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A BIBLIOGRAPHY OF REPORTS ISSUED BY THE URANIUM RAW MATERIALS GROUP AT OAK RIDGE NATIONAL LABORATORY

By

K. B. Brown

OAK RIDGE NATIONAL LABORATORY
OPERATED BY
CARBIDE AND CARBON CHEMICALS COMPANY
A DIVISION OF UNION CARBIDE AND CARBON CORPORATION
OAK RIDGE, TENNESSEE

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A BIBLIOGRAPHY OF REPORTS ISSUED BY THE URANIUM RAW MATERIALS GROUP AT OAK RIDGE NATIONAL LABORATORY

K. B. Brown

January 14, 1952

URANIUM CHEMISTRY OF RAW MATERIALS SECTION
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OAK RIDGE NATIONAL LABORATORY

Operated by
CARBIDE AND CARBON CHEMICALS COMPANY
A DIVISION OF UNION CARBIDE AND CARBON CORPORATION

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ABSTRACT

This report includes the titles and abstracts of topical reports along with a list of current projects on uranium raw materials. Progress Reports are listed in an Appendix.

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INTRODUCTION

This document gives a brief description of the current uranium raw materials projects at Oak Ridge National Laboratory, and includes a list of the titles and abstracts of reports issued by the Uranium Raw Materials Section since its inception in late 1947.

Presentation of this information is being made for two reasons: (1) we have received separate requests for information of this type from several investigators throughout the country, and (2) we have come to recognize the helpfulness of reports of this nature after receiving and making use of similar reports from Massachusetts Institute of Technology (MITG-270) and the United States Geological Survey (Trace Elements Investigation Reports 200 and 201).

Additional copies of the reports listed below are not available at Oak Ridge National Laboratory. Most of the documents are classified "Secret", and can be obtained by authorized persons through the usual AEC distribution channels. If the report has been declassified and an AECD number has been assigned, copies may be procured from the AEC Technical Information Center, Oak Ridge, Tennessee.

BRIEF HISTORY OF GROUP AT ORNL

Late Fall, 1947

Initial arrangements were made for a program on methods for recovering uranium from Tennessee (Chattanooga) oil shales. At that time the group here was a part of the Chemical Development Department of the Y-12 Plant. The work was conducted under direct contract with the Raw Materials Operations office of the AEC.

January, 1948

Experimental work on oil shale problem was started.

Summer, 1948

The contract with Raw Materials Operations was expanded to include a program on the development of improved or new methods for handling Western carnotite ores.

[redacted]

Summer, 1949

Commitments on contracts with RMO had been fulfilled and the program was revised to include a fair amount of greatly needed basic research on those phases of chemistry related to raw materials activities. The program was no longer conducted under RMO contract, but has been carried out since that time as a part of the AEC Research Division's activities.

Early 1950

The Chemical Development Department of the Y-12 Plant became the Materials Chemistry Division of Oak Ridge National Laboratory.

Summer, 1950

It became apparent that the raw materials program at ORNL was occupied mainly with basic research and included too little applied research. A large part of the previous contact with RMO and the everchanging raw materials picture had been lost, making it difficult to keep the program well aligned with the country's requirements. This situation was remedied through discussions with RMO; the amount of applied effort was increased.

January, 1951

The AEC Research Division and ORNL agreed to increase (approximately double) the size of the effort at this site and to increase the versatility of the group such that it could act as the center of the Research Division's activities in the field of uranium raw materials.

Present

The work at ORNL is expanding with about 40 per cent of the effort devoted to fundamental research (see below) and 60 per cent to applied research problems (see below). Such a blending of fundamental and applied research has been very satisfactory.

METHOD OF REPORTING

Progress Reports

During the period in which the work at Oak Ridge was conducted under direct contract with the Raw Materials Operations Office (late 1947 to late 1949), progress reports on the various projects were submitted each month.

Since January, 1950, reports of progress have been made every three months as a part of the Quarterly Progress Report for the Materials Chemistry Division of Oak Ridge National Laboratory. This report, however does not receive wide distribution among those people most interested in raw materials work. Consequently, starting with the third quarter of 1951, a separate quarterly progress report has been issued by the Uranium Raw Materials Section; and this report has been given the standard (Metallurgy - Raw Materials) distribution (for example, see Y-823).

