EMD Uranium (Nuclear Minerals) Committee

EMD Uranium (Nuclear Minerals) Mid-Year Committee Report

Michael D. Campbell, P.G., P.H., Chair

December 12, 2011

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- **Robert Odell, P.G., (Vice-Chair: Industry),** Consultant, Casper, WY
- **Steven N. Sibray, P.G., (Vice-Chair: University),** University of Nebraska, Lincoln, NE
- **Robert W. Gregory, P.G., (Vice-Chair: Government),** Wyoming State Geological Survey, Laramie, WY

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- **Karl S. Osvald, P.G.,** Senior Geologist, U.S. BLM, Casper WY
- **Jerry Spetseris, P.G.,** Consultant, Austin, TX

Committee Activities

During the past 6 months, the Uranium Committee continued to monitor the expansion of the nuclear power industry and associated uranium exploration and development in the U.S. and overseas. New power-plant construction has begun and the country is returning to full confidence in nuclear power as the Fukushima incident is placed in perspective. India, Africa and South America have recently emerged as serious exploration targets with numerous projects offering considerable merit in terms of size, grade, and mineability.

During the period, the Chairman traveled to Columbus, Ohio to make a presentation to members of the Ohio Geological Society on the status of the uranium and nuclear industry in general (More).

Regarding publications, the final draft was reviewed by the Chairman and Michael Wiley (Councilor of the EMD Gulf Coast Region) of the bi-annual update for the *Journal Natural Resources Research* under the leadership of Peter Warrick. This paper will likely be released in early 2012. A link will be posted at the bottom-right column of the EMD Home page (http://emd.aapg.org/index.cfm).

Also, final author editing was completed of the Committee's contribution to the ***AAPG Memoir 101: The History and Path Forward of the Human Species into the Future: Energy Minerals in the Solar System,*** *as* Chapter 9: *Nuclear Power and Associated Environmental Issues in the Transition of Exploration and Mining on Earth to the Development of Off-World Natural Resources in the 21st Century*. This Memoir is now in press and will likely be released during the first or second quarter of 2012. The EMD Annual Report, published in the December issue of the AAPG Bulletin announced the anticipated release dates for this and other EMD publications (p.2128) (more).

This 2011 Mid-Year Report of the Uranium Committee provides information on the current status of the uranium industry via Robert Odell's report on industry activity based on excerpts from his *Rocky Mountain Scout*, a popular source of information on the uranium industry activities in the U.S. and Canada. Thorium activities are also summarized. Finally, the Committee reports on rare-earth activities for the first time, as adopted by the Committee earlier this year. We have added introductory material in this report to form a foundation for the Committee's future reports on rare-earth exploration and mining and associated geopolitical activities. The interest shown by China in lunar exploration and by other countries in off-world exploration for uranium, rare earths, and other commodities continues at this date (more).

STATUS OF U.S. URANIUM INDUSTRY

U.S. Uranium Production as of: 3rd Quarter 2011
(the most recent information available from EIA).

Summary

http://www.I2MAssociates.com/downloads/EIA2010DomesticUraniumProductionReportJuner.pdf

3RD QUARTER 2011

U.S. production of uranium in the third quarter 2011 was 846,624 pounds U_3O_8, down 29 percent from the previous quarter and down 26 percent from the third quarter 2010.

During the third quarter 2011, U.S. uranium was produced at six U.S. uranium facilities.

U.S. URANIUM MILL IN PRODUCTION

1. White Mesa Mill

U.S. URANIUM IN-SITU-LEACH PLANTS IN PRODUCTION

1. Alta Mesa Project
2. Crow Butte Operation
3. Hobson ISR Plant / La Palangana
4. Smith Ranch-Highland Operation
5. Willow Creek Project (Christensen Ranch and Irigaray)

As of September 2011, U.S. uranium concentrate production totaled 3,098,754 pounds U_3O_8. This amount is one-half percent higher than the 3,081,911 pounds produced during the first nine months of 2010.

Vice-Chair Reports:

I. Uranium-Related Industry Activity

By Robert Odell, P.G. (Vice-Chair: Industry), Consultant, Casper, Wy.

Excerpts from *The Rocky Mountain Scout* – Vol. 2011, No. 11
The full November report (Here)

October drilling in the United States totaled 117, and 14 in Canada, for a total of 131 North American drills during the month. Compared to September, Canada drilling lost two rigs while the U.S. gained 13 rigs.

YELLOWCAKE PRICE, as of October 31st 2011, was $52.25, down $.50

UX WEEKLY'S spot price per pound of yellowcake as of October 31, was $ 52.00, down .75 for the month

TRADE TECH'S spot price per pound as of November 4th was $52.25. The long term spot as of October 31st, was $63.00, down $1.00

As of October 31st Dan Burns (DOE) reported U spot market prices at $52.00, down from September.

