RARE-EARTH INFORMATION CENTER NEWS

SUPPORTED BY INSTITUTE FOR ATOMIC RESEARCH

IOWA STATE UNIVERSITY / AMES, IOWA

Volume IV June 1, 1970 No. 2

Emphasis on Magnets—

RE Work at University of Dayton

RARE EARTH RESEARCH GROUP — In the front row from left are David Walsh, Alden Ray, Herbert Mildrum, Helen Rice, Robert Leasure and Charles Shanley. Pictured in the back row from left are Adolf Biermann, Norman Hecht, Andrew Kraus, Joyce Wild, James Tsui and Karl Strnat.

Rare-earth research at the University of Dayton has been concerned mostly with rare earth-transition metal alloys, their physical metallurgy, crystallography, basic magnetic properties and application as permanent magnets. New work deals with the structure of flame-sprayed rare-earth oxide coatings and their compatibility with molten metals.

The Physical Metallurgy Group under Alden Ray has constructed phase diagrams of the rare-earth metals with iron and cobalt and has investigated the crystal structures of the intermediate phases in these systems. The work also is extended to include multi-component alloys because of the intense interest in some of these phases for magnetic uses. Alloys of the types R_2B_7, RB_5 and R_2B_{17} are under study, where R is an individual light lanthanide element or a mixture of several, and B is primarily cobalt with substitutions of other metals, such as iron, copper and manganese. Of primary concern are the factors determining the stability of these phases and the tolerance of the structures for such substitutions. The precipitation and spinodal decompositions which occur in some systems are technologically significant as mechanisms for magnetic hardening.

(Continued on Page 7)

RE's STOP POLLUTION

Rare-earth ions have been found to almost completely remove simple and condensed phosphates in a new approach to wastewater treatment. This significant new use for mixed cerium group rare earths was reported by Recht, Ghassemi and Kleber at the 8th Rare Earth Research Conference.

Present methods of wastewater treatment do not significantly remove phosphorus, which in concentrations greater than 0.01 mg/l leads to massive algae growth and accelerates eutrophication of natural waters.

Phosphorus can now be separated by treating the wastewater with RCl_3, $R_2(SO_4)_3$ or $R(OH)_3$. The insoluble RPO_4 can then be removed by filtration, and the rare earth can be recovered and recycled with losses in the range of 0.1 to 0.5%. Residual phosphate phosphorus and lanthanide concentrations are anticipated to be less than 0.01 mg/1.

If the wastewater from the entire U.S. population were treated using this process, the rare earth requirement would be about 28,000 tons/yr. Preliminary estimates indicate a total cost for phosphate removal by this process to be less than $.10/1000 gal.

This economic method for phosphate removal is a proprietary development of North American Rockwell Corp.

8th Rare Earth Research Conference

The 8th Rare Earth Research Conference was held in Reno, Nevada, April 19-22, 1970. The Conference was well attended with approximately 225 participants (40 from non-U.S. countries) listening to and discussing the 90 papers which were presented during the three-day meeting. A complete listing of the papers appears below.

The keynote address was presented by Dr. Henry Eyring of the University of Utah. In the early portion of his address, he recalled his experiences with some of the early rare-earth pioneers with whom he has had contact during his scientific career. The latter portion of his stimulating talk dealt with his work and ideas on rate processes.

From our discussions with many attendees it was evident this was another highly successful Rare Earth Research Conference – the eighth in a row. Our congratulations go to Tom Henrie and R. E. Lindstrom, their co-workers, and the organizing committee.

The Conference proceedings are available at a cost of $16.00 from:

Dr. T. A. Henrie
Reno Metallurgy Res. Center
U.S. Bureau of Mines
Reno, Nevada 89505 U.S.A.

The Ninth Rare Earth Research Conference is being organized by Dr. Alan F. Clifford, Virginia Polytechnic Institute, Blacksburg, Virginia, and it will be held in October 1971. As more information becomes available it will be announced in RIC News.

KEYNOTE ADDRESS —

Chairman: T. A. HENRIE, U.S. Bureau of Mines

Introductory Address. HENRY EYRING, University of Utah.

SOLID STATE I —

Chairman: K. A. GSCHNEIDNER, JR. — Iowa State University and Ames Institute for Atomic Research

Spin Wave Spectrum for Holmium Metal. (Session Keynote). R. M. NICKLOW, J. C. G. HOUMANN, H. A. MOOK, and M. K. WILKINSON, Oak Ridge National Laboratory.

Permanent Magnet Properties of $PrCo_5$ Alloy Powders. KARL STRNAT and JAMES TSUI, University of Dayton.

SOLID STATE II —

Chairman: W. C. KOEHLER, Oak Ridge National Laboratory

Structural and Magnetic Properties of Intermetallic Compounds in the Ternary System Y-Fe-Co. (Session Keynote). HANS R. KIRCHMAYR, Institut für Experimentalphysik, Ruhr-Universität, Bochum, Germany.

Magnetic Aftereffect and Aging of $Sm(Co, Cu, Fe)_5$ Permanent Magnet Alloys. H. MILDRUM, A. E. RAY, and K. STRNAT, University of Dayton.

Magnetic Structure of $HoFe_2$. J-M MOREAU, C. MICHEL, M. SIMMONS, T. O'KEEFE, and W. J. JAMES, University of Missouri.

Magnetic and Structural Characteristics of the Ternary Intermetallic Systems Containing Lanthanides. BURKE LEON and W. E. WALLACE, University of Pittsburgh.

Magnetic Susceptibility and Nuclear Magnetic Resonance of Some RCu_5 Compounds. K. H. J. BUSCHOW, A. M. van DIEPEN, and H. W. de WIJN, University of Pittsburgh.

Magnetic Properties of Dysprosium Thallium Three. CLAYTON E. OLSEN, GEORGE P. ARNOLD, and NORRIS G. NERESON, University of California, Los Alamos Scientific Laboratory.

Magnetic Properties and Specific Heat of Monochalcogenides of La, Pr, and Tm. E. BUCHER, A. C. GOSSARD, K. ANDRES, J. P. MAITA, and A. S. COOPER, Bell Telephone Laboratories.