A list of all progress reports issued to date is given in the Appendix.

Topical Reports

Topical or summary type reports of work on individual research problems are issued after the experimental work and interpretation of results have reached such a point that a report of this nature seems indicated.

A list of titles and abstracts for all topical reports and memoranda is given directly below. The letter in parentheses after the title is the key to the document's classification. Secret classification is represented by (S), Confidential by (C), Declassified by (D), and Official Use Only by (OUO).

LIST OF TOPICAL REPORTS

Shale

Y-261, "Proposed Program for Precipitation Studies on Shale Leach Solutions," W. R. Grimes, 10-21-48 (S)

Abstract. The objective is an economically sound procedure for the recovery in reasonably pure solid form of the uranium in leaches from oil shales. These liquors will contain relatively large quantities of iron and aluminum along with smaller quantities of many other ions.

Y-276, "Topical Report on the Recovery of Uranium from Oil Shale, Nov. 1, 1947 - Nov. 1, 1948," K. B. Brown, V. L. Saine, 11-9-48 (S)

Abstract. The subjects reported include: description of the shale samples, leaching of raw shale, roasting and leaching of roasted shale, and some special treatments.

Y-386, "Oil Shale Conference at Y-12, January 12, 1949," K. B. Brown, 4-25-49 (S)

Abstract. The subjects discussed included geology of the shale and sampling methods, pretreatment and leaching, precipitation of uranium from leach liquors, and possible byproducts, including fuels.

Y-564, "Recovery of Uranium from Oil Shales. Part I. Extraction of Uranium from the Shale Gangue," K. B. Brown, J. M. Schmitt, F. J. Hurst, and D. J. Crouse, 3-2-50 (S)

Abstract. A search has been made for practicable methods of obtaining uranium from the very low grade Tennessee (Chattanooga) oil shales. Numerous methods for extracting the uranium from the shale gangue have been studied on a laboratory scale. The two most acceptable methods found so far involve either a direct acid leach of the crushed raw shale or a controlled roasting operation followed by a dilute acid leach.

Y-582, "Recovery of Uranium from Oil Shales. Part II. Recovery of Uranium from Acid Leaches of Shale," W. R. Grimes, J. P. Blakely, G. R. Peterson, and G. M. Andranigian, 4-28-50 (S)

Abstract. A search for practicable methods for recovery of uranium from acid leaches of Chattanooga oil shales has been made. A number of methods involving precipitation of the uranium with available inorganic chemicals have been tested on a small laboratory scale. Precipitation of a major fraction of the uranium present in the leach solutions may be accomplished with any of a number of reagents; the poor selectivity of the reagents and the high ratio of extraneous ions to uranium, however, result in copious precipitates of which only a small fraction is uranium. The best of the processes studied consists in precipitation of a uranous phosphate from solutions of low pH with or without added "carrier" material.

Y-B30-61, "Some Current Opinions Regarding Oil Shale as a Source of Uranium," K. B. Brown, 5-3-51 (C)

Abstract. The type of project needed for guiding and conducting possible future investigations is discussed in view of the magnitude of the problem and the status of existing process proposals.

Y-B30-63, "Suggestions Concerning a Research Program on Oil Shales," K. B. Brown, 7-2-51 (S)

Abstract. An amplification in specific details of the discussion given in Y-B30-61, under the headings of Administration, Investigations of Existing Process Proposals, and Further Investigations.

Western Ores

AECD-3241 (Y-499), "Studies of Recovery Processes for Western Uranium-Bearing Ores. Part I. A Critical Examination of the Salt-Roast, Acid-Leach Process for Western Uranium Ores. Part II. Direct Acid Leaching of Western Uranium Ores," V. L. Saine and K. B. Brown, 10-28-49.