Vanadium mid-range price is $6.25, also down $.30 from September.

October Management Interest:

CAMECO'S Quarterly Report late August sees most countries with a nuclear program will increase their commitment to nuclear power, including China, France, Russia, South Korea, the United Kingdom, Canada and the United States.

Saudi Arabia plans to build 16 reactors by 2030.

CROSSHAIR EXPLORATION has changed its name to **CROSSHAIR ENERGY,** and has completed its 2011 drilling program in the Sundance formation of SE Shirley Basin, Wyoming.

The Grand Canyon Moratorium, extended for six months from June 20, 2011 on new uranium mining claims in a million-acre buffer zone around the Grand Canyon as Washington, DC awaits the conclusions of a study of potential environmental effects of mining in the area. Denison Mine's CEO Ron Hochstein is frustrated by the U.S. government's move to extend the ban on uranium mining near the Grand Canyon which "will impact development of the EZ mine and impact our production probably within the next 5-10 years." Denison currently produces around 200,000 to 300,000 pounds of U_3O_8 from the Arizona 1 mine in the region and has construction underway at the nearby PINENUT deposit.

Peninsula Energy Limited, June 23, 2011, announced that it entered into an agreement to raise $15 million through a private placement with NuCore Energy LLC. The placement is priced at 50% average price (VWAP) at the Lance projects in Wyoming. Peninsula will appoint Jim Cornell to the Board as Executive Director—Sales and Marketing. Cornell is the founding Director and CEO of NuCore. Peninsula had one drill operating in October.

Tom Pool reported two publications have come to his attention concerning large electrical generation plans by nuclear, through 2030. The RMS will pursue this information for the November issue.

This Month in the News

Volume 2011 Issue 11

Oct 14th - *The Deseret News* reports Areva SA has won a federal license to build a gas centrifuge uranium enrichment plant near Idaho Falls. The company plans to begin construction of the Eagle Rock Enrichment Facility in 2012 with 2014 as a projected completion date: (http://www.deseretnews.com)

Oct 17th - *Marketwire* reported Energy Fuels Inc. had acquired a 20 year mining lease in Utah's Sage Plain District, from privately held Nuclear Energy Corp. for $1,500,702 US dollars.

(http://www.marketwatch.com/story/energy-fuels-announces-acquisition-of-key-uranium-and-vanadium-property-in-utahs-sage-plain-district-2011-10-17?reflink=MW_news_stmp

Oct 19th *The World Nuclear News* reported Uranium Resources Inc's license to mine uranium in the Churchrock area of New Mexico had been renewed. (http://www.world-nuclear-news.org/ENF-URI_mining_licence_reactivated-1910115.html)

Oct 21st *Uranium Investing News* reports that RIO Tinto PLC has offered $572 million to take over Hathor Exploration Ltd, thus escalating a challenge against an earlier hostile offer from Cameco. (www.uraniuminvestingnews.com)

On Oct 25th - Jeremey Figleberg of the *Casper Star Tribune* reported that Ur-Energy has received Wyoming approval for the Lost Creek Mine Site. The permit is the last needed from the state. (www.casperstartribune.com)

On Oct 26th - *The San Francisco Chronicles Bloomberg Business Report* reported that uranium takeovers are offering investors the largest potential payoffs. (www.sfgate.com)

Oct 27th - *The Sacramento Bee* reported that Athabasca Uranium has commenced the diamond drill pro-gram on its Keefe Lake uranium project. (www.sacbee.com)

October 29th - Nancy Lofholm of the *Denver Post* reported Energy Fuels Inc, Pinon Ridge Uranium and Vanadium Mill in western Montrose County had passed another large hurdle when the Environmental Protection Agency approved construction of tailings ponds. A company official also states the recent federal court ruling that will temporarily stop most uranium leasing and mining but won't stymie the mill plans. (www.denverpost.com)

October 31st - *Seeking Alpha* reported uranium stocks jumped as much as 38% in October, although investors remain skeptical of a huge rally. (http://seekingalpha.com/article/303781-uranium-stocks-set-to-implode-or-explode)

Oct 31st - *PR Newswire* announced UEC had entered an agreement to purchase 740,000 acres of permitted land in Coronel Oveida, Paraguay. The deal increases UEC's holdings in the country to 987,000 acres. (http://www.marketwatch.com/story/uranium-energy-corp-acquiring-major-additional-section-of-coronel-oviedo-uranium-district-in-paraguay-2011-10-31-83000