Rare Earth Ions in a Hexagonal Field I. E. SEGAL and W. E. WALLACE, University of Pittsburgh.

Magnetic Interactions and Crystalline Field in Equiatomic Rare Earth-Noble Metals Compounds. J. PIERRE, Laboratoire d'Electrostatique et de Physique du Métal, C. N. R. S., Grenoble, France.

CHEMISTRY I —

Chairman: L. EYRING, Arizona State University

Mixed Crystal Phases in the System ThO_2-PrO_x. (Session Keynote). G. BRAUER and B. WILLAREDT, Chemisches Laboratorium d. Universitat Freiburg, Germany.

Fluorosulfides, Sulfobromides, and Sulfoiodides of the Rare Earth Elements. C. DAGRON, J. ETIENNE, J. FLAHAUT, M. JULIEN-POUZOL, P. LARUELLE, N. RYSANEK, N. SAVIGNY, G. SFEZ, F. THEVET, Faculté de Pharmacie, Paris, France.

CHEMISTRY II —

Chairman: T. MOELLER, Arizona State University

Electron Diffraction Studies on Thin Films of Samarium Sesquioxide. (Session Keynote). C. BOULESTEIX, PAUL E. CARO, M. GASGNIER, Miss C. HENRY LA BLANCHETAIS, and B. PARDO, Centre National de la Recherche Scientifique, Laboratoire des Terres Rares, Bellevue, France.

Reactions of the Sesquioxides of Pm, Nd, and Sm With Water. H. T. FULLAM and F. P. ROBERTS, Battelle Memorial Institute, Pacific Northwest Laboratory.

Complexes of the Rare Earth Sesquioxides With Divalent Europium Oxide. EDWARD CATALANO, BETTIE L. SHROYER, and W. O. J. BOO. Lawrence Radiation Laboratory, University of California.

Thermal Analysis of Lanthanide Hydroxide Preparations. R. G. HAIRE, Oak Ridge National Laboratory.

Pseudophase Behavior in the Epsilon and Iota Regions of the Praseodymium Oxide-Oxygen System. RHEAL P. TURCOTTE, MICHAEL S. JENKINS, and LEROY EYRING, Department of Chemistry, Arizona State University.

Thulium Oxide Microsphere Preparation and Characterization. C. J. AMBROSE, Donald W. Douglas Laboratories.

Properties of Thulium Oxide Microspheres Prepared by Sol-Gel Methods, S. R. BUXTON, M. H. LLOYD, and T. E. WILLMARTH, Oak Ridge National Laboratory.

Studies of the Europium-Oxygen-Fluorine and Samarium-Oxygen-Fluorine Systems. R. G. BEDFORD and E. CATALANO, University of California, Lawrence Radiation Laboratory.

The Relative Stabilities of the B and C Forms of Sm_2O_3, Eu_2O_3, and Gd_2O_3. GEORGE C. FITZGIBBON, DANIEL PAVONE, and CHARLES E. HOLLEY, JR., University of California, Los Alamos Scientific Laboratory.

The Systems Bi_2O_3-R_2O_3 (R = Y, Gd). R. K. DATTA and J. P. MEEHAN, Lighting Research Laboratory, General Electric Co.

Phase Transitions in Complex Perovskites of the Type Ba_2LnMoO_6. C. D. BRANDLE and H. STEINFINK, University of Texas.

CHEMISTRY III —

Chairman: D. J. MAC DONALD, U.S. Bureau of Mines

A Comparison of Eluting Agents for the Ion-Exchange Purification of Promethium. (Session Keynote). E. J. WHEELWRIGHT, Battelle Memorial Institute, Pacific Northwest Laboratory.

Infrared and Raman Spectra of Trivalent Lanthanide — Di-(2-Ethylhexyl) Phosphoric Acid Solvent Extraction Organic Equilibrium Phases. ROBERT C. LLOYD and HARRY BOSTIAN, University of Mississippi.

Tricyclopentadienyl Complexes of Promethium, Curium, Berkelium, and Californium: Their Preparation and Identification by Microtechniques. P. G. LAUBEREAU and J. H. BURNS, Oak Ridge National Laboratory.

On the Formation Constants of the Rare-Earth Complex Species. YASUO SUZUKI and MARIKO MIKADO, Radioisotope School, Japan Atomic Energy Research Institute, Tokyo, Japan.

Different Hydrated Forms of the Ethylenediaminetetraacetato Complexes of the Rare Earths. J. LINN MACKEY, DAVID E. GOODNEY, and JAMES R. CAST, Austin College.

Analysis of the Elution System of Rare Earths With Chelating Agent as Eluent. ZENZI HAGIWARA and SUSUMU SAKAGUCHI, Faculty of Engineering, Tohoku University, Sendai, Japan.

Mobilities of Rare Earth Cations by Bromine Redox Electrolysis With Porous Carbon Electrodes. E. I. ONSTOTT, University of California, Los Alamos Scientific Laboratory.

SOLID STATE III —

Chairman: E. F. WESTRUM, JR. University of Michigan

An Electronic Transition in Cerium Hydride. (Session Keynote). G. G. LIBOWITZ, J. G. PACK, D. H. HOWLING, and W. P. BINNIE, Ledgemont Laboratory, Kennecott Copper Corporation.

Electrical Resistivity and Magnetic Susceptibility of Definite Compounds in the Tin-Samarium System. A. PERCHERON, J. L. FERON, and O. GOROCHOV, Centre National de la Recherche Scientifique, Laboratoire des Terres Rares, Bellevue, France.

Pressure-Induced Changes in the Electronic and Lattice Properties of Thulium Monotelluride and Their Significance. A. JAYARAMAN, E. BUCHER, and D. B. MC WHAN, Bell Telephone Laboratories.

Semiconduction in Rare Earth Oxides, C. N. R. RAO and G. V. SUBBA RAO, Indian Institute of Technology, Kanpur, India.