Abstract. Part I. The reactions of various carnotite and roscoelite ores to the salt-roast, acid-leach process have been considered from the standpoint of uranium and vanadium recovery, HCl production, and acid consumption. The factor imposing the major

limitation on the process is the concentration of CaO which may be tolerated in the feed. Part II. Most of the uranium and variable fractions of the vanadium were extracted by dilute acid leaches from the carnotite and roscoelite ores available for testing at this laboratory. Acid consumption depended on total bases in the ore, especially calcite. The effects of acid concentration, temperature, time, and ore particle size were examined.

AECD-3238 (Y-500), "Studies of Recovery Processes for Western Uranium-Bearing Ores. Part III. The Recovery of Uranium and Vanadium from Acid Leach Liquors of Carnotite Ores," C. F. Coleman, 12-8-49 (D)

Abstract. Tests are reported on hydrolytic precipitation of uranyl arsenate, and vanadate; uranium peroxide; uranous fluoride, oxalate, and p-toluenesulfinate; and ferrous, ferric, and lead vanadates.

Y-501, "Studies of Recovery Processes for Western Uranium-Bearing Ores. Part IV. Uranous Phosphate-Vanadic Phosphate Precipitation Process," W. F. Arendale and C. F. Coleman, 11-25-49 (S)

Abstract. A process, including a recommended flowsheet, is described for the recovery of uranium and vanadium from the acid leach liquors obtained in the normal processing of carnotite ores. After reduction with iron, the uranium and vanadium are precipitated separately as phosphates. A carbonate fusion of the uranous phosphate leaves a uranium dioxide product of good purity. Material balances and product analyses are included.

AECD-2846 (Y-502), "Studies of Recovery Processes for Western Uranium-Bearing Ores. Part V. Tests of Specific Leaching of Carnotite Ores," C. F. Coleman, 11-16-49 (D)

Abstract. The results of empirical leaching tests of various reagents on carnotite ores are summarized. No reagent was found sufficiently effective and specific for practical use on low grade ores.

AECD-2867 (Y-503), "Studies of Recovery Processes for Western Uranium-Bearing Ores. Part VI. Precipitation of Vanadium Red Cake," F. G. Seeley, and C. F. Coleman, 11-15-49 (D)

Abstract. An empirical study has been made of the precipitation of vanadium red cake from carbonate solutions. Best precipitation was obtained at pH 2.0-2.5. The rate of precipitation was increased by increase of the initial vanadium concentration, or of the sodium chloride or sulfate concentration. Phosphate interferred with the precipitations. The history of the vanadium was important.

AECD-2849 (Y-525), "Studies of Recovery Processes for Western Uranium-Bearing Ores. Part VII. Wet Concentration," D. J. Crouse and K. B. Brown, 12-29-49 (D)

Abstract. Studies have been made of the susceptibility of certain carnotite ores to wet concentration techniques. By scrubbing for long periods, over 90% of the uranium and vanadium can be obtained in the slime concentrates. With brief scrubbing, about 75% of the values are obtained. The slimes were found to be amenable to the usual mill processes for carnotite ores.

Y-571, "Studies of Recovery Processes for Western Uranium-Bearing Ores. Part VIII. Examination of Certain Aspects of the 'Carbonate Processes' as Used at Monticello, Utah," R. S. Lowrie and K. B. Brown, 3-15-50 (OUO)

Abstract. The following topics are discussed: (1) the maximum build-up of uranium in the recycling carbonate leach liquors of both raw and salt-roasted ore, (2) solubilities of certain uranyl vanadates in sodium carbonate solutions, (3) solubility of sodium uranyl tricarbonate in sodium carbonate solutions, (4) analyses for carbonate in the mill liquor, and (5) carbonate consumption during leaching. Some information is also presented on the organic content of the mill liquors, the filtering and settling of raw leach slurries, and the recycle of effluent liquors from the "yellow-cake" precipitation.

AECD-3223 (Y-663), "Studies of Recovery Processes for Western Uranium-Bearing Ores. Part IX. Precipitation of Yellow Cake and of Low Level Vanadium," Emily L. Leyshon and C. F. Coleman, 12-14-50 (D)

Abstract. The precipitation of yellow cake, a sodium uranyl vanadate, has been examined for several types of carbonate liquors. Optimum conditions are given for the precipitation, with suggestions for process control. Several vanadium precipitations have been examined more briefly.