Nov 1st - *Market Watch* reported Crosshair Exploration and Mining Company has changed its name to Crosshair Energy Corp. Crosshair's trading symbols on the Toronto and New York stock exchanges will remain unchanged. (http://www.marketwatch.com/story/crosshair-announces-name-change-to-crosshair-energy-corporation-2011-11-01-831490)

Future competition with Mexico negated with their canceling plans to build as many as 10 new reactors, instead they will focus on gas-fired electricity plants after new natural gas discoveries. For more information see related story in Nov 4, Nuclear Market Review. (http://www.uranium.info)

Nov 4th - *Nuclear Market Review* also reports that Uranium One boosts their Tanzania uranium resources by 42% in a recently updated mineral resource estimate. (http://www.uranium.info)

Regulatory Issues – October 2011

Courtesy of Oscar Paulson

Environmental Protection Agency – 40 CFR Part 61 Subpart W/Impoundments

Radon data collection at the request of the Agency by several licensees was completed on September 30, 2009. The EPA, in spite of industry input to the contrary, continues to state that fluid retention ponds at in-situ uranium recovery facilities will fall under 40 CFR Part 61 Subpart W. This statement was made again by Reid Rosnick of the EPA at a public meeting on September 15, 2010 in Tuba City, Arizona. He also stated at this meeting that he expected a draft rule to be released at the end of 2011.

At a meeting with representatives of the uranium recovery industry on October 29, 2009 in Washington, D.C. he stated that 40 CFR Part 61 Subpart W as it is written, gives the EPA jurisdiction over fluid retention ponds containing 11(e).2 byproduct material fluids. He reiterated that the Agency must review and approve any plans for construction new tailings impoundments, fluid retention ponds and heap leach pads prior to commencement of work. In this latest discussion, heap leach pads were included in addition to fluid retention ponds. He also stated that fluid retention ponds would count against the two (2) operating forty (40) acre impoundment limit in 40 CFR Part 61 Subpart W.

Additional information may be found at:

http://www.epa.gov/radiation/neshaps/subpartw/rulemaking-activity.html

The next conference call is scheduled for Thursday January 5, 2012 at 11:00 a.m. Eastern Time.

The uranium recovery industry as represented by the National Mining Association (NMA) is planning to prepare a technical paper for publication in a peer reviewed journal regarding radon fluxes from fluid retention impoundments.

The Sheep Mountain Alliance (SMA) and Colorado Citizens Against Toxic Waste (CCAT) recently (April 18, 2011) submitted comments to the Environmental Protection Agency (EPA) on 40 CFR Part 61 Subpart W and its application to the proposed Pinon Ridge Mill.

On the conference call of Thursday, July 7, 2011, it was announced that the report on radon from tailings impoundments and fluid retention impoundments should be available for public review at the end of August 2011. This report is being prepared by S. Cohen and Associates. It is not yet available. In the conference call on Thursday, October 6, 2011, Agency staff stated that its release has been delayed because a member of Agency staff assigned to review the report has been ill. It now appears that a proposed rulemaking will be released in either January or February 2012.

The next conference call is scheduled for Thursday January 5, 2012 at 11:00 a.m. Eastern Time. The call in number is 1-866-299-3188. You will be prompted for a conference code, which will be 2023439563. After entering the conference code press the # key and you will then be placed into the conference call.

Updates to Uranium Recovery Guidance by the Nuclear Regulatory Commission (NRC)

The following is the schedule for updating uranium recovery guidance presented by Stephen J. Cohen and Dominick A. Orlando of the Nuclear Regulatory Commission (NRC) in a presentation entitled *Guidance Update and Licensing Logistics* presented at the uranium recovery workshop on Thursday, May 26, 2011 in Denver, Colorado:

In-situ uranium recovery rulemaking (Deferral of Active Regulation of Ground-Water Protection at In Situ Leach Uranium Extraction Facilities) – delayed until the Environmental Protection Agency (EPA) completes the 40 CFR 192 rulemaking.

Regulatory Guide 8.30 - Health Physics Surveys in Uranium Recovery Facilities - delayed

NUREG-6733 - A Baseline Risk-Informed Performance-Based Approach for In Situ Leach Uranium Extraction Licensees - delayed

NUREG-1569 – Standard Review Plan for In Situ Leach Uranium Extraction License Applications - delayed

Regulatory Guide 4.14 – Radiological Effluent and Environmental Monitoring at Uranium Mills - work beginning.

