polar stationary liquid-phase. Thus, these packings are ideal if the separated materials require further characterization such as mass spectroscopy or desulphurization because there will be no contamination by column bleed.

Dans la présente étude les auteurs ont étudié la séparation des hydrocarbures et des composés sulfureux du pétrole en utilisant une garniture de colonne qui se compose de silice à diatomées et de silice poreuse recouverte de chlorure de lithium. Les températures nécessaires pour séparer la plupart de ces composés ne sont pas supérieures à celles requises pour effectuer des séparations semblables en chromatographie en phase gazeuse, de plus l'efficacité est comparable. Les valeurs de rétention du soufre de dialkyl et d'alkylaryl sont plus grandes que celles des hydrocarbures poly-aromatiques à points d'ébullition semblables. Les valeurs de rétention sont indiquées aux termes des interactions spécifiques et des interactions non-spécifiques, pour montrer que les composés à points d'ébullition similaires sont séparés suivant leur type de structure. Un nombre de fractions ayant des intervalles d'ébullition de 20°C recueillies au cours des distillations simulées du pétrole par chromatographie en phase gazeuse, sont rechromatographiées sur ces garnitures inorganiques de colonne. L'interprétation du résultat de la séparation des composés pétroliers est basée sur les valeurs de rétention obtenues pour des composés purs. Etant donné que les garnitures de colonne sont thermiquement stables, elles peuvent être utilisées pour séparer des composés à points d'ébullition élevés sans risquer de contaminer. La contamination se produit sur des colonnes à phase stationnaire liquide relativement instable et d'une grande polarité. Donc, les garnitures inorganiques de colonne sont idéales si les composés séparés exigent plus de traitement comme par exemple la désulfuration ou l'analyse par l'entraînement de la phase stationnaire de la colonne.

Price 50 cents

Catalogue No. M38-1/260

\* Research Scientists and \*\* Technologist, Fuels Research Centre, Department of Energy, Mines and Resources, Ottawa, Canada.

R - 261 The Hydrocracking of Residual Oils and Tars Part 4: Catalyst De-Activation with Bitumen from Athabasca, Cold Lake, and Lloydminster  
by E. C. McColgan\*, P. S. Soutar\*, J. M. Denis\*\*, and B. I. Parsons\*\*

The report describes an investigation of the effect of low concentrations of clay and silt (<1 %) in bitumen feed stocks on catalyst de-activation in hydrocracking and desulphurization processes. The experiments were done in the liquid phase in a bottom-feed, continuous-flow apparatus at 2000 psi and a liquid hourly space velocity of 1.05 over a commercial cobalt molybdate catalyst. Feed stocks used were bitumens from the Athabasca tar sands (0.88 % solids), Cold Lake (0.03 % solids) and Lloydminster (0.07 % solids). The extent of catalyst de-activation observed with each feed stock was essentially the same. In addition, no significant amounts of clay or silt were found in the catalyst bed at the conclusion of experiments. From these observations it is concluded that finely dispersed clay and silt tend to wash out of the reaction system and, as such, are not the prime cause of catalyst de-activation.

Dans ce rapport, les auteurs décrivent une recherche sur l'effet de basses concentrations d'argile et de limon dans des stocks d'alimentation de bitume sur la désactivation du catalyseur dans les procédés d'hydrocraquage et de désulfuration. Ils ont fait des expériences à la phase liquide en utilisant un appareil d'écoulement continu avec un réacteur d'alimentation par le bas à 2000 psi et aux vitesses spatiales liquides par heure de 1.05 sur un catalyseur commercial au cobalt et au molybdène. Ils ont utilisé des stocks d'alimentation qui sont des bitumes des sables asphaltiques "d'Athabasca" (solides de 0.88 %) du "Cold Lake" (solides de 0.03 %) et du "Lloydminster" (solides de 0.07 %). Le degré de la désactivation du catalyseur observé avec chaque stock d'alimentation était essentiellement le même. De plus ils n'ont pas trouvé de montants significatifs d'argile et de limon dans la couche du catalyseur à la fin de n'importe quelles séries d'expériences. D'après ces observations ils sont venus à la conclusion que l'argile et le limon finement dispersés ont tendance à s'entraîner hors du système de réaction et, de ce fait, ne sont pas la cause principale de la désactivation du catalyseur.

Price 50 cents

Catalogue No. M38-1/261

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\*Technicians and \*\*Research Scientists, Fuels Research Centre, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

R - 262 Thermal Decomposition of Hydrated Sodium Sulphide  
by R. C. Kerby\* and M. R. Hughson\*\*

The thermal decomposition of  $\text{Na}_2\text{S}\cdot 9\text{H}_2\text{O}$  to  $\text{Na}_2\text{S}$  resulted in the formation of several intermediate hydrates. The stabilities of  $\text{Na}_2\text{S}\cdot \text{H}_2\text{O}$ ,  $\text{Na}_2\text{S}\cdot 2\text{H}_2\text{O}$  and  $\text{Na}_2\text{S}\cdot 3\text{H}_2\text{O}$  were determined as a function of water vapour partial pressure and temperature. The heats and free energies associated with the dehydration reactions were estimated from this data. The monohydrate  $\text{Na}_2\text{S}\cdot \text{H}_2\text{O}$  was shown to exist over a wide range of temperatures and water vapour partial pressures.

Les auteurs ont trouvé que la décomposition thermique de  $\text{Na}_2\text{S}\cdot 9\text{H}_2\text{O}$  à  $\text{Na}_2\text{S}$  a mené à la formation de plusieurs hydrates intermédiaires. Ils déterminent les stabilités de  $\text{Na}_2\text{S}\cdot \text{H}_2\text{O}$ ,  $\text{Na}_2\text{S}\cdot 2\text{H}_2\text{O}$  et  $\text{Na}_2\text{S}\cdot 3\text{H}_2\text{O}$  en fonction de la pression partielle de vapeur d'eau et de la température. Ils ont pu estimer les chaleurs et les énergies libres associées aux réactions de déshydratation de ces données. Les auteurs ont montré que le monohydrate  $\text{Na}_2\text{S}\cdot \text{H}_2\text{O}$  existait à travers de très grandes intervalles de température et de pressions partielles de vapeur d'eau.

Price 50 cents

Catalogue No. M38-1/262

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\*Research Scientist and \*\* Physical Scientist, Extraction Metallurgy Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada. K1A 0G1

R - 263 The Hydrocracking of Residual Oils and Tars Part 5: Surface-Coated Cobalt Molybdate Catalysts for Hydro-Treating  
by E. C. McColgan\*, P. S. Soutar\*, M. A. Rethier\*\*, and B. I. Parsons\*\*\*

A surface-layering technique is described for preparing low-cost, powdered cobalt molybdate catalysts for hydrocracking and desulphurizing residual oils in liquid phase systems. A small quantity of peptized alumina is milled on to the surface of 100 to 500-micron particles of alumina monohydrate (Boehmite). Concentrated solutions of salts of the active ingredients are dispersed in the peptized alumina, then the mixture is dried and calcined. Catalysts were prepared containing (over-all) concentrations of combined oxides of 13.0, 3.3, and 1.6 % by weight. The hydrocracking and desulphurizing capability of each catalyst was determined with bitumen separated from the Athabasca tar sands at a liquid hourly space velocity of 1.05, and 2000 psi hydrogen pressure. The activity of the 13.0 and 3.3 % catalysts were quite similar. The activity of the 1.6 % combined oxides system was measurably less. The practical lower-limit of oxides concentration for catalysts prepared by the described method is about 3 % by weight.

Price 50 cents

Catalogue No. M38-1/263

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R - 263 - Cont.

Dans ce rapport, les auteurs décrivent une technique d'enduisage de surface pour la préparation peu coûteuse des catalyseurs de cobalt et de molybdène en poudre pour l'hydrocraquage et la désulfuration des huiles résiduelles dans des systèmes à phase liquide. Ils ont enduit une petite quantité d'alumine peptisée sur la surface des particules de 100 à 500 microns de monohydrate d'alumine (Boémite). Ils ont dispersé les solutions concentrées de sels d'ingrédients actifs dans l'alumine peptisée puis ils ont séché et calciné le mélange. Les auteurs ont préparé les catalyseurs contenant des concentrations (totales) d'oxydes combinés de 13.0, 3.3, et 1.6 % par pesantier. Ils ont déterminé la capacité de l'hydrocraquage et de la désulfuration de chaque catalyseur avec le bitume séparé des Sables bitumineux d'athabasca à la vitesse spatiale liquide par heure de 1.05 et à une pression d'hydrogène de 2000 psi. Ils ont trouvé que l'activité des catalyseurs de 13.0 et de 3.3 % était très semblable. Ils ont aussi trouvé que l'activité des systèmes d'oxydes combinés de 1.6 % était très inférieure. La limite inférieure et pratique de la concentration d'oxydes pour les catalyseurs préparés par la méthode décrite est à peu près 3 % par pesantier.

R -264 Removal of Cobalt from Synthetic Zinc Sulphate Electrolyte by Cementation with Zinc Dust by D. J. MacKinnon\*

The removal of cobalt from synthetic zinc sulphate electrolyte by zinc dust cementation has been investigated with respect to the effect of metallic ions and electrolyte impurities. At 90°C, a satisfactory rate of cobalt cementation resulted when the ratio Co:Te:Cu was 1.0:0.4:10. The cobalt cementation rate decreased with increasing zinc sulphate concentration and when the Cd<sup>++</sup> concentration in the electrolyte was greater than 200 ppm. The effects of pH, type of zinc dust, stirring velocity, and initial cobalt concentration have also been determined.

L'auteur a étudié l'enlèvement du cobalt de l'électrolyte synthétique de sulfate de zinc par la cémentation des poudres de zinc du point de vue de l'effet des ions métalliques et des impuretés d'électrolyte. A 90°C, il a pu obtenir une vitesse satisfaisante de cémentation de cobalt quand le rapport de Co:Te:Cu était de 1.0:0.4:10. La cémentation de cobalt a diminué avec la croissance de la concentration de sulfate de zinc et quand la concentration de Cd<sup>++</sup> dans l'électrolyte était plus que 200 ppm. Il a aussi déterminé les effets de pH, un type de poudres de zinc, la vitesse d'agitation et la concentration initiale de cobalt.

Price 75 cents

Catalogue No. M38-1/2

\*Research Scientist, Research Section, Extraction Metallurgy Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada. KIA 0G1

R - 265 Plume Dispersion Research at Natural-Gas Sulphur-Extraction Plants  
by G. K. Lee\*, H. Whaley\* and J. G. Gainer\*\*

The rise and dispersion have been determined for four plumes emitted by three natural-gas sulphur-extraction plants in Alberta. This report describes the data acquisition techniques employed and gives a preliminary evaluation of the results. At one plant, two plumes were studied, one under inversion conditions and the other under limited mixing conditions. One plume from each of the other two plants was studied under neutral conditions. The results indicate that the standard deviations of plume spread cannot be reliably estimated for limited mixing conditions and that plume behaviour is strongly influenced by local topography.