Kondo Effect and the Influence of Crystalline Electric Field on the Electrical Resistivities of the Intermetallic Compounds $CeAl_3$ and $CeAl_2$. V. U. S. RAO, W. SUSKI, R. S. CRAIG, and W. E. WALLACE, University of Pittsburgh.

CHEMISTRY IV —

Chairman: A. F. CLIFFORD, Virginia Polytechnic Institute

Chemistry and Physics of Lower Valence States of Lanthanides in Ionic Crystals. (Session Keynote). FRANCIS K. FONG, Purdue University.

Studies of the Divalent Oxides of the Rare Earths. GREGORY J. McCARTHY, WILLIAM B. WHITE, and RUSTUM ROY, Materials Research Laboratory, Pennsylvania State University.

On the Existence of Divalent Ytterbium in Some Oxide Systems. J. C. ACHARD and O. de POUS, Centre National de la Recherche Scientifique, Laboratoire des Terres Rares, Bellevue, France.

An Investigation of the Eu-Eu_2O_3 System and the Equilibria Between the Europium Oxides and the Eu-Pt System, With Related Studies of the Sm-Sm_2O_3 and the Yb-Yb_2O_3 Systems. R. G. BEDFORD and E. CATALANO, University of California, Lawrence Radiation Laboratory.

A Study of the Binary Systems SmF_2-SmF_3, EuF_2-EuF_3, and YbF_2-YbF_3 and Their Equilibria With Corresponding Ln-Pt Systems. R. G. BEDFORD and E. CATALANO, University of California, Lawrence Radiation Laboratory.

Growth and Properties of Lanthanum Oxysulfide Crystals. L. E. SOBON, K. A. WICKERSHEIM, R. A. BUCHANAN, and R. V. ALVES, Lockheed Palo Alto Research Laboratory.

Vacancy and Charge Ordering in the Th_3P_4 Structure. FORREST L. CARTER and M. O'HARA, U.S. Naval Research Laboratory.

The Ytterbium-Carbon System: Vaporization of $YbC_{1.25+y}$. JOHN M. HASCHKE and HARRY A. EICK, Michigan State University.

Vapor Pressure Measurements in the SmC_2-C and TmC_2-C Systems. ROBERT L. SEIVER and HARRY A. EICK, Michigan State University.

Isotopic Enrichment of the Product of a Lanthanide Neutron Capture Reaction. D. O. CAMPBELL, Oak Ridge National Laboratory.

CHEMISTRY V —

Chairman: R. K. DATTA, Lighting Research Laboratory, General Electric Co.

Predicting the Fermi Surface of Rare Earth Compounds Using Simple Chemical Concepts. (Session Keynote). FORREST L. CARTER, U.S. Naval Research Laboratory.

The Dissociation Energy of Diatomic Cerium and Predicted Stability of Gaseous Intermetallic Cerium Compounds. K. A. GINGERICH and H. C. FINKBEINER, Texas A and M University.

Electron-Transfer Absorption in Some Actinide (III) and Lanthanide (III) Tricyclopentadienides and the Standard II-III Cation Oxidation Potentials. L. J. NUGENT, P. G. LAUBEREAU, G. K. WERNER, and K. L. VANDER SLUIS, Oak Ridge National Laboratory.

Energy Transfer in Rare Earth Activated Systems. R. C. ROOP, Westinghouse Electric Corporation.

The Heat Capacity of Scandium From 6 to 300K. B. C. GERSTEIN, W. A. TAYLOR, W. D. SHICKELL, and F. H. SPEDDING, Ames Laboratory, USAEC, Iowa State University.

Thermal Study of Absolute Ionic Entropies and Crystal Field Splittings in Heavy Rare Earth Trichloro-Hexahydrates. Heat Capacities From 5-300° K. F. H. SPEDDING, D. C. RULF, and B. C. GERSTEIN, Iowa State University.

Distribution 4f et 5d-6s du Gadolinium et de l'Europium dams le Metal et l'Oxyde. C. BONNELLE and R. C. KARNATAK, Laboratoire de Chimie Physique de la Faculte des Sciences de Paris, France.

EPR of Gd^{3+} in Hydrated and Deuterated Rare Earth Double Nitrates and Ethyl Sulphates. H. A. BUCKMASTER, Y. SHING, University of Calgary, Calgary, Alberta, Canada.

A Structural and Thermogravimetric Investigation of the Rare Earth Formates. RHEAL P. TURCOTTE, MICHAEL S. JENKINS, JOHN M. HASCHKE, and LEROY EYRING, Arizona State University.

A New Room-Temperature Phase of Europium (II) — Orthosilicate. G. BUSCH, E. KALDIS, and R. VERREAULT, Laboratorium fur Festkorperphysik, Zurich, Switzerland.

Europium Bromides and Hydrated Bromides. HARRY A. EICK and JOHN M. HASCHKE, Michigan State University.

METALLURGY —

Chairman: C. E. LUNDIN, Denver Research Institute

Phase Diagrams for the Ce-Co, Pr-Co, and Nd-Co Alloy Systems. (Session Keynote). ALDEN E. RAY and GARY I. HOFFER, University of Dayton

A Comparison of Sublimation and Vaporization for Purification of Samarium Metal. J. E. MURPHY, E. MORRICE, and M. M. WONG, Reno Metallurgy Research Center, U.S. Bureau of Mines.

The Proper Handling of Rare Earth Metals and Alloys for Lattice Parameter Studies. F. H. SPEDDING and B. J. BEAUDRY, Ames Laboratory, USAEC, Iowa State University.

Preparation of ^{147}Pm Metal and Determination of the Density and Melting Point. E. J. WHEELWRIGHT, Battelle Memorial Institute, Pacific Northwest Laboratory.

The Prediction of the Rare Earth Compounds With Other Elements by Means of Electronic Computers. E. M. SAVITSKY and V. B. GRIBULJA, Institute of Metallurgy of Banku, Academy of Sciences, USSR, Moscow.

Effect of the Sixth Period Elements on the Melting and Transformation Temperatures of Praseodymium. R. B. GRIFFIN and K. A. GSCHNEIDNER, JR., Ames Laboratory, Iowa State University.