Y-747, "Studies of Recovery Processes for Western Uranium-Bearing Ores. Part X. Recovery of Uranium from a Marysvale Ore by Sulfuric Acid Leach and Uranous Phosphate Precipitation, Preliminary Report," D. J. Crouse, F. G. Seeley, C. F. Coleman, 7-11-51 (S)

Abstract. A complete process for the recovery of uranium from ore from the Marysvale district is presented on a preliminary basis. Steps outlined for this process include leaching by sulfuric acid, followed by precipitation of the uranium as uranous phosphate. Results of leaching tests with other agents are included.

Y-826, "Studies of Recovery Processes for Western Uranium-Bearing Ores. Part XI. The Recovery of Uranium and Vanadium from High Lime Carnotite Ores," K. B. Brown, F. J. Hurst, and J. M. Schmitt, To be Issued January, 1952, (S)

Abstract. Several methods for recovering uranium and vanadium from high lime carnotite ores are proposed. These different methods have included (1) direct leaching with H_2SO_4 or H_2SO_4-Na_2SiF_6 solutions; (2) treatment of the ores with H_2SO_4 to "fix" the calcium as $CaSO_4$, followed by roasting with NaCl in the normal manner; (3) roasting with reagents such as $NaHSO_4$ or Na_2SiF_6 which will also fix the calcium as $CaSO_4$ or CaF_2 and thus prevent interference with the production of water-soluble sodium vanadate, (4) removal of the calcite by flotation so that the ore, essentially, is converted to a low lime material and can be handled accordingly; and (5) roasting the ores with small amounts of NaCl or Na_2SiF_6 at low temperatures to render the vanadium more available to a subsequent acid leach.

In most instances the extractions of uranium and vanadium from the ore gangue have been quite satisfactory. Processing data for the various methods have not been obtained in detail, but it is estimated that the recovery costs will be somewhat higher for the high lime ores than for the low lime sources. The operating costs for each method would depend to a great extent upon local conditions.

Basic Studies and Other Information of General Interest

Y-485, "Supplemental Research Program," G. H. Clewett 9-15-49, (S)

Abstract. Description and discussion of the research projects, both fundamental and applied, which are now being investigated or are anticipated for the near future.

Y-622, "Uranium Chemistry of Raw Materials," K. B. Brown and C. F. Coleman, 7-6-50 (S)

Abstract. A general discussion of current studies on the uranium chemistry of raw materials is presented as well as a brief description of previous work on some of the raw material processing problems.

Y-664, "Solubility of Uranous p-Toluenesulfinate and Related Compounds," W. F. Arendale and C. F. Coleman, 10-26-50 (C)

Abstract. A series of aromatic sulfinic acids was prepared and purified. The solubilities of zirconium, hafnium, thorium, uranous, and ferric p-toluenesulfinates and of other uranous sulfinates were determined, with emphasis on the thorium and uranium compounds. A discussion of the structure of the aromatic sulfinate ion is included.

Y-673, "Studies in the Carbonate-Uranium System. Part I. Investigations in the Four Component System UO_3-Na_2O-CO_2-H_2O," C. A. Blake, R. S. Lowrie, K. B. Brown, D. G. Hill, 12-27-50 (D)

Abstract. Numerous solubility studies in the UO_3, Na_2O, CO_2, H_2O system have been made. This system is characterized by a narrow region of solubility and a deep solubility well. Solutions containing greater than 320 grams of uranium per liter have been obtained. A cross cut of the important solubility regions is given by the Na_2CO_3, UO_2CO_3, H_2O, plane.

AECD-3229 (Y-678), "Studies in the Carbonate-Uranium System. Part II. The Solubility of Sodium Uranyl Tricarbonate in Solutions of Certain Sodium Salts," K. B. Brown and J. M. Schmitt, 10-20-50 (D)

Abstract. Determinations have been made of the solubility of sodium uranyl tricarbonate in water and in solutions of sodium carbonate, sodium sulfate, sodium chloride and sodium perchlorate. The solubility is presented in its relation to the molarity of the co-solute and the solubility product is presented in its relation to the total ionic strength. The data are also considered as to their bearing on plant processes such as those employed in the carnotite mill at Monticello, Utah.