Les auteurs ont déterminé la montée et la dispersion de quatre émissions de fumée en forme de plume de trois usines d'extraction de soufre du gaz naturel. Dans ce rapport, ils décrivent les techniques employées dans l'acquisition des données et ils donnent aussi une évaluation préliminaire des résultats. À une des usines, les auteurs ont étudié deux émissions de fumée en forme de plume, une sous conditions d'inversion et l'autre sous conditions de mélange limité. Ils ont aussi étudié une émission de fumée en forme de plume de chacune de deux autres usines sous conditions neutres. Les résultats indiquent que les déviations normales d'étendue de fumée en forme de plume ne peuvent être évaluées avec certitude dans des conditions de mélange limité et la topographie influence fortement le comportement de la fumée en forme de plume.

Price 75 cents

Catalogue No. M38-1/265

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\*\*Senior Engineer, Exploration and Production Department, Gulf Oil Canada Ltd., Calgary, Alberta.

R - 267 A Gas Liquid-Gas Solid Chromatographic Method for the Identification of Sources of Oil Pollution by A. E. George\*, H. Sawatzky\*, G. T. Smiley\*\*, and D. S. Montgomery\*\*\*

A two-step gas chromatographic fingerprinting technique has been developed for the identification of petroleum that may be conveniently applied to oil spills. The first step consists of a gas chromatographic separation on nonpolar silicone rubber (SE-30) which separates according to boiling point. Five arbitrary 20° cuts are made then further separated by gas chromatography on columns of lithium chloride supported on diatomaceous silica (Chromosorb A). The advantage of this inorganic packing is its high thermal stability that permits the separation of high-boiling oil components not readily affected by weathering. It also has the added advantage of causing no "bleeding" problems that can complicate further analyses involving mass spectroscopy. The simultaneous use of the flame ionization detector and the Melpar sulphur detector provides highly characteristic fingerprints. This method has been applied to two heavy crude oils, and two fuel oils involved in oil spills from the "Arrow" and "Irving Whale" to demonstrate the potential of the method.

Une technique à deux étapes chromatographiques a été développée pour l'identification du pétrole. Cette technique peut être pratiquement appliquée pour les échappés du pétrole. La première étape se compose de chromatographie sur le caoutchouc silicone (SE-30) non polaire qui fait la séparation selon le point d'ébullition. Cinq fractions arbitraires ayant des intervalles de débullition de 20°C sont recueillies pour rechromatographier sur une colonne qui se compose de silice à diatomées (Chromosorb A) recouverte de chlorure de lithium. L'avantage de ce remplissage inorganique de colonne est sa stabilité thermique élevée qui permet de séparer les composés du pétrole à haut point d'ébullition. Ces composés résistent à la dégradation sous les conditions atmosphériques. Le remplissage inorganique a aussi l'avantage de ne pas causer de problème d'entraînement de la phase stationnaire qui puisse ainsi compliquer les autres étapes d'analyse qu'engage l'usage de la spectroscopie de masse. L'application simultanée du détecteur à ionisation de flamme et du détecteur Melpar de soufre permet d'obtenir des empreintes très caractéristiques du pétrole. La méthode a été appliquée à deux pétroles lourds et à deux mazouts recueillis lors des échappés d'une culbute de "l'Arrow" et de "l'Irving Whale" pour démontrer l'efficacité de la technique proposée.

Price 75 cents

Catalogue No. M38-1/267

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\*Research Scientists, \*\*Technologist and \*\*\*Head, Fuels Research Centre, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

R - 268 · Complex Ions of Copper and Cyanide  
by H. L. Noblitt\*

To define the role of cyanide and cupro-cyanide ions in flotation, a method for their identification and measurement is necessary. Absorption spectroscopy provides a non-destructive means of obtaining that information. Maximum cyanide ion consumption was determined in relation to cupric ions in solution. A method for monitoring cyanide ion concentration is suggested.

Pour définir le rôle du cyanure et des ions de cyanure de cuivre en flottation, il est nécessaire de se servir d'une méthode valable pour leur identification et leur valorisation. La spectroscopie par adsorption fournit la méthode nécessaire et assuré une analyse nondestructive. L'on détermine la relation entre la consommation des ions de cyanure en fonction des ions cupriques et l'on propose un moyen de contrôle pour la concentration des ions de cyanure.

Price 75 cents

Catalogue No. M38-1/268

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TECHNICAL BULLETINS

TB - 158 Continuous Ion Exchange in Fluidized Beds  
by M. J. Slater\* and P. Prud'homme\*\*

A continuous ion-exchange plant using a multi-stage fluidized-bed extraction column coupled with moving-bed regeneration and wash columns has been built and tested. Hydrodynamic studies on resins and ore leach pulps have been made and a mathematical model has been developed to predict the performance of the extraction column.

Clarified solutions from the leaching of uranium ore and leach pulps of 5 and 10 w/o have been used with IRA 430 ion exchange resin.

The mathematical model requires refinement but its actual performance has been satisfactory for predicting the extraction of uranium.

Les auteurs ont construit et ont mis à l'essai une installation d'échange continu d'ions en utilisant une colonne d'extraction à plusieurs étages de lit fluidisé; celle-ci étant couplée avec une colonne régénératrice et une colonne de lavage à lit mobile. Ils ont fait des études hydrodynamiques sur les résines et sur les fines de lixiviation des minerais; et ils ont développé un modèle mathématique pour prédire le rendement de la colonne d'extraction.

Ils ont employé des solutions clarifiées de la lixiviation du minerai d'uranium et des fines de lixiviation de 5 et 10 w/o\*\*\* avec la résine d'échange d'ions (IRA-430).

Les auteurs ont trouvé que c'était nécessaire d'améliorer le modèle mathématique mais que son rendement actuel était satisfaisant pour prédire l'extraction de l'uranium.

Price \$1.25

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\*National Research Council Post-Doctorate Fellow with the Extraction Metallurgy Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada, from the School of Chemical Engineering, University of Bradford, Yorks, U.K.

\*\*Technician, Hydrometallurgy Section, Extraction Metallurgy Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

\*\*\*eau/organique.

TB - 162 Measurement of the Surface Areas of Mineral Powders with a Modified Perkin-Elmer, Model 212-D, Sorptometer Using a Nitrogen-Helium Gas Mixture  
by K. Bartels\*

This work compares the surface-area measurements made on four powdered materials (alumina, quartz, and two sodium carbonate powders) using the Sorptometer, employing nitrogen gas as adsorbate, with those made using the precise volumetric method (B.E.T.), employing krypton gas as adsorbate. It was found that the Sorptometer may be used successfully for rapidly comparing the surface areas of a large number of samples of a given material. However, if absolute accuracy is required, the Sorptometer must first be calibrated for each powdered material by the B.E.T. method.

The use of the Sorptometer with a pre-mixed adsorption gas (35% N<sub>2</sub>/65% He, by volume) is described. The one-point method of evaluating the B.E.T. equation and the specific surface-area calculation for one of the carbonate samples are outlined. A computer program, written in FORTRAN IV language, which calculates the specific surface areas from Sorptometer data, is provided.

Dans ce travail, l'auteur compare les mesures de surface faites de quatre matériaux en poudre (l'alumine, le quartz et deux poudres de carbonate de sodium) utilisant le "Sorptometer" en employant le gaz d'azote comme adsorbat, pour celles faites avec la méthode volumétrique précise (B.E.T.) et en employant le gaz de krypton comme adsorbat. Il a trouvé que le "Sorptometer" peut être utilisé avec succès pour comparer rapidement les surfaces d'un grand nombre d'échantillons d'un matériel donné. Cependant, s'il est nécessaire d'avoir une précision absolue, il faut que le "Sorptometer" soit premièrement calibré pour chaque matériel en poudre par la méthode B.E.T.

L'auteur décrit l'utilisation du "Sorptometer" avec un gaz d'adsorption mélangé auparavant (35%N<sub>2</sub>/65% He, par volume). Il présente un aperçu d'une méthode à point unique pour évaluer l'équation B.E.T. et le calcul spécifique de surface pour un des échantillons. Il présente aussi un programme machine dans le langage de FORTRAN IV qui calcule les surfaces spécifiques des données du "Sorptometer".

Price 75 cents

Catalogue No. M34-20/162

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\*Technologist, Surface Sciences Group, Mineral Sciences Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

TB - 163 Refractory-Grade Magnesia in Canada  
by M. Palfreyman\*

The increasing demand for magnesia refractories is a direct result of the increasing use of the basic oxygen furnace in the steel industry. This trend may be expected to continue, at least until the open-hearth furnace has been phased out. At the same time, the specifications for refractory-grade magnesia are becoming more rigid, particularly with respect to iron oxide and to boron, which is present in seawater magnesia. As a result, more interest is being shown in the beneficiation of natural magnesitic ores to produce high-purity magnesia free from boron and very low in iron oxide.

This bulletin discusses the properties of refractory-grade magnesia, reviews the magnesia industry in Canada both past and present, and lists known Canadian sources of magnesitic rock.

A cause de l'utilisation croissante du four basique à oxygène dans l'industrie d'acier, il y a une demande progressive pour des réfractaires de magnésie. On peut s'attendre à ce que cette tendance continue au moins jusqu'à ce que le four à sole disparaîtra. En même temps, les spécifications des réfractaires de qualité de magnésie deviennent de plus en plus rigides particulièrement en ce qui concerne l'oxyde de fer et aussi le bore qui est présent dans la magnésie d'eau de mer. Par conséquent, il y a plus d'intérêt dans l'enrichissement des minerais magnétiques naturels pour produire de la magnésie d'une pureté élevée, libre du bore et d'une teneur très basse en oxyde de fer.

L'auteur discute dans ce bulletin des propriétés des réfractaires de qualité de magnésie et il présente une revue du passé et du présent de l'industrie de magnésie au Canada. De plus il donne une liste de sources canadiennes connues de roches magnétiques.

Price 75 cents

Catalogue No. M34-20/16

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\*Research Scientist, Ceramic Section, Mineral Processing Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

TB - 164 Development of An Empirical Mathematical Method for a Pulse Sieve-Plate Extraction Column  
by R. F. Pilgram\* and F. J. Kelly\*\*

A satisfactory empirical mathematical model has been obtained to relate the extraction of uranium from an aqueous solution that pulsates through vertically-spaced horizontal sieve-plates in a short vertical column to the sieve-plate spacing, pulse frequency, pulse height, flow rate of aqueous solution, plate diameter, and to the position of the inlet for the organic extractant. This was done by multivariable regression analysis of 34 statistically designed tests. The final model is complex but it indicates, in general, that higher extractions are related to the result of the interaction between the pulse frequency and pulse height, to closer plate-spacing, to lower aqueous flow rates, to larger-diameter sieve-plates, and to the distance between the inlet for the organic extractant and the axis of the column.

It was also shown that assessment of optimum operating conditions for the column by traditional visual observations was not satisfactory for the tests described herein.

Les auteurs ont obtenu un modèle empirique et mathématique pour relier l'extraction d'uranium d'une solution aqueuse qui jaillit par intermittence à travers des plaques criblées horizontales aux espaces verticaux dans une colonne courte et verticale à l'espacement de la plaque criblée, à la fréquence de pulsation, à l'hauteur de pulsation, au débit de la solution aqueuse, au diamètre du plateau et à la position de l'admission pour l'extraction organique. Les auteurs ont fait cela par l'analyse de la régression multivariable de 34 essais conçus du point de vue de la statistique. Le modèle final est complexe mais celui-ci indique en général que les extractions supérieures se rapportent au résultat de l'action réciproque entre la fréquence de pulsation et la hauteur de pulsation, à l'espacement plus fermé de la plaque, aux débits aqueux plus inférieurs, au diamètre plus larges des plaques criblées et à la distance entre l'admission pour l'extraction organique et l'axe de la colonne.