High Pressure Synthesis of New Heavy Rare Earth Carbides. M. C. KRUPKA, N. H. KRIKORIAN, University of California, Los Alamos Scientific Laboratory.

The Reaction of Selected Lanthanide Carbides With Platinum and Iridium. N. H. KRIKORIAN, University of California, Los Alamos Scientific Laboratory.

Correlations Between Systems of Yttrium With the Groups IVB and VB Elements. O. N. CARLSON, O. D. McMASTERS, and F. A. SCHMIDT, Ames Laboratory of U.S. Atomic Energy Commission.

SOLID STATE IV —

Chairman: H. A. EICK, Michigan State University

The Effect of Co^{3+} on the Magnetic Properties of Yttrium Iron Garnet Single Crystals. (Session Keynote). G. WALLEZ, H. MAKRAM, and J. LORIERS, Laboratoire de Recherche sur les Terres Rares, Centre National de la Recherche Scientifique, Bellevue, France.

Magnetic Properties of Transition Metal — Rare Earth Chalcogenide Spinels. LAWRENCE SUCHOW and ALFRED A. ANDO, Newark College of Engineering.

Crystal Field, g-Factor and Magnetic Susceptibility Calculations for Eu^{3+} and Tb^{3+} in the Rare-Earth Oxysulfides. J. J. PEARSON, R. V. ALVES, K. A. WICKERSHEIM, and R. A. BUCHANAN, Lockheed Palo Alto Research Laboratory.

Mössbauer Effect Studies on Eu^{151} in Mixed Oxide Structures. G. W. DULANEY and A. F. CLIFFORD, Virginia Polytechnic Institute.

Optical, Electrical Transport and Dielectric Studies of Rare Earth Perovskites. C. N. R. RAO and G. V. SUBBA RAO, Department of Chemistry, Indian Institute of Technology, Kanpur, India.

X-Ray Study of Coloration Phenomenon in Lanthanum Oxide. STAFFAN A. BERGWALL and ARUN S. NIGAVEKAR, Institute of Physics, University of Uppsala, Uppsala, Sweden.

An Elevated Temperature X-Ray Diffraction and an Electron Microscopy Study of the Transformations to the Samarium-Type Structure in Gadolinium-Cerium Alloys. C. C. KOCH, P. G. MARDON, and C. J. McHARGUE, Oak Ridge National Laboratory.

Vibrational Spectra of the C-Type Rare Earth Oxide Structure. WILLIAM B. WHITE, Materials Research Laboratory, Pennsylvania State University.

Radiative and Radiationless Transitions from $^4F_{5/2}$ State of the Nd^{3+} Ion. S. A. POLLACK, TRW Systems Group.

SOLID STATE V —

Chairman: R. O. ELLIOTT, University of California Los Alamos Scientific Laboratory

Some Optical and Crystallographic Properties of Eu_2SiO_4. (Session Keynote). G. BUSCH and R. VERREAULT, Laboratorium für Festkörperphysik ETH, Zurich, Switzerland.

Crystal Chemistry of the Rare Earth Silicates. J. FELFCHE, Swiss Federal Institute of Technology, Zurich, Switzerland.

Effect of Composition on the Europium Charge-Transfer-Band Absorption in the $(Y, La, Eu)_2O_2S$ System. R. E. SHRADER and P. N. YOCOM, RCA Laboratories, David Sarnoff Research Center.

Zeeman Studies of Eu^{3+} and Tb^{3+} in Rare-Earth Oxysulfide Hosts. R. V. ALVES, J. J. PEARSON, K. A. WICKERSHEIM, and R. A. BUCHANAN, Lockheed Palo Alto Research Laboratory.

Energy Transfer From Y_2O_2S Host to Tb^{3+} and Pr^{3+} at Very Low Concentrations. HAJIME YAMAMOTO, TSUYOSHI KANO, and YOSHIRO OTOMO, Central Research Laboratory, Hitachi, Ltd., Kokubunji, Tokyo, Japan.

Photoluminescence of Rare-Earth Oxides and Orthovanadates Activated by Bi^{3+}. Study of the Energy Transfer Processes. G. BOULON and F. GAUME-MAHN, Faculté des Sciences, Laboratoire de Spectroscopie et Luminescence, Villeurbanne, France.

Fluorescence Spectrum of Eu^{3+} Ion in the Site of D_3 Symmetry of $LaAlO_3$ — Selection Rules — Crystal Field Parameters. F. GAUME-MAHN, C. LINARES, J. C. SOUILLAT, Université de Lyon, Laboratoire de Spectroscopie et de Luminescence, Villeurbanne, France.

Trivalent Rare Earths Luminescent Characteristics in Different Inorganic Glass Hosts. R. REISFELD, E. GREENBERG, L. KIRSHENBAUM, and G. MICHAELI, Department of Inorganic and Analytical Chemistry, Hebrew University of Jerusalem, Israel.

Infrared Spectra of Matrix Isolated Lanthanide Trifluorides. R. H. HAUGE, J. W. HASTIE, and J. L. MARGRAVE, Department of Chemistry, Rice University.

Cerium (III) — Sensitized Terbium (III) Luminescence in Thorium-Orthophosphate. R. HEINDL, V. GUÉRIN and J. LORIERS, Centre National de la Recherche Scientifique, Laboratoires de Bellevue, France.

INDUSTRIAL PROCESSES AND GEOCHEMISTRY

Chairman: J. F. NACHMAN, Solar Division of International Harvester Company

Recent Developments in the Applications of the Rare Earth Metals in Nonferrous Metallurgy. (Session Keynote). I. S. HIRSCHHORN, Ronson Metals Corporation.

Rare-Earth Element Distributions in the Apollo 11 and Apollo 12 Lunar Samples. C. C. SCHNETZLER and J. A. PHILPOTTS, NASA-Goddard Space Flight Center.

The Use of a Mixer-Settler to Up-Grade a Rare Earth Mixture for Promethium Purification. J. A. PARTRIDGE, Battelle Memorial Institute, Pacific Northwest Laboratory.