Y-794, "Studies in the Carbonate-Uranium System. Part III. Spectrophotometric Investigation of the Carbonate-Uranyl Complexes," C. A. Blake, R. S. Lowrie, K. B. Brown, D. G. Hill, 10-9-51 (S)

Abstract. Additional evidence for the existence in solution of the uranyl tricarbonate ion, $UO_2(CO_3)_3^{-4}$, has been obtained by continuous variation spectrophotometric methods. Evidence has also been obtained for the presence in sodium carbonate solutions of two additional complex ions having carbonate to uranium combining ratios of 0.5 and 2.0. Though not uniquely proven, the ionic compositions appear to be $UO_2(CO_3)^{-2}$, dicarbonate ion, and $U_2O_5OHCO_3^-$, semicarbonate ion. The stability of these ions in salt solutions and the effect of hydrogen ion concentration has been studied.

Concentrations of each of these ions in various solutions have been estimated by a method which involves the measurement of the pressure of CO_2 over these solutions and subsequent calculation of the amount of uncomplexed carbonate in solution.

Using these data, approximations have been made of the extent of the dissociation of the tricarbonate ion and the dicarbonate ion according to the following mechanisms:

$$UO_2(CO_3)_3^{-4} \overset{K_3}{\rightleftharpoons} UO_2(CO_3)_2^{-2} + CO_3^{-2};$$

$$K_3 = 4.5 \times 10^{-7}$$

$$2UO_2(CO_3)_2^{-2} + 2H_2O \overset{K_2}{\rightleftharpoons} U_2O_5OHCO_3^- + 3HCO_3;$$

$$K_2 = 8.4 \times 10^{-8}$$

AECD-3212 (Y-771), "Spectrophotometric Investigation of the Uranyl Fluoride Complexes," C. A. Blake, R. S. Lowrie, K. B. Brown, 5-24-51 (D)

Abstract. The absorption spectra have been studied at pH levels of 0.5, 1.0, 2.0, 3.0, and 6.0 for uranyl nitrate, sodium fluoride solutions having fluoride to uranium mole ratios ranging from 0 to 9.

Evidence is presented for the existence of three uranyl fluoride complexes, UO_2F^+, UO_2F_2, and $UO_2F_4^{-2}$.

Approximate dissociation constants are calculated according to the equations:

$$UO_2F^+ = UO_2^{+2} + F^-$$

$$\text{and } UO_2F_4^{-2} = UO_2^{+2} + 4F^-$$

Y-816, "Topical Report on Anion Exchange Studies, E. V. Spivey, E. L. Leyshon, F. J. Hurst, D. J. Crouse, and C. F. Coleman, 11-13-51 (S)

Abstract. The various ion exchange investigations being carried on in this laboratory are presented, with the results obtained to date. Topics include description and capacity measurements of several resins, simple exchange equilibrium coefficients, and sorption of uranium and some other substances from simple solutions and from process liquors. The competition of various anions with uranium sorption was measured. The evidence obtained for formulation of some of the anionic uranium complexes is discussed.

Y-B30-59, "Memorandum Review of Information Pertinent to a Research Program on Uranium Raw Materials," K. B. Brown, 1-26-51 (S)

Abstract. Estimates of the importance of various domestic sources of uranium are given along with discussions of the experimental investigation required for the development of these sources. The role of ORNL in the raw materials research program is suggested.

CURRENT PROJECTS

Applied

1. Studies are being made of methods for extracting and recovering the uranium and byproducts in Bartow clay.

2. A rather extensive amount of work on the development of processes for handling various types of Western ores has been conducted in the past,and this program is being continued in a more limited manner. Processes for handling high lime carnotite ores and Marysvale type ores are currently being studied.

3. The possibilities for recovering uranium from lignites are being considered and a small laboratory investigation of this problem has been started.

4. Recovery of uranium from oil-bearing shales has not received active attention at this laboratory for some time. Work on certain aspects of this problem may be conducted at intervals if time permits.