Ils ont montré que l'évaluation des conditions à marche optimales pour la colonne par des observations visuelles et traditionnelles n'était pas satisfaisante pour ces essais.

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\* and \*\* Research Scientists, Ore Treatment Section, Extraction Metallurgy Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.



TB - 165 On the Use of a Penetrant Dye to Study Ore Permeability  
by S. Kaiman\*

Tests showed that fractures and porous mineral constituents in rock specimens can be revealed by wetting the specimens with Zyglo, a surface-active oil. The fluorescence of Zyglo under ultraviolet light makes it possible to study the extent of its penetration and thus to assess the permeability of the ore. Application of the technique to a radioactive conglomerate confirmed the suspected co-occurrence of permeable zones in the ore and uranium mineral concentrations. This could explain the amenability of the ore to leaching.

Les essais ont montré que les fractures et les minéraux poreux dans l'échantillon de roche peuvent être vus après avoir mouillé l'échantillon avec du "Zyglo" qui est une huile tensio-active. À cause de la fluorescence du "Zyglo" sous lumière ultra-violette, il est possible d'étudier la mesure de sa pénétration et d'évaluer la perméabilité du minerai. L'application de la technique à un conglomérat radioactif a confirmé la coïncidence soupçonnée des zones perméables dans le minerai et les concentrations de minéral d'uranium. Cela pourrait expliquer la convenance du minerai au lessivage.

Price 50 cents

Catalogue No. M34-20/16'

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\*Physical Scientist, Mineralogy Section, Extraction Metallurgy Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

TB - 166 Comparative Corrosion Resistance of Zinc Coatings Prepared from Mines Branch and Commercial Cyanide Plating Baths  
by A. W. Lui\* and G. R. Hoey\*\*

The corrosion resistance of zinc coatings deposited on mild steel from one Mines Branch and three commercial cyanide plating baths were compared by the following three testing methods: (a) neutral salt spray, (b) humidified SO<sub>2</sub>-air, and (c) combined humidified SO<sub>2</sub>-air and environmental chamber. No significant difference in corrosion rate was found when coatings of equal thickness prepared from the four different baths were tested under identical conditions. The corrosion resistance of the zinc coatings at various thickness levels indicated that the service lives of the coatings depended on the thickness of zinc applied and not on the type of bath from which the zinc was deposited.

Price 50 cents

Catalogue No. M34-20/16'

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\*Research Scientist

\*\*Head, Corrosion Section, Extraction Metallurgy Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

TB - 166 Cont.

Les auteurs ont comparé la résistance à la corrosion du zinc déposé sur l'acier doux de quatre bains de placage de cyanure de zinc, un de la Direction des Mines et les trois autres de l'industrie, en suivant trois méthodes d'essais: (a) le brouillard salin (neutre), (b) l'air-SO<sub>2</sub> humidifié, (c) la combinaison de deux méthodes: l'air-SO<sub>2</sub> humidifié et la chambre pour contrôler les conditions de l'environnement. Ils n'ont pas trouvé de différence significative dans la vitesse de corrosion quand les couches de la même épaisseur préparées de quatre bains différents ont été mises à l'essai sous des conditions identiques. La résistance à la corrosion des dépôts à épaisseur variée a indiqué que les durées de service des couches dépendent de l'épaisseur du zinc appliqué et non pas du type de bain dans lequel le zinc était déposé.

TB - 167 Copper-Molybdenum Ore, HV-1: Its Characterization & Preparation for Use As a Standard Reference Material  
by Members of the Staff of the Mineral Sciences Division  
(Compiled by G. H. Faye, W. S. Bowman and Sutarno)

A copper-molybdenum ore, HV-1, has been prepared and characterized for use as a standard reference material. HV-1 is the third ore of metallic minerals to be issued for sale as part of the Canadian Standard Reference Materials Project, of the Mines Branch, Department of Energy, Mines and Resources.

This report gives the mineralogical, geological and chemical characteristics of HV-1, as well as some details of methods used for its comminution and blending, and for assessing its homogeneity. Twenty-three laboratories provided analyses for copper and molybdenum; the recommended mean values for these are: 0.52% and 0.058%, respectively. The analytical results and the evaluation of statistical parameters for copper and molybdenum are reported.

Les auteurs ont préparé et caractérisé un minerai de cuivre-molybdène, HV-1 utilisé comme matériau type de référence. HV-1 est le troisième minerai des minéraux métalliques qui sera disponibles pour achat comme partie du Projet canadien des matériaux types de références de la Direction des mines du ministère de l'Énergie, des Mines et des Ressources.

Dans ce rapport, les auteurs donnent les caractéristiques minéralogiques, géologiques et chimiques du HV-1, ainsi que quelques détails des méthodes utilisées pour sa pulvérisation, son mélange et pour l'évaluation de sa homogénéité. Vingt-trois laboratoires ont fourni les analyses pour le cuivre et le molybdène; la moyenne recommandée pour ceux-là sont: 0.52% et 0.058% respectivement. Ils donnent aussi les résultats analytiques et l'évaluation des paramètres statistiques pour le cuivre et le molybdène.

Price 75 cents

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TB - 168 Methods for the Analysis of Ilmenite, Titanium-Bearing Slags and Other Electric Furnace Slags  
Part IV A. The Complexometric Determination of Aluminum in Ilmenite, Titaniferous Slags, and Iron  
Ores  
by A. Hitchen\*

A procedure is described for the accurate and precise determination of aluminum in ilmenite, titaniferous slags, and iron ores. After fusion of the sample with sodium peroxide, triple precipitations with sodium hydroxide-peroxide solutions are performed to remove the bulk of interfering elements such as iron and titanium. The interferences remaining in the filtrate and accompanying the aluminum are removed by solvent extraction in chloroform with sodium diethyldithiocarbamate at pH 2. The aluminum in the aqueous layer is determined by means of a back-titration of an excess of 1,2-cyclohexylenedinitrilotetraacetic acid (DCYTA) with standard zinc solutions at pH 5 to 5.5 and xylenol orange as the indicator.

L'auteur décrit un procédé pour la détermination exacte et précise de l'aluminium dans l'ilménite, dans les scories titanifères et dans les minerais de fer. Après la fusion de l'échantillon avec du peroxyde de sodium, il exécute trois précipitations avec les solutions d'hydroxyde-peroxyde de sodium afin d'enlever la quantité importante des éléments qui interfèrent comme le fer et le titane. Ensuite, il enlève les interférences qui restent dans le filtrat et qui accompagnent l'aluminium par extraction par solvant dans du chloroform avec du diéthylthiocarbamate de sodium à pH2. L'auteur détermine la quantité de l'aluminium dans la couche aqueuse par un tirage en retour d'un excès de l'acide 1, 2-diaminocyclohexane-tétracétique (DCYTA) avec les solutions titrées de zinc de pH 5 à 5,5 et le xylénol orange comme indicateur.

Price \$1.00

Catalogue No. M34-20/168

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\*Chemist, Chemical Analysis Section, Extraction Metallurgy Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

TB - 169 Methods for the Analysis of Ilmenite, Titanium-Bearing Slags and Other Electric Furnace Slags  
Part IV B: The Determination of Aluminum in Other Types of Ores and Slags  
by A. Hitchen\* and G. Zechanowitsch\*\*

Adaptation of the method described in the previous report in this series\*\*\* to the determination of aluminum in a wide variety of ores and slags of quite different composition is described. Compatible methods for dissolution of these materials are also given.

Price 75 cents

Catalogue No. M34-20/169

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\*\*\*Part IV A.

TB - 169 Cont.

Les auteurs décrivent l'adaptation de la méthode décrite dans le rapport précédent de cette série\*\*\* pour la détermination de l'aluminium dans une grande variété de minerais et de scories de composition assez différente. Ils présentent aussi des méthodes compatibles pour la dissolution de ces matériaux.

TB - 170 Influence of Plating Bath Composition and Steel Surface Treatment on Corrosion Resistance of Cadmium Coatings  
by A. W. Lui\* and G. R. Hoey\*\*

The corrosion resistance of cadmium coatings on mild steel prepared from the Mines Branch cyanide plating bath and a commercial bath, was assessed by means of humidified SO<sub>2</sub>-air and combined humidified SO<sub>2</sub>-air and environmental chamber tests. The mild-steel surfaces had been prepared by three different techniques.

There was no significant difference in corrosion resistance between coatings on surfaces prepared by the same cleaning method but plated from different cyanide baths. However, the corrosion resistance of cadmium coatings on surfaces prepared by a nitric acid-acetic acid-phosphoric acid treatment was higher than those on surfaces prepared by other methods. The corrosion rates in the combined humidified SO<sub>2</sub>-air and environmental chamber test were higher than those in the humidified SO<sub>2</sub>-air test.

The experimental results indicate that the service life of cadmium coatings of equal thickness is determined by the severity of the environment and the method of surface preparation but not by the type of cyanide plating bath used to plate mild steel.

Les auteurs ont évalué la résistance à la corrosion du cadmium déposé sur l'acier doux préparé de deux bains de placage de cyanure, un de la Direction des Mines et l'autre de l'industrie par moyen de deux tests: (a) l'air - SO<sub>2</sub> humidifié, (b) la combinaison de l'air - SO<sub>2</sub> humidifié et de la chambre pour contrôler les conditions de l'environnement. Ils ont préparé les surfaces d'acier doux par trois techniques différentes.

Ils n'ont pas trouvé de différence significative dans la résistance à la corrosion entre les dépôts sur les surfaces préparées par la même méthode de nettoyage mais plaqués des bains de cyanures différents. Cependant, les auteurs ont trouvé que la résistance à la corrosion des dépôts de cadmium sur les surfaces préparées par un traitement d'acide nitrique, acétique et phosphorique était plus élevée que sur les surfaces préparées par d'autres méthodes. Les vitesses de corrosion dans le test de la combinaison de l'air-SO<sub>2</sub> humidifié et de la chambre pour contrôler les conditions de l'environnement étaient plus élevées que celles dans le test de l'air-SO<sub>2</sub> humidifié.

Price 50 cents

Catalogue No. M34-20/170

\*Research Scientist, \*\*Head, Corrosion Section, Extraction Metallurgy Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

TB - 170 Cont.

Les résultats expérimentaux ont indiqué que la durée de service des dépôts de cadmium de la même épaisseur est déterminée par la sévérité de l'environnement et par la méthode de préparation de la surface et non pas par le type de bain de placage de cyanure utilisé pour plaquer l'acier doux.

TB - 172 The Influence of Gamma Radiation on the Flotation of Minerals  
by H. P. Dibbs\* and R. A. Fortin\*\*

The effect of gamma radiation on the flotation and the collector-adsorption properties of quartz has been studied for radiation doses between  $1.1 \times 10^4$  and  $7 \times 10^7$  rads. No difference in behaviour was found between the irradiated and the non-irradiated samples. Flotation studies were also made on irradiated and non-irradiated galena and chalcopyrite; here again, no radiation-induced effects were observed.