A New Use for Rare Earths. HOWARD L. RECHT, MASOOD GHASSEMI, and EUGENE V. KLEBER, Atomics International, North American Rockwell.

Separation of Neodymium, Samarium, and Gadolinium by Liquid — Liquid Chromatography. J. OSCAR WINGET and R. E. LINDSTROM, Reno Metallurgy Research Center, U.S. Bureau of Mines.

The Use of Organophosphorous Compounds in the Separation of the Rare Earths, R. E. LONG, JR. and T. K. KIM, Sylvania Electric Products, Inc.

Separation of the Heavy Lanthanides From Yttrium. J. R. GUMP, Central Michigan University.

Activation Analysis of Yttrium in Ores. K. G. BROADHEAD and H. H. HEADY, Reno Metallurgy Research Center, U.S. Bureau of Mines.

Buckley Award to Geballe, Matthias

Geballe

Matthias

The American Physical Society's 1970 Oliver E. Buckley Solid State Physics Prize was awarded to Theodore H. Geballe and Bernd T. Matthias for their work in superconductivity. Geballe is professor of applied physics at Stanford University and Matthias is professor of physics at the University of California, San Diego.

The two were cited for "their joint experimental investigations of superconductivity which challenged theoretical understanding and opened up the technology of high-field superconductors." Geballe and Matthias, working together at Bell Telephone Laboratories, have greatly extended the list of known superconductors.

Among the superconductors discovered by the Buckley Prize recipients are some that remain superconducting in high magnetic fields and have high transition temperatures, up to almost 21° K. Some of their work on superconductors includes studies on rare-earth materials.

Ionization Potential Work Aids Theory

In late 1969 two papers were published, independent of one another, on the third ionization potentials of the lanthanide elements. The availability of these values at long last is greeted with great joy, since this will enable scientists to make various theoretical calculations.

The paper by M. M. Faktor and R. Hanks [*J. Inorg. Nucl. Chem.*, 31, 1649-1659 (1969)] was submit-

(Continued on Page 6)

Lawrence Award To Rare Earther

Cobble

James W. Cobble, professor of chemistry at Purdue University, received the U.S. Atomic Energy Commission's Ernest Orlando Lawrence Memorial Award in ceremonies held May 11 at the University of California in Berkeley.

Dr. Cobble was cited for "outstanding contributions to the physical chemistry of aqueous electrolyte solutions and to the chemistry of technetium, the lanthanides, and actinides; for the discovery of ternary fission of ^{238}U, and for his investigations of chemically bound neutrons in LiF at low temperatures." He was one of five scientists honored for their recent meritorious contributions in the field of atomic energy.

The Lawrence Award was established in 1959 to honor the memory of the inventor of the cyclotron and first director of the AEC's radiation laboratory at Berkeley and Livermore, Calif., which now bears his name. The award, made annually to scientists not more than 45 years old who are United States citizens, includes a gold medal, a citation and a cash prize of $5000.

HOT WINE

In a study of various parts of grapevines for absorption of fission product fallout activity, radiocerium was found in the surface or shallow part of the root [*Rev. Roum. Phys.* 14, 287-301 (1969)]. The authors determined that ^{144}Ce had been absorbed through the foliage surface, *but not in the grape.*

Although wine dregs were found to contain relatively large amounts of ^{40}K as an insoluble salt, the quantities of ^{90}Sr and other radioactive substances in the raisin were below the maximum allowable amount set by the International Atomic Energy Agency.

RARE EARTHS IN PERIODIC TABLE

Rare-Earth Elements and Their Position in the Periodic System by D. N. Trifonov is now available as an English translation.

Trifonov divides the development of ideas on the position of the rare-earth elements in the periodic system into five stages. The early chemical and analytical stages deal with the discovery of the rare earths, the confirmation of their trivalency and the discovery of the periodic law. Mendeleev's views on the position of the rare earths as well as Brauner's, Meyer's and a number of others are explored. But it is not until the electronic structure of the lanthanides is determined in the physical stage of development that the position of the rare earths is established. Trifonov explains that even today the position of the 4*f* families remains a problem and requires prolonged and thorough investigations.

This translation, AEC-tr-6875, is available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151, USA, price $3.00, 240 pages.

RARE-EARTH BIBLIOGRAPHY

Bibliography on Rare-Earth Elements (Including Scandium and Yttrium) 1958-1962, K. E. Mironov and L. A. Chernikova, is now available as an English translation. This volume contains references to 3594 journal articles, monographs, collections, and abstracts pertaining to the rare-earth elements, alloys, and compounds which were published from 1958-1962.

The references are grouped under more than 50 subject headings to assist the reader in finding the desired subject matter. Both a subject and an author index are included in this 426 page volume.

The English translation is available as AEC-tr-6981 from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151 U.S.A., price $3.00.

Rare Earths at High Temperature

A number of papers on the chemistry and physics of refractory rare-earth compounds at elevated temperatures appear in *Chemistry of High-Temperature Materials,* N. A. Toropov, ed., Consultants Bureau, New York, 1969 ($25.00). This book is the English translation of the Proceedings of the Second All-Union Conference on the High-Temperature Chemistry of Oxides held in Leningrad, 1965.

The use of rare-earth cations to stabilize a ZrO_2 phase may lead to promising materials for high-temperature technology, according to one of the papers. The use of ZrO_2 has been hindered by volume changes during phase transformations, but the addition of 3-7 mol % heavy RE oxides produces solid solutions which are stable in various gaseous environments and undergo no phase transformations up to 2000° C. Another interesting paper on new materials proposes that RE doped niobates and tantalates could be used as laser materials because of their spectroscopic properties.

A number of papers contain information of interest on rare-earth oxides including electrical properties, polymorphic transformations under vacuum at high temperatures, a direct method for computing lattice sums of distorted and complex cubic lattices, and a superpositional method for computing Madelung constants of defect lattices.

In mixed oxide systems one paper describes the use of statistics and probability theory to establish a dependence between composition and density, melting, and liquidus temperature for the rare-earth oxide-silicate system. Another paper discusses the ionic and electronic conductivity of the ZrO_2-$PrO_{1.83}$ system over a broad composition and temperature range. RE chromites are also discussed in several papers covering the synthesis and physicochemical properties of the chromites and the phase transformations of chromite single crystals.