Basic

1. A fairly complete characterization is being made of solutions containing phosphate and uranium. This program includes solubility studies, identification of complex ionic species, and where possible, the determination of the stability of the complex ions. Work thus far has been conducted only with sexavalent uranium. The uranous ion will be studied later.

2. Investigations are being made of methods for separating uranium and thorium from solutions, containing various other metallic contaminants, using organic reagents which will form extractable complexes or insoluble precipitates. Extractions from solutions containing appreciable quantities of sulfate and/or phosphate are of particular interest.

3. Studies are being made of the reduction of uranium by sodium hydrosulfite in sodium carbonate solutions. This work may be extended later to include more general studies of sulfite-uranium chemistry.

4. Previous studies of the Na_2O-UO_3-CO_2-H_2O system at ordinary temperatures and pressures have been extended to include measurements at greater temperatures and pressures. Some investigations are also being made in the K_2O-UO_3-CO_2-H_2O system.

5. Continued studies are being made of the separation of uranium from various types of solutions with ion exchange resins.

6. We hope that time will be available for a general program devoted to a study of the chemical properties of uranium minerals. Such a program, we feel, would be of value to the geologist as well as the extractive metallurgist.

APPENDIX

Shales

Y-60, "Progress Report on Special Projects for the Month of October, 1947, G. H. Clewett, 11-18-47 (S)

Y-78, "Progress Report on Special Projects for the Month of November, 1947, G. H. Clewett, 12-9-47 (S)

Y-108, "Progress Report on Special Projects for the Month of December, 1947," G. H. Clewett, 1-12-48. (S)

Y-118, "Progress Report on Special Projects for the Month of January, 1948, G. H. Clewett, 2-10-48 (S)

Y-139, "Progress Report on Special Projects for the Month of February, 1948," 3-16-48, G. H. Clewett (S)

Y-145, "Progress Report on Special Projects for the Month of March, 1948," G. H. Clewett, 4-12-48 (S)

Y-163, "Progress Report on Special Projects for the Month of April, 1948," G. H. Clewett, 5-20-48 (S)

Y-176, "Progress Report on Special Projects for the Month of May, 1948," G. H. Clewett, 6-15-48 (S)

Y-197, "Progress Report on Special Projects for the Month of June, 1948," G. H. Clewett, 7-28-48 (S)

Y-216, "Progress Report on Special Projects for the Month of July, 1948, Section III, Recovery of Uranium from Oil Shale," G. H. Clewett, 8-11-48 (S)

Y-235, "Progress Report on Shale Studies, August, 1948," K. B. Brown, W. R. Grimes, C. D. Susano, 9-17-48 (S)

Y-260, "Progress Report on Shale Studies for the Month of September, 1948," K. B. Brown, W. R. Grimes, C. D Susano, 10-15-48.

Y-279, "Progress Report on Shale Studies for the Month of October, 1948," K. B. Brown, W. R. Grimes, C. D. Susano, 11-15-48 (S)

Y-304, "Progress Report on Shale Studies for the Month of November, 1948," K. B. Brown, W. R. Grimes, C. D. Susano, 12-22-48 (S)

Y-310, "Progress Report on Shale Studies for the Month of December, 1948," K. B. Brown, W. R. Grimes, C. D. Susano, 1-6-49 (S)

Y-341, "Progress Report on Shale Studies for the Month of January, 1949," K. B. Brown, W. R. Grimes, C. D. Susano, 2-21-49 (S)

Y-361, "Progress Report on Shale Studies for the Month of February, 1949," K. B. Brown, W. R. Grimes, C. D. Susano, 3-22-49 (S)

Y-379, "Progress Report on Shale Studies for the Month of March, 1949," K. B. Brown, W. R. Grimes, C. D. Susano, 4-15-49 (S)

Y-404, "Progress Report on Shale Studies for the Month of April, 1949," K B. Brown, W. R. Grimes, C. D Susano, 5-26-49.(S)

Y-420, "Progress Report on Shale Studies for the Month of May, 1949," K. B. Brown, W. R. Grimes, C. D. Susano, 6-15-49 (S)

Y-446, "Progress Report on Shale Studies for the Month of June, 1949," K. B. Brown, W. R. Grimes, C. D. Susano, 7-20-49 (S)