Les auteurs ont fait une étude sur l'effet de la radiation gamma sur la flottation et sur les propriétés d'absorption par collecteur pour les doses d'irradiation entre les rads de  $1.1 \times 10^4$  et  $7 \times 10^7$ . Ils n'ont pas trouvé de différence dans le comportement entre les échantillons irradiés et non irradiés. Ils ont aussi fait des études de flottation sur la galène et la chalcopyrite irradiées et non irradiées, ici encore ils ont observé qu'il n'y avait pas d'effets d'irradiation induite.

Price 50 cents

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\*\*Formerly Technician, Surface Science Group, now with Analytical Chemistry Section, Mineral Sciences Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

TB - 176 Noble-Metals-Bearing Sulphide Concentrate PTC: Its Characterization and Preparation for use as a Standard Reference Material  
by R. C. McAdam\*, Sutarno\*\* and P. E. Moloughney\*\*\*

A sulphide flotation concentrate from Sudbury, Ontario, has been prepared and characterized as a standard reference material for platinum, palladium, rhodium, gold, and silver. The recommended values for the contents of these elements in oz/ton are as follows: platinum 0.087, palladium 0.37, silver 0.17, rhodium 0.018, and gold 0.019. Several iridium, ruthenium, and osmium contents were reported by the laboratories that participated in the "round-robin" analytical program and these have been included in this report.

The sample preparation and characterization of the reference material are described and a statistical evaluation of the analytical values has been performed. This reference standard is now available from the Chairman of the Canadian Standard Reference Materials Project (CSRMP), Mineral Sciences Division, Mines Branch, Department of Energy, Mines and Resources, 555 Booth Street, Ottawa, Ontario, K1A 0G1.

Les auteurs ont préparé et caractérisé un concentré du sulfure de Sudbury, Ontario utilisé comme matériau type de référence pour du platine, du palladium, du rhodium, de l'or et de l'argent. Les valeurs recommandées pour la teneur de ces éléments en oz/tonne sont les suivantes: le platine 0.087, le palladium 0.37, l'argent 0.17, le rhodium 0.018 et l'or 0.019. Dans ce rapport, on trouve un compte rendu de plusieurs teneurs en iridium, ruthénium et osmium provenant des laboratoires qui ont participé dans le programme analytique.

Les auteurs ont décrit la préparation de l'échantillon et la caractérisation des matériaux de référence et ils ont aussi effectué une évaluation statistique des valeurs analytiques. Maintenant, on peut obtenir ses étalons de référence en s'adressant au Président du Programme canadien des produits étalons (PCPE), Division des sciences minérales, Direction des mines, ministère de l'Énergie, des Mines et des Ressources, 555 rue Booth, Ottawa, Ontario, K1A 0G1.

Price 75 cents

Catalogue No. M34-20/176

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\*Head, Analytical Chemistry Section, \*\*Research Scientist, Physical Chemistry Group, and \*\*\*Group Leader, Fire Assay Laboratories, respectively, Mineral Sciences Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

TB - 177 Nickel-Copper-Cobalt Ores SU-1 and UM-1: Their Characterization and Preparation for use as Standard Reference Materials  
by Members of the Staff of the Mineral Sciences Division  
(Compiled by G. H. Faye, W. S. Bowman and Sutarno)

Two nickel-copper-cobalt ores, SU-1 and UM-1, have been prepared and characterized for use as standard reference materials.

This report describes the nature and origin of SU-1 and UM-1, and gives information on procedures used for their preparation and for assessing their homogeneity. Twenty-five laboratories provided analytical results for nickel, copper and cobalt; the recommended values are, respectively: 1.51%, 0.87% and 0.063% for SU-1, and 0.88%, 0.43% and 0.035% for UM-1. The analytical results and the evaluation of statistical parameters for the three elements are reported for both ores.

On a préparé et caractérisé deux minerais de nickel, de cuivre et de cobalt, SU-1 et UM-1, pour les utiliser comme matériaux types de référence.

Dans ce rapport, les auteurs décrivent la nature et l'origine de SU-1 et UM-1, et donnent des renseignements sur les méthodes utilisées pour leur préparation et la vérification de leur homogénéité. Vingt-cinq laboratoires ont fourni des résultats d'analyse du nickel, du cuivre et du cobalt; les valeurs recommandées sont, respectivement, les suivantes: 1.51%, 0.87% et 0.063% pour SU-1, et 0.88%, 0.43% et 0.035% pour UM-1. Les résultats d'analyse et l'évaluation des paramètres statistiques pour les trois éléments sont donnés pour les deux minerais.

Price \$1.00

Catalogue No. M34-20/17

TB - 179 The Hydrodesulphurization of Heavy Gas-Oils (650 - 975<sup>o</sup>F) Derived from Athabasca Bitumen by P. S. Soutar\*, E. C. McColgan\*, W. H. Merrill\*\* and B. I. Parsons\*\*

The hydrodesulphurization characteristics of three heavy gas-oils derived from Athabasca bitumen were determined and compared. The experimental work was undertaken in a bench-scale flow system at 2000 psi with the oil and hydrogen percolating up through a fixed-bed of cobalt molybdate catalyst, i.e., the system was operated in a bottom-feed, mixed-phase mode. The range of temperatures investigated was from 320 to 420 at liquid hourly space velocities of 1, 2, and 3 with a hydrogen flow rate of 5000 scf/bbl. The reference stock was a gas-oil prepared commercially (500-850<sup>o</sup>F) from Athabasca bitumen by delayed coking. This was compared to two experimentally produced gas-oils (650-975<sup>o</sup>F) generated by the thermal and catalytic hydrocracking of Athabasca bitumen in a Mines Branch pilot plant.

Price 50 cents

Catalogue No. M34-20/17

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\*Technicians and \*\*Research Scientist, Fuels Research Centre, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

TB - 179 Cont.

The reaction characteristics of the three gas-oils were found to be very similar. Products comparable to ASTM Grades 4 and 5 fuel oils containing 0.3 to 1% sulphur could be produced at all the space velocities investigated at low reaction temperatures 340 to 400°C. Slightly more light-ends were produced with the lower-boiling coker gas-oil than with the higher-boiling hydrocracked gas-oils but the amounts involved were not large. No significant catalyst deactivation was observed with any of the feed stocks over the 45-50 operating hours involved in any of the series of experiments.

Les auteurs déterminent et comparent les caractéristiques d'hydrodésulfuration de trois types de gas-oil dérivés du bitume de l'Athabasca. Le travail a été entrepris à l'aide d'un système d'écoulement à échelle expérimentale à une pression de 2,000 livres par pouce carré avec du pétrole et de l'hydrogène passant à travers un lit fixe d'un catalyseur à molybdate de cobalt, i.e. le système a été exploité selon le mode d'alimentation par le bas, en phase mixte. L'échelle des températures de l'expérience était de 320 à 420°C aux vitesses spatiales liquide par heure de 1, 2, and 3 avec un débit d'hydrogène de 5,000 pieds cubes normaux/baril. Le stock d'alimentation de référence était un gas-oil préparé commercialement (500-850°F) à partir du bitume de l'Athabasca par cokéfaction différée. On l'a comparé à deux types de gas-oil expérimentaux qui sont le produit de l'hydrocraquage thermique et catalytique du bitume de l'Athabasca à l'installation d'essai de la Direction des mines.

Les caractéristiques de la réaction des trois types de gas-oil ont semblé être tout-à-fait semblables. On pourrait obtenir des produits comparables aux huiles combustibles de l'ASTM de qualités de 4 et 5 contenant de 0.3 à 1% de soufre à toutes les vitesses spatiales expérimentées à basses températures de réaction de 340 à 400°C. On a produit un peu plus de fractions légères avec le gas-oil de l'unité de cokéfaction à bas point d'ébullition qu'avec les types de gas-oil hydrocraqués à un point d'ébullition plus élevé, mais les quantités en question n'étaient pas importantes. On n'a pas observé de déactivation du catalyseur chez aucun des stocks d'alimentation après les 45-50 heures d'opération pour chacune des séries d'expériences.

Price 50 cents

Catalogue No. M34-20/179

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\*Technicians and \*\*Research Scientists, Fuels Research Centre, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Ontario.



TB - 180 Mining Technology in 1972  
by Amil Dubnie\*

During 1971, there was a slight decrease in the tons of ore mined from surface metal mines and a slight increase in ore mined underground. As a result, the ratio of surface-mined to total showed a decrease from 0.69 to 0.66.

In surface non-metal mines during 1971, the increase in underground ore was greater than for surface-mined ore. This resulted in a decrease in the ratio of surface ore to total ore from 0.66 to 0.65.

The substantial increases in surface-mined coal continued and the ratio of surface-mined to total coal rose to 0.75.

During 1971, about 33% of underground metallic ore was mined by cut-and-fill stoping or variations thereof, followed by open stoping with long-hole drilling at 26%. In terms of tons mined in underground metal mines, sublevel caving accounted for about 17%, making this the third most important method.

Decreases in mining costs occurred in underground mining of potash by the room-and-pillar method, and gold-quartz mining by shrinkage stoping. Other methods showed substantial increases. It is apparent that advances in underground mining technology are not keeping pace with rising costs.

An important advance during 1972 was the introduction on a production scale of slurries for underground blasting and means for bulk handling and loading them.

Price 75 cents

Catalogue No. M34-20/18

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\*Mining Engineer, Mining Research Centre, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

INFORMATION CIRCULARS

IC - 295 The Environmental Cracking of Line-Pipe Steels: A Short Review  
by G. J. Bieffer\*

Such forms of environmental cracking of line pipe steels as sulphide cracking, hydrogen embrittlement cracking, and stress-corrosion cracking are briefly reviewed.

Ce rapport donne un compte rendu des différentes formes de fissuration environnementale, telles que fissuration par sulfures, fissuration due à la fragilisation par l'hydrogène et fissuration par corrosion sous tension.

Price 50 cents

Catalogue No. M38-3/295

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\*Head, Corrosion Section, Physical Metallurgy Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

IC - 296 Bibliography of High-Temperature Condensed States Research Published in Canada, October -  
December, 1972  
by Norman F. H. Bright\*

This report contains bibliographic information concerning research work on high-temperature condensed states published in Canadian journals from October 1 to December 31, 1972. This is the final issue of this quarterly series of Information Circulars. In future, the information will be provided by Professor C. B. Alcock, Department of Metallurgy, University of Toronto.

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, 1972. C'est la dernière publication de ces séries trimestrielles des Circulaires d'information. A l'avenir le Professeur D. B. Alcock du département de Métallurgie de l'Université de Toronto donnera les renseignements requis.

Price 50 cents

Catalogue No. M38-3/296

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\*Head, Physical Chemistry Group, Mineral Sciences Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

IC - 297 Reactions and Periodic Occurrences at a Platinum Anode in Alkali Sulphide Solutions  
by H. Gerischer, Z. Elektrochem., 54 (1950) 540  
Translated from German by K. Bartels\*

A platinum electrode, anodically polarized in a  $\text{Na}_2\text{S}$  solution, can take on adsorbents in three different regions of potential. In the lowest region, some type of polysulphide is formed and then sulphur is precipitated. In the next region, the main product, besides polysulphide and sulphate, is thiosulphate. In the uppermost region, sulphate is practically the only product. The existence of the upper potential regions is explained by the formation of a layer of oxygen on the electrode. With this formation, the periodic phenomena, which can be shown to be of three different types, can be derived from a basic concept. The periodic reaction mechanism is thoroughly discussed.