Rare Earths In the News

DISTRIBUTOR

Royal Sulphuric Acid Works Ketjen, Ltd., Amsterdam, The Netherlands, has been named the exclusive agent in Europe and Israel for Shin-Etsu Chemical Industry Co., Ltd., Japan. Ketjen, Europe's largest manufacturer of petroleum cracking catalysts, plans to begin rare-earth production soon. Ketjen is a member of the Akzo group of companies of The Netherlands.

MERGER

Kerr-McGee and Vulcan Materials have announced plans to merge, bringing together the complementary product lines of the two companies. Kerr-McGee is an integrated oil and gas producer and refiner with interests in chemicals while Vulcan makes chemicals, construction materials and metals.

ACQUISITION

International Chemical and Nuclear Corp. has reached an agreement with Koch-Light Laboratories, Ltd., to acquire the Buckinghamshire, England firm outright. Acquisition of Koch-Light will mark International Chemical's first venture outside the United States. Koch-Light produces research chemicals for sale on the world market.

NEW RE ISOTOPES

Rare-earth isotopes ^{151}Er, ^{156}Yb and ^{157}Yb have been discovered by scientists working with the Oak Ridge isochronous cyclotron. The isotopes were made by bombarding ^{162}Er and ^{156}Dy with a helium-3 beam at 100 MeV. Discoverers of the new rare-earth isotopes were Dr. M. A. Ijaz, Virginia Polytechnic Institute, Blacksburg, Va., and Drs. K. S. Toth and R. L. Hahn, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

LANTHANUM CERAMIC

Lanthanum is a key ingredient in what is claimed to be the first truly transparent ferroelectric ceramic ever produced. The ceramic, made at Sandia Laboratories, Albuquerque, N.M., is said to provide 10 times more contrast than previous ones in black and white image displays, and has a greater color range and lower switching voltages. The ceramic is made by adding 4 wt% or more La to the conventional lead zirconate-lead titanate formulation.

Detection of RE Reactor Poisons

A simple yet extremely sensitive method for determining the "neutron poisons" Gd, Sm, Eu and Dy in reactor materials such as uranium and zirconium has been developed by a team of scientists at the AEC's Ames Laboratory.

Employing quaternary oxide compounds with the empirical formulae $2Li_2O \cdot SrO \cdot UO_2 \cdot WO_3$ and $Na_2O \cdot 2SrO \cdot 2ZrO_2 \cdot WO_3$ as hosts for the rare earths under study, P. D'Silva, E. DeKalb and V. A. Fassel were able to detect and determine ultratrace amounts of these elements in the 5 to 10 part per billion (10^9) range in uranium and zirconium. They made their analyses by using x ray-excited, optical fluorescence techniques. Previous analytical methods required lengthy chemical preconcentration procedures to bring the rare-earth concentration up to the detectability level of other instrumental techniques.

Analytical methods for determining Gd, Sm, Eu and Dy in the range of one part per 10 million down to one part per billion are essential in the development of reactor materials. Because of their exceptionally high thermal-neutron capture cross sections (46000, 5600, 4300 and 950 barns, respectively, for Gd, Sm, Eu and Dy), their presence in reactor materials at levels of even less than part per billion amounts can reduce the thermal neutron economy in nuclear reactors.

Rare Earths in the Sun

For the first time the solar abundances of Er, Tm, and Lu have been determined. N. Grevesse and G. Blanquet used data from a new high-resolution solar spectrum obtained at the International Scientific Station of the Jungfraujoch, Switzerland, to measure the abundances of the rare earths in the sun [*Solar Phys.* 8, 5-17 (1969)].

The results obtained in this study are in general agreement with those of earlier authors. However, in comparing solar and meteoritic abundances the authors found agreement only for Eu, Gd, Dy, Er, and Yb. The solar abundances of La, Ce, Pr, Nd, Sm, Tm, and Lu were greater than the meteoritic values.

The abundances of the rare earths are important in testing the s- and r-processes in nucleosynthesis. Unfortunately, the authors concluded, the solar abundances found in this study were unexplainable on the basis of nucleosynthesis theories.

HIGH-PRESSURE ION EXCHANGE

Adjacent lanthanide elements have been separated in less than one hour on a 100 mg scale using a high-pressure ion exchange method developed by Campbell and Buxton [*Ind. Eng. Chem. Process Design Develop.* 9, 89-94 (1970)].

Mixtures of neodymium and praseodymium and of samarium, europium and gadolinium were successfully separated as long as only a small percentage of the resin was loaded with the lanthanides. The authors studied the effects of flow rate, resin loading, eluent composition, and temperature on the separations.

High pressure is required for reasonable flow rates in the system. Glass columns 50 cm in length are suitable for pressures below 800 p.s.i, while stainless steel columns up to 150 cm in length are used at pressures up to 2500 p.s.i. Dowex 50-X12 resin which had been graded to 20- to 40-micron size was used in most of the experiments. Separation was achieved using solutions of α-hydroxyisobutyric acid as the eluent.

The authors anticipate that scale-up of the procedure will be practical, and that high-pressure ion exchange will be applicable to actinide separations.

Ionization Potential
(Continued from Page 3)
ted for publication slightly less than two months before that by D. A. Johnson [*J. Chem. Soc. A.* **1969**, 1525-1528]. Basically the authors of both papers determined their values of the third ionization potential in the same manner, however, there were a few minor differences in detail.

The two sets of values were derived from the experimental heats of formation of the lanthanide oxides and heats of sublimation of the lanthanide metals; a knowledge of the first and second ionization potentials; and an estimate of the electron affinity of oxygen and the lattice energy of the lanthanide oxide. Faktor and Hanks also used the heats of formation of the lanthanide arsenides to make their estimates of the third ionization potential.

The two sets of values are in good agreement with each other, generally within 0.2 eV. The authors estimate that the uncertainity in their values range from 0.4 to 0.8 eV.