Y-459, "Progress Report on Shale Studies for the Month of July, 1949," K. B. Brown, 8-15-49 (S)

Western Ores

Y-211, "Progress Report on Special Projects for the Month of July, 1948, Section II, The Recovery of Uranium from Carnotite Ores," G. H. Clewett, 8-9-48 (C)

Y-229, "Progress Report on Carnotite Studies, August, 1948," K. B Brown, C. F. Coleman, W. R. Grimes and C. D. Susano, 9-8-48 (S)

Y-256, "Progress Report on Carnotite Studies, September, 1948," K. B. Brown, C. F. Coleman, W. R. Grimes, and C. D. Susano, 10-11-48 (S)

Y-277, "Progress Report on Carnotite Studies," October, 1948," K. B. Brown, C. F. Coleman, W. R. Grimes, and C. D Susano, 11-10-48 (S)

Y-294, "Progress Report on Carnotite Studies, November, 1948," K. B. Brown, C. F. Coleman, W. R. Grimes, and C. D. Susano, 12-10-48 (S)

Y-312, "Progress Report on Carnotite Studies, December, 1948," K. B. Brown, C. F. Coleman, C. D. Susano, 1-12-49 (S)

Y-335, "Progress Report on Carnotite Studies, January, 1949," K. B. Brown, C. F. Coleman, C. D. Susano, 2-10-49 (S)

Y-360, "Progress Report on Carnotite Studies, February, 1949," K. B. Brown, C. F. Coleman, C. D. Susano, 3-15-49 (S)

Y-375, "Progress Report on Carnotite Studies, March, 1949," K. B. Brown, C. F. Coleman, W. R Grimes, C. D. Susano, 4-9-49 (S)

Y-396, "Progress Report on Carnotite Studies: Acid Process, April, 1949," K. B. Brown, C. F. Coleman, C. D. Susano, 5-10-49 (S)

Y-398, "Progress Report on Carnotite Studies: Carbonate Process, April, 1949," K. B. Brown, C. F. Coleman, C. D. Susano, 5-10-49 (D)

Y-415, "Progress Report on Carnotite Studies: Carbonate Process, May, 1949," K. B. Brown, C. F. Coleman, C. D. Susano, 6-10-49 (D)

Y-416, "Progress Report on Carnotite Studies: Acid Process, May, 1949," K. B. Brown, C. F. Coleman, C. D. Susano, 7-19-49 (S)

Y-440, "Progress Report on Carnotite Studies: Acid Process, June, 1949," K. B. Brown, C. F. Coleman, C. D. Susano, 7-19-49 (S)

AECD-2955 (Y-441), "Progress Report on Carnotite Studies: Carbonate Process, June, 1949," K. B. Brown, C. F. Coleman, C. D. Susano, 7-19-49 (D)

Y-458, "Progress Report on Carnotite Studies: Acid Process, July, 1949," K. B. Brown, C. F. Coleman, 8-18-49 (S)

AECD-3140 (Y-460), "Progress Report on Carnotite Studies: Carbonate Process, July, 1949," K. B. Brown, C. F. Coleman, 8-18-49 (D)

AECD-3142 (Y-481), "Progress Report on Carnotite Studies: Carbonate Process, August, 1949," K. B. Brown, C. F. Coleman, and W. R. Grimes, 9-19-49 (D)

Y-482, "Progress Report on Carnotite Studies: Acid Process, August, 1949," C. F. Coleman, 9-16-49 (S)

AECD-3076 (Y-498), "Progress Report on Carnotite Studies: Carbonate Process, September, 1949," K. B. Brown and C. F. Coleman, 10-20-49 (D)

Recent Quarterly Reports

Y-585, "Progress Report Y-12 Chemical Research Division, January 1, 1950 to March 31, 1950," G. H. Clewett, 6-6-50 (S)

Y-635, "Progress Report Materials Chemistry Division, April 1, 1950 to June 30, 1950," G. H. Clewett, 8-25-50 (S)

Y-670, "Progress Report Materials Chemistry Division, July 1, 1950 to September 30, 1950," G. H. Clewett, 11-6-50 (S)

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