Price 50 cents

Catalogue No. M38-3/297

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\*Technologist, Physical Chemistry Group, Mineral Sciences Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

IC - 298 An Index of Scientific and Technical Papers Published by the Staff of the Mines Branch in 1972

Price \$1.00

Catalogue No. M38-3/298

IC - 299 The Physical Metallurgy of Quenched and Tempered Low-Carbon Steel, with Special Reference to Large Diameter Line Pipe Applications  
by J. D. Boyd\*

This report summarizes the present state of the art of the physical metallurgy of line pipe steels and considers the possibilities for developing new high-strength, high-toughness grades of steel suitable for arctic pipelines. It is suggested that, for large-diameter, heavy-walled line pipe in which 80 to 100-ksi ( $550$  to  $690\text{-MN/m}^2$ ) yield strength is required, quenched and tempered low-carbon steels ( $<0.10\text{C}$ ) offer an attractive combination of strength, toughness, formability, weldability, and economy of production. Two possible methods for manufacturing line pipe incorporating a quench and temper process are outlined, and the techniques for controlling microstructure are discussed for both methods. Finally, the relations between the microstructure of quenched and tempered low-carbon steel and two important mechanical properties are discussed in detail. The mechanical properties which are considered are the basic strengthening mechanisms and the origins of fracture toughness, with particular reference to dynamic toughness.

Price \$1.00

Catalogue No. M38-3/299

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\*Research Scientist, Ferrous Metals Section, Physical Metallurgy Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

IC - 299 Cont.

Dans ce rapport, l'auteur donne un résumé de l'état actuel de l'art de la métallurgie physique des aciers utilisés pour les tuyaux de conduite et il considère les possibilités pour développer l'acier de qualité à haute résistance et à haute ténacité convenable pour les pipelines arctiques. Pour un pipeline à large diamètre et de forte épaisseur dans lequel la limite d'élasticité de 80 à 100-kis (550 à 690-MN/m<sup>2</sup>) est nécessaire, l'auteur suggère que les aciers trempés et revenus à basse teneur en carbone (<0.10C) offrent une combinaison attrayante de résistance, de ténacité, de ductilité, de soudabilité et d'économie de production. Il donne les généralités sur deux méthodes possibles pour la fabrication du tuyau de conduite qui incorpore un procédé de trempe et de revenu et il discute aussi des techniques pour contrôler la microstructure pour les deux méthodes. Dernièrement, il discute en détail les rapports entre la microstructure de l'acier trempé et revenu à basse teneur en carbone et les deux propriétés mécaniques sont les mécanismes résistants de base et les origines de la ténacité de fracture, avec une référence particulière à la ténacité dynamique.

IC - 300 Roll Compaction of Metal Powders Bibliography for Period 1900 to 1972  
by J. A. Strasser\*

The references used in this bibliography have been collected from many sources such as metallurgical abstracts and Metal Powder Report. The references are grouped into yearly divisions and each year is arranged alphabetically by senior author. Annotated references have been inserted wherever possible to assist the reader in determining the value of the publication for his individual needs. Patents are included in the bibliography in the year that the application for patent was made by the inventor.

Several references are included in the bibliography which do not deal directly with the roll compaction of metal powders. These references are cited to provide the reader with a more complete insight into the relevant factors involved in the roll compaction process.

L'auteur a rassemblé les références utilisées dans cette bibliographie de plusieurs sources telles que les résumés métallurgiques et les Rapports de poudre métallique. Il a groupé les références par divisions annuelles et chaque année, les références sont classifiées alphabétiquement par auteur principal. L'auteur a inséré les références avec commentaire à l'occasion pour aider au lecteur à déterminer la valeur de la publication pour ses besoins particuliers. Il a inclus les brevets d'invention et l'année de la demande du brevet d'invention.

L'auteur a aussi inclus plusieurs références dans la bibliographie qui ne traitent pas directement du laminage (compaction) des poudres métalliques. Il a cité ces références pour donner au lecteur une connaissance plus complète des facteurs pertinents et compris dans le procédé de laminage (compaction).

Price \$1.25

Catalogue No. M38-3/300

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\*Research Scientist, Nuclear and Powder Metallurgy Section, Physical Metallurgy Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

IC - 301 Vegetation of Mine Waste Embankments in Canada  
by D. R. Murray\*

The main conclusions of this report are that revegetation of most mine wastes requires a well-planned program and that technology is available. The physical and chemical properties of some wastes are such that research is required to determine satisfactory revegetation procedures.

Canada is similar in many ways to other countries with respect to the physical texture and variety of its mining wastes and the associated problems of erosion and surface instability. Straw mulching, chemical binders, and wind breaks, as applied elsewhere with some success to control erosion, are used to some extent in Canada.

Chemical properties of a waste depend a great deal on the geology and treatment of the ore. This is not unique to Canadian mines but the influence of environment makes it a significant problem. Climate influences the weathering of wastes to soils that are highly regional. Usually the revegetation program that suits one mine waste will not suit another even though the same ore is being mined.

Plant choice is very specific to Canadian wastes, and establishment of plants involves fertilization, seeding, and cultivation procedures. In any specific case, any one of a large number of factors relating to the development of either a program or, a reclamation sequence may be critical and these are discussed. If either a physical or chemical property is extreme, e.g. high acidity in sulphide tailings, research must be directed to finding a solution. Every case is different and must be approached systematically.

Les conclusions principales de ce rapport sont les suivantes: (a) la révégétation de la plupart des remblais miniers exigent un programme bien conçu, et (b) la technologie est disponible. Les propriétés physiques et chimiques de quelques remblais sont telles que la recherche est nécessaire pour déterminer les procédés de révégétation satisfaisants.

Le Canada est semblable aux autres pays de bien des façons en ce qui concerne la texture physique et la variété de ses remblais miniers et les problèmes associés d'érosion et d'instabilité de la surface. Le paillage, les liants chimiques et les brises-vents, utilisés ailleurs avec un certain succès pour contrôler l'érosion, sont utilisés dans une certaine mesure au Canada.

Les propriétés chimiques d'un remblai dépendent beaucoup de la géologie et du traitement du minerai. Elles ne sont pas uniques aux mines canadiennes mais elles ont une influence significative sur l'environnement. Le climat influence la désagrégation des remblais dans des sols hautement régionaux. Ordinairement le programme de révégétation qui convient au remblai minier ne conviendra pas à un autre, même si le minerai exploité est le même.

Price \$1.00

Catalogue No. M38-3/301

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\*Agronomist with the Elliot Lake Laboratory, Mining Research Centre, Department of Energy, Mines and Resources, Mines Branch, Elliot Lake, Ontario.

IC - 301 Cont.

Le choix végétal est très spécifique aux remblais canadiens, et la réussite du plantage dépend de la fertilisation, des semences et des méthodes de culture utilisées. Dans tout cas spécifique, n'importe quel facteur relatif au développement soit d'un programme soit d'une succession de régénération peut être critique; ces facteurs sont discutés. Si une propriété physique ou une propriété chimique est extrême, i.e. haute acidité dans les résidus de sulfure, la recherche doit être dirigée pour trouver une solution. Chaque cas est différent et doit être abordé systématiquement.

IC - 302 Mineralogical and Textural Study of the Copper-Molybdenum Deposit of Brenda Mines Limited, South-Central British Columbia  
by A. E. Johnson\*

Samples from the copper-molybdenum deposit of Brenda Mines Limited were studied mineralogically using, in some instances, the reflecting ore microscope for identification and, in others, the electron microprobe for identification by quantitative analyses.

The assemblage of ore minerals and their textural relationships are relatively simple. Chalcopyrite and molybdenite are the two ore minerals of major interest and both occur interstitially within quartz-filled fractures. Pyrite occurs sporadically within the quartz veins and as disseminations in the country rock. Chalcopyrite appears to be of more than one age as shown by its textural relationship to pyrite. The remaining ore minerals are present in relatively minor amounts.

L'auteur a fait une étude des échantillons du gisement de cuivre-molybdène de "Brenda Mines Limited" du point de vue minéralogique en utilisant, dans certaines instances, le microscope à réflexion de minerai pour l'identification et dans d'autres instances, la micro-sonde électronique pour l'identification par les analyses quantitatives.

L'assemblage des minéraux métalliques et leurs rapports texturaux sont relativement simples. La chalcopyrite et la molybdénite sont deux minéraux métalliques d'un intérêt majeur et toutes les deux se trouvent interstitiellement dans les cassures remplies de quartz. La pyrite se trouve sporadiquement dans les veines de quartz et comme disséminée dans la roche encaissante. La chalcopyrite semble avoir plus qu'un âge, cela se voit par le rapport textural avec la pyrite. Le reste des minéraux métalliques se trouve relativement en quantités plus petites.

Price 50 cents

Catalogue No. M38-3/302

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\*Research Scientist, Mineralogy Group, Mineral Sciences Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

IC - 303 Mineralogical and Textural Study of the Copper-Iron Deposit of Craigmont Mines Ltd., South-Central British Columbia  
by A. E. Johnson\*

A suite of samples from the copper-iron deposit of Craigmont Mines Ltd., was studied mineralogically and texturally using the reflecting ore microscope.

The assemblage of ore minerals and their textural relationships are relatively simple. Chalcopyrite and magnetite are the two ore minerals of major interest and both occur as impregnations in a skarn host. Pyrite is relative sparse in this deposit. Textural relationships suggest at least two ages of hematite relative to magnetite. The remaining ore minerals are present in relatively minor amounts.

Zoning occurs in the mine, and is characterized by a greater proportion of magnetite at the east end, and by hematite predominating at the west end.

L'auteur a fait une étude d'une série d'échantillons du gisement de cuivre-fer de "Craigmont Mines Ltd." du point de vue minéralogique et textural en utilisant le microscope à réflexion de minerai.

L'assemblage des minéraux métalliques et leurs rapports texturaux sont relativement simples. La chalcopyrite et la magnétite sont deux minéraux métalliques d'un intérêt majeur et toutes les deux se trouvent imprégnées dans le skarn original. La pyrite est relativement peu abondante dans ce gisement. Les rapports texturaux suggèrent au moins deux âges d'hématite en relation avec la magnétite. Le restant des minéraux métalliques se trouvent dans des montants relativement petits.

La minéralisation change et est caractérisée par une plus grande proportion de magnétite à l'est de la mine et par une plus grande proportion d'hématite à l'ouest de la mine.

Price 50 cents

Catalogue No. M38-3/303

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\*Research Scientist, Mineralogy Group, Mineral Sciences Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

IC -304-F Fonçage Mécanique de Tunnels et de Montées  
par M. D. Everell\*

On présente dans ce rapport une revision des connaissances pratiques actuelles en fonçage mécanique de tunnels et de montées. La présentation se veut relativement complète tout en étant dirigée vers des usagers éventuels de ces machines plutôt que vers des experts dans ces domaines. Elle couvre plusieurs sujets dont les plus importants sont: les méthodes disponibles, l'ingénierie générale des machines, les rendements, les coûts ainsi que les renseignements géologiques nécessaires. L'auteur a également attaché un importance à l'identification des perspectives d'avenir dans ces domaines de pointe en technologie minière.

Prix \$1.00

N<sup>o</sup> de catalogue M38-3/

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\*Chercheur scientifique, Groupe de recherche sur la fracture des roches, Centre de recherches minière, Direction des mines, Ministère de l'Énergie, des Mines et des Ressources, Québec, Québec, Canada.