RIC Issues RE Review

RIC has just published *Reviews on Rare Earths. A Compilation of Books, Journal Articles, Reports, Conference Proceedings, and Bibliographies Published from 1946 to 1968* by C. C. Bertrand and K. A. Gschneidner, Jr.

The bibliography is composed of about 500 general and specific reviews which have been placed in sections best classifying their contents. The reviews in each section are grouped according to books, chapters, journal articles and reports, bibliographies and conference proceedings. A subject and an author-editor index are included.

To obtain a copy, order USAEC Report IS-RIC-3 from the Clearinghouse for Federal and Scientific Technical Information, Springfield, Virginia 22151, U.S.A.; the price is $3.00.

Rare-Earth Metals in Steels

The effect of rare-earth additions to steels is explored in a special report, IS-RIC-4, prepared by RIC in a study sponsored by Molybdenum Corporation of America.

Rare-Earth Metals in Steels by Nancy Kippenhan and Karl A. Gschneidner, Jr. discusses the question of rare-earth additions to steels by reviewing the literature published on the subject during the 1960's. The information is presented according to increasing complexity of the steels involved. Data on the effect of rare earths on the various characteristics and properties of steel as well as the effect of individual rare earths can be easily located from tables included at the end of each main section. A discussion and summary of the survey has also been included. The 61 page report contains 88 references.

Copies of this report can be obtained without charge from RIC or from Molybdenum Corporation of America, 280 Park Avenue, New York, N.Y. 10017.

Metallic Chlorides

An unusual example of metal-metal bonding has been reported by D. A. Lokken and J. D. Corbett in a lower gadolinium chloride, $GdCl_{1.58\pm0.06}$ [*J. Am. Chem. Soc.* 92, 1799-1800 (1970)].

The compound was produced by reacting $GdCl_3$ vapor with gadolinium metal at 610° for several days. The unusual feature of the structure is the presence of chains of gadolinium atoms running parallel to the unique axis. The chains are made up of elongated octahedra sharing opposite edges, with the repeat distance being 3.896Å, the *b* dimension. Sheaths of chlorine atoms at distances of 2.71 to 2.83Å separate the chains of gadolinium atoms from each other.

The structure seems to have features of both metallic and ionic (plus covalent) bonding. The distances within the chain are appropriate for metal-metal bonding, while the geometry and chlorine distances are suitable for Gd^{3+}-Cl^- interactions.

GEOCHEMISTRY

Problems of Geochemistry, N. I. Khitarov, ed., is a special jubilee collection of papers by Soviet and non-Soviet scientists in honor of the 70th birthday of A. P. Vinogradov. Originally published in Russian in 1965, the volume is now available as an English translation, TT-68-50450.

The 754-page volume contains papers in the areas of cosmochemistry and creation of the earth, geochemistry of individual elements and isotopes, genesis of rocks and geochemistry, mineralology and geochemistry, geochemistry of radioactive elements, biogeochemistry, geochemistry of the ocean, and problems of regional geochemistry.

The papers dealing with rare earths discuss the similarities in the distribution of rare-earth elements in meteorites and in rocks of the earth's crust, the behavior of the rare-earth elements in the hydrothermal process, the separation of the rare earths in the magmatic process, and the abundances of yttrium and ytterbium in igneous rocks.

This translation, TT-68-50450, may be obtained from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va., 22151, U.S.A.; the price is $3.00.

Makes Grant to RIC

International Energy Company, Midland, Texas, has become the 20th private industrial concern to provide financial support for RIC. The Center derives its support from grants such as the one by International Energy, and from Iowa State University's Institute for Atomic Research.

Reports Booklets Brochures

DAVISON CHEMICAL

Davison Chemical, a division of W. R. Grace & Co., has issued two new brochures dealing with rare earths. One, *Rare Earths and Thorium*, describes the processing of rare-earth chemicals and includes a photographic portrayal of the derivation of various rare-earth and thorium products from monazite sand, plus a three dimensional-style illustration showing the relation of rare earths to other elements in the periodic table. The second brochure describes cerium oxide polishing powders, their history, manufacture and uses. Copies may be obtained by writing Davison Chemical Division, W. R. Grace & Co., 4000 N. Hawthorne St., Chattanooga, Tenn. 37406, USA.

CERAC

Cerac, Inc. has product data sheets available for lanthanum boride, rare-earth borides and cerium oxide. The data sheets include information on properties and applications. To obtain copies write: Cerac, Inc., Box 597, Butler, Wisconsin 53007, USA. You can order data sheets by number; LA-569 (lanthanum boride), REB-965 (rare-earth borides), and CEO-568 (cerium oxide).

Photochromics

Z. J. Kiss (*Physics Today* 23, 42-49, Jan. 1970) has described the present state of the art of photochromic materials. In reading the article it is very evident that rare-earth materials play a leading role.

A photochromic material is one which changes color in a reversible manner under illumination by light. The color change is due to a photo-induced charge transfer between deep lying impurity levels or from lattice defects, or combinations of both. With some photochromic materials it is possible to perform "read", "write" and "erase" operations.

As Kiss points out there are still several problems to be solved, ranging from the need for a better theoretical model to the growth of large high-quality crystals. Utilization of photochromics is possible in optical information storage (especially in conjunction with computers), optical processing and display systems (possibly in a three-dimensional television display).

Plans to Drop RE Stockpile

With Congressional approval the United States Government in Fiscal 1971 will sell 5288 short dry tons (sdt) of its rare-earth stockpile in a move to reduce its present inventory toward the 6500 sdt stockpile objective announced in mid-1969.

As of Dec. 31, 1969 the Government had 13,521 sdt of rare earths on hand – an excess of 7021 sdt over the stockpile objective. Sale of the 5288 sdt will still leave an excess of 1733 sdt over the announced inventory objective. The 5288 sdt excess available for sale in Fiscal 1971 is valued at $1.9 million. In a later move the Office of Emergency Preparedness, which makes stockpile recommendations for the Government, advised that rare earths be dropped from the list of strategic stockpile materials.