IC - 304-F - Cont.

The report is a review of present practical knowledge in mechanical boring of tunnels and raises. The presentation while being relatively complete is first of all directed towards eventual users of the machines rather than experts in this field. It covers many subjects of which the most important are: the methods available, the general engineering of the machines, the performances, the costs as well as the geological data necessary. The author has also attached a certain importance to future prospects in these domains of new development in mining technology.

IC - 305 Evaluation of Canadian Commercial Coals: 1972 Saskatchewan, Alberta and British Columbia by T. E. Tibbetts\* and W. J. Montgomery\*\*

The physical and chemical analyses of forty-one samples of coal are reported. In addition, the chemical analyses of ash of most of the same coals are reported in a separate section.

Coals from eleven mining operations in the three coal mining provinces, Saskatchewan, Alberta, and British Columbia - are represented; they include lignite, subbituminous, and bituminous coals.

The samples were taken and analysed by the Fuels Research Centre during the year 1972. They represent the production, on a specified day, of the coals as commercially prepared at the mine or, referring to the channel samples, the coal seam where mining was in progress or planned.

L'auteur décrit les résultats d'analyses physiques et chimiques de 41 échantillons de houille. Il donne de plus les résultats de l'analyse chimique de la cendre de la plupart de ces charbons dans une section séparée.

Les échantillons proviennent de 11 charbonnages dans trois provinces de l'ouest, soit la Saskatchewan, l'Alberta et la Colombie-Britannique; ils comprennent de la lignite, de la houille maigre et de la houille grasse.

Les échantillons ont été prélevés et analysés en 1972 par le Centre de recherche sur les combustibles. Ils sont représentatifs de la production journalière de la houille préparée commercialement à la mine, ou, dans le cas des échantillons de veines, de la couche de houille où l'extraction était en cours ou projetée.

Price 75 cents

Catalogue No. M38-3/305

\*Head, Coal and Peat Resources Evaluation, Fuels Research Centre, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

\*\*Head, Solid Fuels Laboratory, Fuels Research Centre, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.



IC - 306 Survey of Physical-Mineralogical Characteristics of Underground Mines in Canada  
by R. Sage\* and D. F. Coates\*\*

A survey of underground mines in Canada has been made to determine the nature and extent of orebodies, mining techniques, and physical properties of rocks. The response to the survey was good in that 85% of the mines participated. The results are stored on tape, and a computer program has been written to search for particular mine characteristics. The results show that Canadian underground mining is over a wide range of depths (to 8000 ft), generally in steeply dipping orebodies and in a wide variety of rock types and conditions. Cut-and-fill is the commonest mining method, although all techniques are used. The variability of mining conditions requires careful planning and development to establish the optimum mining methods and equipment.

Les auteurs ont fait une étude sur les mines souterraines au Canada pour déterminer la nature et l'étendue des corps de minerai, des techniques minières et des propriétés des roches. La participation a été très bonne; 85% des mines ont pris part au sondage. Ils ont enregistré les résultats sur une bande magnétique et ils ont écrit un programme machine pour trouver les caractéristiques particulières d'une mine. D'après les résultats, les auteurs ont pu montrer que l'exploitation souterraine au Canada couvre une vaste gamme de profondeurs (jusqu'à 8000 pieds) généralement dans des corps de minerai très inclinés avec des types et conditions de roches très variés. Ils ont trouvé que la méthode d'abattage de déblais et remblais était la plus employée quoique toutes les techniques soient employées. Ils ont trouvé aussi que la variabilité des conditions minières exige une planification et un développement bien soignés afin d'établir les meilleurs méthodes et équipements pour l'exploitation minière.

Price 75 cents

Catalogue No. M38-3/3C

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\*Engineer and \*\*Head, Mining Research Centre, Mines Branch, Department of Energy, Mines and Resources, 555 Booth Street, Ottawa, Canada.

- IC - 307 Infra-Red (IR) Spectra of Certain Sulphides and Analogous Binary Compounds in the Long-Wave Region  
 by A. S. Povarennykh, G. A. Sidorenko, L. S. Solntseva, B. P. Solntsev  
 (Kiev Institute for Geochemistry and Physics of Minerals Academy of Sciences of the Ukrainian SSR, Moscow, VIMS)  
 (Translated by A. H. Gillieson\*)

A systematic study of the infrared spectra of twenty-two minerals in the long wavelength region from 20 to 167 microns (500-60 cm<sup>-1</sup>) is presented. The minerals were mainly binary compounds, 14 sulphides, 6 arsenides, 1 telluride, and one element (native arsenic). The infrared spectrometer used was an Hitachi FIS-1, and the thickness of the mineral sections was 3-5 mg/cm<sup>2</sup>.

Price 50 cents

Catalogue No. M38-3/307

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\*Section Head, Spectrochemistry Group, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

- IC - 309 Standard Reference Ores and Rocks Available from The Mines Branch as of October 1973  
 Compiled by G. H. Faye\*

The current program of preparing standard reference ores and rocks is a major facet of what is now called the Canadian Standard Reference Materials Project (CSRMP). The CSRMP is an off-shoot of the activities of the Canadian Association for Applied Spectroscopy (CAAS) which, in 1955, began the production of copper and copper-alloy standards with the assistance of the Mines Branch and various Canadian metallurgical industries.

In 1966, the CAAS, which has since become the Spectroscopy Society of Canada (SSC), entered the geochemical field by issuing a syenitic rock (SY-1) and a sulphide ore (SU-1) as reference materials with provisional analytical results.

During the mid-sixties, the Mines Branch, EMR, became the major collaborator in the production of standard reference materials and gradually this activity was transferred from the SSC to the Mines Branch. This was a logical step because the Branch has the personnel and equipment necessary not only for production but also for distribution and sales. Because of its impartiality, it is an appropriate organization to co-ordinate the inter-laboratory programs that are necessary to obtain analytical results for the certification of standard reference materials.

In January 1973, the CSRMP became officially sponsored by the Mines Branch. Although the Director of the Branch has the overall responsibility for the project, the day-to-day business is conducted by the Chairman of the CSRMP who is, at present, Dr. A. H. Gillieson, Mineral Sciences Division, Mines Branch.

Price 75 cents

Catalogue No. M38-3/309

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\*Coordinator, Ores Task Force, Canadian Standard Reference Materials Project, Mineral Sciences Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

IC - 309 - Cont.

Within the CSRMP, there are now three groups active in the preparation of standard reference materials, one for ferrous spectrographic standards, one for radioactive ores and radiometric standards, and one for Canadian metal-bearing ores. Because of the increasing demand for standard reference ores that are typical of major deposits in Canada, the last group is the largest and most active. Consequently, the majority of materials listed in this catalogue are ores or metallurgical products that have been prepared and characterized by this group.

The first catalogue (Mines Branch Information Circular IC 294) of ores and rocks, prepared and sold by the CSRMP, was issued in November 1972. Since that time, four new certified materials have been made available for sale and two more ores are being processed prior to their certification; therefore, the preparation of this up-dated catalogue, or Information Circular, was made necessary.

This Circular describes the standard reference ores and rocks that may be purchased from the Mines Branch through the Chairman, CSRMP, as of October 1973. Where possible, the source, mineralogical and chemical composition, the recommended values of the certified elements, and the price are given for each available material. Also included are brief descriptions of materials that are being processed and their approximate date of availability.

It is anticipated that new Circulars will be prepared periodically as new information on existing materials becomes available and as new standard ores are added to the list.

IC - 310      X-Radiometric Assaying in The Mining of Molybdenum-Wolfram Ores  
by E. P. Leman, N. G. Bolotova and V. V. Kotel'Nikov  
(G. V. Plekhanov Mining Institute, Leningrad)  
Translated by A. H. Gillieson\*

An x-ray fluorescence method is described for the estimation of molybdenum and tungsten (wolfram) in the walls of mines. Excitation by a cadmium-109 radioisotopic source and detection by a xenon proportional counter enables the simultaneous determination of both elements.

Price 50 cents

Catalogue No. M38-3/310

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\*Section Head, Spectrochemistry Group, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

REPRINT SERIES

RS - 120 Structural Analysis of Features on Natural and Artificial Faults  
 by D. K. Norris\* and K. Barron\*\*  
 Reprinted from the Proceedings of the Conference on Research in Tectonics, Ottawa,  
 pps 136-174, March 14-15, 1968.

Many beds in the coal measures of the eastern Cordillera have been detached from one another because of buckling and of differential translation on thrust surfaces. Striae, steps and polish on bedding faults were compared with similar features produced in the laboratory to evaluate their usefulness in kinematic analysis.

Pitches of striae on the same bed at various localities in Upper Marsh seam in the eastern Cordillera approximate a circular normal distribution with a preferred direction of slip essentially perpendicular to the regional strike. This distribution includes a very large number of discrete directions of slip representing some phase of the kinematic activity on bedding. Statistical tests provide reasonable assurance that samples of pitch of striae from one and more slip surfaces are from the same movement picture.

Steps on bedding and on extension faults are of two basic types: those of mineralized gouge plastered on the slip surface (accretion) and those cut into the solid rock (fracture). Both types may be linear or arcuate in projection on the slip surface; they commonly trend about at right angles to the preferred direction of slip and they may be modified or erased by later movement. Accretion steps adjacent to Upper Marsh seam are usually localized at irregularities in surface configuration. In any specimen or locality they characteristically occur on the same flank of depressions. Microscopically they consist of a complex lamination of quartz and carbonate with carbonaceous gouge. Layers of gouge feathered out in the quartz and carbonate, sigmoidal tension gashes, tension fissures filled with mineralization, and fragments of steps plucked from the risers indicate that these steps commonly face in the preferred direction of slip of the opposed wall. The steps are, therefore, plastered in the lee of irregularities in the rock surface. The fine structure, however, suggests modification of some steps of slip in a reversed direction consistent with observations of some faults which have themselves been cut and displaced in the coal seam. Fracture steps may originate in at least three ways in and adjacent to Upper Marsh seam: by inheritance from the initial fracture configuration of the slip surface, by plucking of platy fragments, and by faulting of the slip surface.

Polish on and within beds is widespread adjacent to Upper Marsh seam. It may be due to relatively large shear displacement over considerable area on individual beds or to microscopic shear on a multitude of slip surfaces of limited area within beds.

Price 25 cents

Catalogue No. M38-8/120

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\*Institute of Sedimentary and Petroleum Geology, Geological Survey of Canada, Calgary, Alberta.  
 \*\*Mining Research Centre, Ottawa, Ontario.

RS - 120 - Cont.

Steps and striae were created in the laboratory on prepared and induced slip surfaces in cylindrical specimens of soapstone, mudstone and siltstone loaded axially under confining pressures up to 9,000 psi. The steps were similar to the two basic types observed in the field. Both were oriented more or less perpendicular to the direction of the striae. Risers on accretion steps were observed to face in opposing directions depending largely on whether the fragments of compressed gouge stuck to one side or other of the specimen when the slip surfaces were separated for viewing. The directions in which the risers faced, therefore, were not consistent with the known sense of slip. Prominent fracture steps were observed to be due to faulting of the principal slip surface on the conjugate shear set. They consequently opposed motion on the principal surface.

Both field and laboratory data, therefore, indicate that accretion steps are formed as slip surfaces are parted, and depending on which wall retains the gouge, the steps will face in the one direction or other. Because the gouge is more readily bonded to the lee flank of irregularities, however, it commonly sticks there so that risers face preferentially in the direction of motion of the opposed block. Fracture steps on the other hand can face in either direction and therefore cannot be used indiscriminately as a definitive criterion for sense of slip. Where their nature and origin are understood, however, both kinds of steps may be used with meaningful samples of pitch measurements to establish directions of slip and therefore to document at least part of the kinematic history of faulting and folding in orogenesis.

**In Situ Stresses**

by H. V. Bielenstein\* and K. Barron\*\*

Reprinted from the Proceedings of the 7th Canadian Rock Mechanics Symposium, Edmonton, pp 3-14, March 25-27, 1971

This paper presents a summary of the presentations made during the session on in situ stresses. The objective of this session was to discuss, with examples, some of the problems and approaches to the interpretation and significance of in situ stress determinations from both the engineering and geologic viewpoints. The session coordinators (BIELENSTEIN and BARRON) posed a series of questions aimed at identifying problem areas; individual contributors (HERGET, BENSON, VARNES, BROWN and GOODMAN) reported on specific studies aimed at trying to answer some of these questions and, in turn, raised a number of more detailed problems. This summary is not comprehensive but merely attempts to report some of the highlights of the session in a cohesive framework. Many of the questions posed remain unanswered, some ideas presented may be controversial, but nonetheless it is thought that this session achieved a frank discussion between engineers and geologists and some mutual appreciation of how each discipline might aid the other in the search for answers.

Price 25 cents

Catalogue No. M38-8/120

\*Research Scientist, Western Office, Mining Research Centre, Mines Branch, Department of Energy, Mines & Resources, Calgary, Alberta.

\*\*Manager, Western Office, Mining Research Centre, Mines Branch, Department of Energy, Mines & Resources, Calgary, Alberta.

RS - 121 Communication Methods in Underground Mines  
 by R. O. Tervo\* and M. D. Everell\*\*  
 Reprinted from Canadian Mining Journal, Volume 93 (Part One) Number 8, pp 36-43, August.  
 (Part two) Number 11, pp 61-63, November, Montreal, 1972.

A review of communication methods used in underground mines. In Part one, various types of both wired and wireless systems, and listed equipment available on the market are described in general terms. In Part two, the authors go into the theory of radio propagation and conclude by pointing out the relative merits of the various systems.

Price 25 cents

Catalogue No. M38-8/121

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\*Research Scientist, Energy, Mines and Resources, Mines Branch, Mining Research Centre, Elliot Lake, Ont.  
 \*\*Research Scientist, Energy, Mines and Resources, Mines Branch, Mining Research Centre, Quebec, P.Q.

RS - 122 Elements of Planning in Deep Mining  
 by D. F. Coates\* and M. Dickhout\*\*  
 Reprinted from Canadian Mining Journal 91, Number 9, pp 74-78, September, 1970.

The authors discuss ground control in deep mines (5000 ft) for minimizing rockbursts with respect to rock failure, planning (stopping and development) and instrumentation.

Price 25 cents

Catalogue No. M38-8/122

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\*Head, Mining Research Centre, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.  
 \*\*Assistant to Chief Mines Engineer, International Nickel Company of Canada, Limited, Copper Cliff, Ontario, Canada.

Stope-and-Pillar Design for the Elliot Lake Uranium Mines  
 by D. G. F. Hedley\* and F. Grant\*\*

In 1958, the Ontario Department of Mines appointed a committee to study the accident situation and mining methods used in the uranium mines in the Elliot Lake district. This committee reviewed the existing knowledge on mine design, pillar support and roof spans and came to the conclusion that scientific knowledge had not yet reached the stage of producing rational design procedures which would reduce the dependence on trial-and-error methods.

Price 25 cents

Catalogue No. M38-8/122

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\*Research Scientist, Mining Research Centre, Mines Branch, Department of Energy, Mines & Resources.  
 \*\*Research Scientist, Western Office of the Mining Research Centre in Calgary.

RS - 122 - Cont.

Since that time, the Mining Research Centre has made numerous stress measurements in two mines to define the pre-mining and pillar stresses. A comprehensive series of tests has been done in the laboratory to measure the compressive strength of the rock; a geological survey of the region has been made to evaluate tectonic stresses; and a survey was done on mining conditions with regard to stable and unstable pillar configurations.

This information has been used to evaluate pillar design as effected by pillar width and height, depth below surface, extraction and pre-mining stress fields. The resultant design of pillar widths and corresponding extraction as the depth increased is in line with past and present experience in these mines. The information available on roof stability is still insufficient to design stable stope spans with the same degree of confidence; experience and trial-and-error methods are still required.

RS - 123 Seismic Measurements and Bore Hole Photographic Observation  
by G. E. Larocque, F. Kapeller and D. F. Coates\*  
Reprinted from Canadian Mining Journal Volume 94, Number 3, pp 44-45 March, Montreal, 1973.

Preliminary seismic refraction measurements were made on the upper surfaces of benches in an iron mine. The purpose of the measurements was to evaluate seismic refraction surveying as a method of determining zones of altered structural properties in rock that had been blasted. Zones of reduced seismic velocity were found to exist in these upper surfaces. Photographic observations have shown that these are zones of fractured rock. I ref.

Price 25 cents

Catalogue No. M38-8/1

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\*Respectively Research Scientist, Technician and Head, Mining Research Centre, Mines Branch, Energy, Mines Resources, Ottawa, Canada.

Comparative Ground-Shock Measurements for Evaluating Pre-Splitting  
by G. E. Larocque\* and D. F. Coates\*\*  
Reprinted from Western Miner Volume 45, Number 12, pp 33, 34, 36, 38, December, Vancouver, 1972.

Considerable interest exists in establishing the effectiveness of pre-splitting in controlling damage in the walls left after blasts in open pits. The mechanics of pre-splitting under idealized conditions are well known. The effects of geological discontinuities on these mechanisms can be determined, at the present time, only by field experiments. Further, the effects on mine profitability of successful pre-splitting

Price 25 cents

Catalogue No. M38-8/2

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\*\*Head, Mining Research Centre, Mines Branch.

RS - 123 - Cont.

remain difficult for each mine to determine for its particular conditions.

Measurements of the ground shock transmitted into wall rocks at three different sites were made for pre-splitting blasts, production blasts with pre-splitting, and termination blasts without pre-splitting.

Whereas it would be desirable to have an adequate number of measurements in any one rock mass to determine the mean parameters and to conduct such trials in a large variety of rock masses, some tentative conclusions can be drawn from the present work. In competent rock, as would be expected, pre-splitting may cause less physical damage than conventional termination blasting. On the other hand, in badly fractured rock, pre-splitting may cause more damage to the walls than the conventional termination blast where hole spacing and explosive charge are reduced.

With the evolution of the research equipment used in this work, it is now possible to make measurements of acceleration and particle velocity with practically no loss of materials.

RS - 124 Air Pollution and Energy Reserves - La Pollution Atmosphérique et les Reserves d'Energie  
by T. D. Brown\*  
Reprinted from The Civil Service Review March 1973, Vol XLVI, No 1, March, 1973.

At the 57th International Labour Conference the ILO pledged support to any concerted campaign for the protection and enhancement of the human environment. The Canadian government has already taken steps in this direction by the establishment of a Department of the Environment, the employees of which belong to the PSAC,s Environment Component. This article, the first in a projected series, is a scientific presentation in layman's language dealing with one aspect of pollution.

A la 57e Conférence internationale du Travail, l'OIT s'est engagée à appuyer toute campagne concertée pour la protection et l'embellissement de l'environnement humain. Le gouvernement du Canada a déjà pris de mesures dans ce sens en créant le ministère de l'Environnement, dont les employés appartiennent à l'El.ment de l'Environnement de l'AFPC. L'article qui suit, le premier d'une série, est un exposé scientifique, mais en langage profane, d'un aspect de la pollution.

Price 25 cents

Catalogue No. M38-8/124

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



RS - 125 Low No<sub>x</sub> Combustion: The Effect of External Flue Gas Recirculation on Emissions from Crude Oil Combustion  
by T. D. Brown\*  
Reprinted from the Italian Flame Day Pisa, March 20-21, 1973.

Nitric oxide is the most important oxide of nitrogen formed in modern high-temperature boilers and, after emission, it will react with atmospheric oxygen to produce toxic nitrogen oxides.

Atmospheric photochemical reactions between nitrogen oxides, oxygen, and hydrocarbons produce smog which reduces visibility and produces further reaction products including the lachrymatory peroxyacetyl nitrates. In high concentrations, the smog products damage vegetation and aggravate human respiratory difficulties. Nitrogen dioxide (NO<sub>2</sub>) is more hazardous than carbon monoxide (CO) because it combines with haemoglobin and forms acids in the lungs.

The advent of control legislation limiting the emission of nitric oxide will undoubtedly pose new problems for combustion engineers because high-temperature operation for maximum boiler efficiency inevitably increases the formation of nitric oxide. The objectives of this research program are to define the relevant combustion performance parameters that can be controlled or manipulated in such a manner as to minimize the formation of nitric oxide in flames.

Price 25 cents

Catalogue No. M38-8/12F

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\*Research Scientist Canadian Combustion Research Laboratory, Fuels Research Centre, Mines Branch.

RS - 126 Environmental Restraints on Energy Conversion  
by E. R. Mitchell\*  
reprinted from the Canadian Mining and Metallurgical Bulletin, June 1973.

The physical magnitude of the Canadian air, land and water environments together with their natural scavenging mechanisms can assimilate more pollution than is produced in energy conversion. Nonetheless concentrations of pollution at single sources and the proliferation of sources exceeds the capacity of the environment in some specific, but widely separated, areas. Thus, if our environments are to be given a reasonable opportunity to assimilate pollution, there is no choice, but to ensure that stack emissions are minimized and, having done that, to make full use of the dispersion capacity of air sheds. However, neither fuel highgrading, i.e. the use of premium fuels as an expedient for the moment, nor pollution controls that waste energy are viable long-term solutions for protecting the environment.

Price 25 cents

Catalogue No. M38-8/11

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\*Head, Canadian Combustion Research Laboratory, Fuels Research Centre, Mines Branch.

ADMINISTRATION REPORTS

ADM - 73-1 Fourth Mines Branch Seminar on Environmental Improvement;  
compiled by Mines Branch Staff, January 1973.

SECTION 2 - PAPERS PUBLISHED IN PERIODICALS

## EXTRACTION METALLURGY DIVISION

Electrical Conduction Properties of Liquid Vanadates, Part I. Vanadium Pentoxide; R. C. Kerby and J. R. Wilson; Canadian Journal of Chemistry, Vol. 50, No. 17, 2865 to 2870, 1972.

Electrical Conduction Properties of Liquid Vanadates, Part II. The Sodium Vanadates; R. C. Kerby and J. R. Wilson; Canadian Journal of Chemistry, Vol. 50, No. 17, 2871 to 2876, 1972

Electrical Conduction Properties of Liquid Vanadates, Part III. The System  $V_2O_5 - Na_2O - Fe_2O_3$ ; R. C. Kerby and J. R. Wilson; Canadian Journal of Chemistry, Vol. 50, No. 17, 2877 to 2881, 1972.