Separation Review

A comprehensive review of the separation methods involving rare-earth elements appears in *Modern Methods for the Separation of Rarer Metal Ions*, J. Korkisch (Pergamon Press, New York, 1969).

Cation and anion exchange separations as well as other chromatographic, extraction, and coprecipitation methods are surveyed in this chapter. References are given for effective separations from a number of mediums including alloys, rocks, meteorites, sea water, biological materials, fission products, and environmental samples. The 58-page chapter contains more than 500 references.

RE Work at Dayton
(Continued from Page 1)

The Magnetics Group directed by Karl Strnat continues to work on a new class of permanent magnet materials based on the RCo_5 phases whose industrial development it has pioneered. This exciting work has stimulated industry and government to organize large development efforts which have already resulted in $SmCo_5$ magnets with properties far superior to any commercial magnets, with still better and cheaper magnets in store for the future. (This development has been the subject of several previous items published in the *RIC News*, 1, [3], 4; 1, [4], 7 and 3 [3], 1.

Related systematic studies of basic magnetic properties of rare-earth intermetallics are aimed at a better understanding of the spin order and especially the magnetocrystalline anisotropy, a key property for the magnet application.

Norman Hecht is conducting an evaluation of flame-sprayed coatings of Y_2O_3, La_2O_3, CeO_2, Pr_2O_3 and Nd_2O_3 on refractory metals and ceramics. Deposition techniques, crystal and microstructure of the deposits, the strength of their bond to the substrate and their resistance to corrosion by various molten metals (Fe, Ni, Ti, Co) will be studied. Such coatings are of potential technological importance for crucibles and containers for use in the metallurgical processing of steels and high-strength alloys.

RIC News
Vol. V, No. 2 June 1, 1970
published in
March, June, September and December
by
Rare-Earth Information Center
Institute for Atomic Research
Iowa State University

* * *

Second-Class postage
paid at Ames, Iowa

* * *

Telephone: Area Code 515 294-2272
K. A. Gschneidner, Jr. . . . . Editor
Nancy Kippenhan and W. H. Smith
Staff Writers

Eu Orthosilicate

Two recent publications on preparation and properties of Eu_2SiO_4 have revealed some interesting characteristics of this material. These papers by G. Busch, E. Kaldis, R. Verreault, and J. Felsche and by Kaldis and Verreault appeared in *Mater. Res. Bull.* **5**, 9-18 (1970) and in *J. Less-Common Metals* **20**, 177-189 (1970), respectively.

Eu_2SiO_4 is of interest because it is ferromagnetic (~5°K), transparent and an anisotropic semiconductor. In the first paper the authors state that the room temperature form is monoclinic and that it transforms to an orthorhombic modification at 165°C. This phase transformation is accompanied by a color change, a decrease in the semiconducting energy gap of 0.12 eV, and an anomaly in the dielectric constant.

In the second paper the authors discuss the method of preparing single crystals by a high-temperature chemical transport technique, the stoichiometry, purity and optical properties. The influence of Eu^{+3} ions is also noted in their presentation.

More Bubbles

The Bell Laboratory workers headed by L. G. Van Uitert have reported some more experimental details on the bubble domain devices; *Appl. Phys. Letters,* **16**, 84-85 (1970) and *Mater. Res. Bull.*, **5**, 153-162 (1970). Both of these papers are concerned with the effect of substituting small quantities of Co for iron in rare-earth orthoferrites, $RFeO_3$. The substitution of as little as 5% Co has a marked effect on the magnetocrystalline anisotropy and can reorient the net moment from the *c* axis to the *a* axis.

The bubble domain devices are thin plates about 1 cm (0.4 in.) on an edge and 0.0025 cm (0.001 in.) thick with the easy direction of magnetization normal to the plate. The problem heretofore has been that the bubble diameter has been too large by a factor of four to be useful in these devices. But by the substitution of cobalt this goal has been achieved.

The authors have also discussed the method of preparing the plate-like crystals by a flux growth technique in the *Mater. Res. Bull.* paper.

RARE AIR

The proverbial "breath of fresh air" is becoming rare. A typical sample of urban air was found to contain more than 20 elements including Sc, La, Ce, Sm, Eu, Yb, and Lu [*Anal. Chem.* **42**, 257-265 (1970)].

Atmospheric aerosols were analyzed by neutron activation analysis. and the concentrations observed for the rare earths varied from $2 \times 10^{-3}\ \mu g/m^3$ for Ce to $1 \times 10^{-5}\ \mu g/m^3$ for Lu.

Although the rare earth level was extremely low, one of the most notable results of the study was that the unusually high vanadium concentration of 0.4 to 2.0 $\mu g/m^3$ may constitute a health hazard.

STAMP

The chemical symbol for scandium appears on the 1965 4K Russian stamp commemorating the 20th IUPAC (International Union of Pure and Applied Chemistry) Congress in Moscow. The symbol appears in the spelling of MoScOW.

RIC Display

In recent weeks RIC has been developing a display of rare earths and rare-earth products. The lighted display is located in wall-hung cases in a corridor near the RIC office.

Rare earths on display include oxides, metals, metal products, crystals, ceramic tile, glassware and optical glass, RE-doped light bulbs, industrial chemicals, phosphors and magnets. Display items have been donated by about 12 rare-earth producers and research installations.

We would be happy to receive additional display items from those of you who have rare-earth material available for such purposes. Appropriate credit will be given to each donor.

ATOMIC SPECTRA

"Bibliography on the Analysis of Optical Atomic Spectra," C. E. Moore, U.S. National Bureau of Standards Special Publication 306, includes all references necessary to compile tables of atomic energy levels, classified lines and Zeeman data for rare-earth spectra.

The bibliography has been published in four sections; the references on Sc are in section 1, Y in 2, La in 3, and the lanthanides La through Lu in section 4.

This publication is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, U.S.A.; price for section 1–\$1.00, section 2–\$.60, section 3–\$.50, section 4–\$.55.

Rare-Earth Information Center
Institute for Atomic Research
Iowa State University
Ames, Iowa 50010

Second-Class postage paid at Ames, Iowa.