Corrosion of Metals by Liquid Vanadium Pentoxide and the Sodium Vanadates; R. C. Kerby and J. R. Wilson; Journal of Engineering for Power, Vol. 95, No. 1, 36 to 43, 1973.

A Comparison of the Processing and Economics of Uranium Recovery from Leach Slurries by Continuous Ion Exchange or Solvent Extraction; G. M. Ritcey, M. J. Slater and B. H. Lucas; International Symposium on Hydrometallurgy (AIME Annual Meeting Chicago), 419 to 474, 1973.

An Automated Analysis for Kinetic Studies on the Leaching of Nickel Sulphides; R. J. C. MacDonald; Advances in Automated Analysis, 1972 Technicon International Congress, Vol. 8, 91 to 100, 1972.

Percolation Leaching of Bornite Ore; J. E. Dutrizac and R. J. C. MacDonald; the Australasian Institute of Mining and Metallurgy Proceedings, No. 245, 25 to 31, 1973.

Corrosive and Erosive Wear of Metals in Mineral Slurries; A. W. Lui and G. R. Hoey; Canadian Metallurgical Quarterly, Vol. 12, No. 2, 185 to 190, 1973.

The Reaction of Tungsten with Sulphur Vapour; J. E. Dutrizac; Journal of the Less-Common Metals, Vol. 31, No. 2, 281 to 297, 1973.

Operation Analysis, Process Design, Process Control; F. J. Kelly; Canadian Mining Journal, Vol. 94, No. 6, 43 to 44, 1973.

The Synthesis of Some Copper Sulphides and Copper Sulfosalts in 500-700 Gram Quantities; J. E. Dutrizac and R. J. C. MacDonald; Materials Research Bulletin, Vol. 8, 961 to 971, 1973.

The Reaction of Tungsten with Selenium Vapour; J. E. Dutrizac; Journal of the Less-Common Metals, Vol. 33, No. 3, 341 to 353, 1973.

A Study of Transient Processes Preceding the Electrodeposition of Cr on Pt; J. C. Saiddington and G. R. Hoey; Journal of the Electrochemical Society, Vol. 120, No. 11, 1475 to 1484, 1973.

Preparation of Capillary Mounts in a Dry Box; S. Kaiman; Journal of Applied Crystallography, Vol. 6, Part 6, 500, 1973.

The Analysis of Complex Materials by X-Ray Emission Spectrometry Without the Use of a Computer; J. C. Ingles and J. B. Zimmerman; Proceedings of the Fourth Annual Meeting of the Canadian Mineral Analysts, 9 to 32, 1973.

Operations Analysis, Process Design and Control in the Canadian Mineral Recovery and Metal Production Industries; F. J. Kelly; Proceedings of the Fifth Annual Meeting of the Canadian Mineral Processors, 349 to 363, 1973.

Recovery of Copper from Concentrated Solution by Solvent Extraction Using Kelex 100; G. M. Ritcey; CIM Bulletin, Vol. 66, No. 732, 75 to 83, 1973.

The Determination of High Concentrations of Elements in Multi-Element Solutions by X-Ray Fluorescence Spectrometry Using a Spiking-Mathematical Correction Technique; J. B. Zimmerman and J. C. Ingles, Canadian Journal of Spectroscopy, Vol. 17, No. 5, 156 to 163, 1972.

Determination by X-Ray Fluorescence Spectrometry of the Metal Concentration in the Organic Phase from Solvent Extraction Processes; J. B. Zimmerman; Canadian Journal of Spectroscopy, Vol. 18, No. 6, 147 to 152, 1973.

Further Studies on Acid Pressure Leaching a Chalcopyrite-Pentlandite-Pyrrhotite Concentrate; J. A. Vezina; CIM Bulletin, Vol. 66, No. 733, 57 to 60, 1973.

Solvent Extraction Contactors; G. M. Ritcey; Technical Papers of the AIChE Symposium on Solvent Ion Exchange, 1973.

## MINERAL PROCESSING DIVISION

"Additional Information Related to the Paper: 'Alignment of Carbon and Other Man-Made Fibres by Magnetic Fields', V. Timbrell, J. Appl. Phys, 43 (11), Nov. 1972, by A. A. Winer.

"Surface Forces in Flotation", Mineral Science and Engineering (South Africa Review Journal), by S. R. Rao.

"Effect of Below-freezing Temperatures on Strength Development of Concrete", by V. M. Malhotra and Carl Berwanger, Proceedings, Symposium on Effect of Temperature Extremes on Strength Development of Concrete, Amer. Concrete Institute.

"Water Recycling Experience in Canadian Mills", by D. E. Pickett and E. G. Joe, for submission to AIME for publication.

"Evaluation of the Windsor Probe Test for Estimating Compressive Strength of Concrete", by V. M. Malhotra, for publication in RILEM Materials and Structures Journal, Paris, France.

"Effect of Sustained and Cyclic Temperature Exposures on Lightweight Concrete", by N. G. Zoldners and H. S. Wilson, Symposium Volume, ACI Spec. Publ. Series.

"Summary of Recent Trends in Canadian Mineral Processing", by E. G. Joe, for publication by CIMM.

"The Utilization of Mineral Wastes", by R. K. Collings, A. Winer, D. G. Feasby, for publication in the Canadian Ceramic Journal, 1973.

"Are 4 x 8-inch Concrete Cylinders as Good as 6 x 12-inch Cylinders for Quality Control of Concrete?", by V. M. Malhotra, Journal, American Concrete Institute, Detroit, U.S.A.

"Fired Microstructure of Freeze-dried Lime-stabilized Zirconia", by T. A. Wheat, Journal of the Canadian Ceramic Society.

## MINERAL SCIENCES DIVISION

- The Nomenclature of the Natural Alloys of Osmium, Iridium and Ruthenium Based on New Compositional Data of Alloys from World-Wide Occurrences. (Submitted to The Canadian Mineralogist), by D. C. Harris and L. J. Cabri, January 16, 1973.
- Semi-Automatic Gravimetric-Spectrophotometric Titration System with a Digital Read-Out (Presented at the 1973 Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, Cleveland, Ohio, March 5-9m 1973), by B. Nebesar, February 22, 1973. (Abstract)
- Flotation and Semiconducting Properties of Minerals: Theoretical Considerations. (Presented at the 47th National Colloid Symposium, A.C.S., Division of Colloid and Surface Chemistry, Carleton University, Ottawa, June 18-20, 1973), by S. M. Ahmed, February 27, 1973, (Long Abstract)
- The Crystal Structure of Synthetic Mooihoekite,  $\text{Cu}_9\text{Fe}_9\text{S}_{16}$ . (Submitted to Acta Crystallographica), by S. R. Hall and J. F. Rowland, January 25, 1973.
- Some Aspects of the Geochemistry of Platinum-Group Elements. (Submitted to Geol. Soc. South Africa), by L. J. Cabri, March 22, 1973.
- The On-Stream Analysis of Hematite Ore Fractions Using Radioisotopes. (Submitted to X-Ray Spectrometry), by D. J. Reed, J. L. Dalton and A. H. Gillieson, March 8, 1973.
- On the Mechanism of the Adsorption of Trace Copper by Bentonite. (Submitted to Clay and Clay Minerals), by H. F. Steger, April 5, 1973.
- The Crystal Structure of Argentinian Pentlandite  $(\text{Fe},\text{Ni})_8\text{AgS}_8$ . (Submitted to The Canadian Mineralogist), by S. R. Hall and J. M. Stewart, April 16, 1973.
- Some Characteristics of the Silver Deposits in the Guanajuato Mining District, Mexico. (Submitted to the Journal of Economic Geology), by W. Petruk, May 7, 1973.
- A Refinement of the Structure of Cubanite  $\text{CuFe}_2\text{S}_3$ . (Submitted to Zeit. Krist.), by J. T. Szymanski, May 10, 1973.
- X-Ray Tube Versus Radioisotope as an Excitation Source for X-Ray Fluorescence Analysis. (Presented at the Instrument Society of America, Mining & Metallurgical Group Symposium, June 11-13, 1973, Toronto, Ontario), by A. H. Gillieson, May 10, 1973.
- Slurry Density Measurements by Gamma-Ray Attenuation. (Presented at a Seminar on Computer Control of Orientation, Arranged by Noranda Research for the Anaconda Group, Montreal, May 24, 1973; and published in Noranda Research Proceedings), by J. L. Dalton, May 23, 1973.
- The Crystal Structure of High-Temperature  $\text{CuFe}_2\text{S}_3$ . (Submitted to Zeitschrift für Kristallographie), by J. T. Szymanski, May 28, 1973.
- The Crystal Structure of Haycockite,  $\text{Cu}_4\text{Fe}_5\text{S}_8$ . (Presented at the Summer Meeting of the Am. Cryst. Ass'n. at Storrs, Connecticut, June 17-22, 1973), by J. F. Rowland and S. R. Hall, June 1, 1973. (Abstract).
- The Crystal Structure of Argentinian Pentlandite,  $(\text{Fe},\text{Ni})_8\text{AgS}_8$ . (Presented at the Summer Meeting of the Am. Cryst. Ass'n., at Storrs, Connecticut, June 17-22, 1973), by S. R. Hall and J. M. Stewart (Abstract).
- Standard Reference Materials: Their Production and Use. (Presented at the 22nd Annual Denver X-Ray Conference and the Community Bureau of Standards, (ISPRA, Italy), by A. H. Gillieson, June 20, 1973.
- Temagamite, a New Palladium-Mercury Telluride from the Temagami Copper Deposit, Ontario, Canada. (Submitted to The Canadian Mineralogist), by L. J. Cabri, J. H. G. Laflamme and J. M. Stewart, June 26, 1973.
- Activities of the Ores Task Force of the Canadian Standards Reference Materials Project. (Submitted to the Northern Miner), by G. H. Faye, September 6, 1973.
- Platinum Deposits and Mines of South Africa. Book Review - P. A. Wagner, 338 p. C. Struik (Pty). Capetown, 1973, Price R12.50. (Submitted to Geolog. Newsletter of the Geological Association of Canada), by L. J. Cabri, July 17, 1973.

Automatic Timing of the Spectrophotometric Iodometric Titration by Leco Sulfur Determinator. (Submitted to Analytical Chemistry), by B. Nebesar and J. V. Krzyzewski, September 17, 1973.

Precision of Compression Test for Iron Ore Pellets. (Presented at CAC/ISO/TC-102/SC-3 Meeting held in Sept Iles, Quebec, October 2, 1973), by R. Sutarno, September 19, 1973).

Growth of Synthetic Mineral Crystals. (Submitted to the Northern Miner), by L. G. Ripley and A. H. Webster, September 19, 1973.

The Use and Importance of the Electron Microprobe in the Mining Industry. (Submitted to the Northern Miner) by D. C. Harris, September 21, 1973.

A Complex Bismuthian Palladium Telluride Intergrowth from the Stillwater Area, Montana. (Submitted to Economic Geology), by L. J. Cabri and K. M. Pickwick, September 24, 1973.

Ruthenarsenite and Iridarsenite, Two New Minerals from the Territory of Papua and New Guinea and Associated Irarsite, Laurite and Cubic Iron-Bearing Platinum. (Submitted to The Canadian Mineralogist), by D. C. Harris, September 28, 1973.

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- IR 73-15 Evaluation of Finely Divided Industrial Wastes for Use as Pozzolans in Concrete, by G. G. Carette.
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