Regulatory Guide 3.51 – Calculational Models for Estimating Radiation Doses to Man from Airborne Radioactive Materials Resulting from Uranium Milling Operations - Complete in Fiscal Year 2012

Regulatory Guide 3.59 – Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations - Complete in Fiscal Year 2012

It has been decided not to revise *Regulatory Guide 3.63 - Onsite Meteorological Measurement Program for Uranium Recovery Facilities -- Data Acquisition and Reporting.*

In a Federal Register notice (Federal Register /Volume 76, Number 185 / Friday, September 23, 2011 /Notices pages 59173 to 59174) the Nuclear Regulatory Commission (NRC) withdrew *Draft Regulatory Guide (DG)-3024 Standard Format and Content of License Applications for Conventional Uranium Mills stating, "…has decided not to revise RG 3.5 at this time. For this reason, DG–3024 will be withdrawn*."

Response to Comments on Regulatory Issues Summary *(RIS) 2009-05 URANIUM RECOVERY POLICY REGARDING:*

1) *THE PROCESS FOR SCHEDULING LICENSING REVIEWS OF APPLICATIONS FOR NEW URANIUM RECOVERY FACILITIES, AND*

2) *THE RESTORATION OF GROUND WATER AT LICENSED URANIUM IN SITU RECOVERY FACILITIES*

The NMA and the WMA submitted comments on this document to the Commission on or about June 2009. No response from the Commission has been received. A NMA conference call to discuss this issue was held on Thursday, December 3, 2009. The WMA has sent a reminder letter to Commission staff regarding these comments.

The regulation (10 CFR Part 40 Appendix A Criterion 5B) referenced in this document may ultimately be revised if the underlying Environmental Protection Agency (EPA) regulation (40 CFR part 192) is revised. 40 CFR part 192 is currently under review by the Agency and potentially may be revised.

This Regulatory Issues Summary (RIS) is impacting the use of the Standard Review Plan for In Situ Leach Uranium Extraction License Applications. NRC Staff has stated that, despite any indications otherwise, applicants should follow NUREG-1569 Standard Review Plan for In Situ Leach Uranium Extraction License Applications exactly as published, presumably with the exception of guidance regarding 10 CFR Part 40, Appendix A, Criterion 5(B)(5) incorporated in the Regulatory Issues Summary (RIS). At the May 25 to 26, 2011 Uranium Recovery Workshop in Denver, Colorado, it was stated that any proposed revisions to 10 CFR Part 40 Appendix A Criterion 5B will not be released until after the Environmental Protection Agency (EPA) has completed its review of 40 CFR Part 192. In addition, any revisions to *NUREG-1569 – Standard*

Review Plan for In Situ Leach Uranium Extraction License Applications will be delayed until completion of the review of 40 CFR Part 192 as well.

Preparation of NUREG document entitled "*Standard Review Plan for Conventional Mill and Heap Leach Uranium Extraction License Applications*."

The NRC has decided to revise some existing Regulatory Guides and NUREGS as well as write new ones. The Commission has contracted with the Southwest Research Institute to prepare a NUREG entitled *Standard Review Plan for Conventional Mill and Heap Leach Uranium Extraction License Applications*. They are seeking input and data from industry. Two of the four current conventional uranium mill licensees are Association members. A conference call on this issue hosted by the NMA involving all of the four conventional mill licensees as well as two (2) companies planning conventional mills was held on Friday, March 26, 2010.

If you have questions, please contact:

Jim Durham
Center for Nuclear Waste Regulatory Analyses
San Antonio, TX 78238
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E-mail: jsdurham@cnwra.swri.edu

The draft table of contents for this document is as follows:
Proposed Activities

Site Characterization

Description and Design of Proposed Facility (including liner design)

Management

Monitoring

Reclamation

Accidents

An internal draft is scheduled for completion by September 30, 2011. It is unclear how the withdrawal of *Draft Regulatory Guide (DG)-3024 Standard Format and Content of License Applications for Conventional Uranium Mills will impact this work.*

Discharge of Pumping Test Water from Pumping Testing Related to Proposed or Operating Uranium Recovery Operations

The Wyoming Mining association (WMA) submitted a letter to the Department of Environmental Quality (DEQ) Water Quality Division (WQD) regarding discharge of pumping test water exceeding 60 pCi/L radium on the ground surface. Currently, such water cannot be discharged but must be either treated and released, evaporated in holding ponds or hauled to a deep disposal well. The Association is arguing that it would be best, due to the low risks involved with such water, to allow it to be discharged on to the ground surface. Members of the uranium recovery industry discussed this issue with Nancy Nuttbrock, the new Land Quality Division (LQD) Administrator, on Wednesday, October 12, 2011.

Legacy Boreholes/Borehole Plugging

The State of Wyoming is delving deeper into the issue of legacy bore holes (old exploration holes drilled in the 1960s and 1970s) in areas now being permitted for in-situ uranium recovery. One critical issue is the interpretation of WS 35-11-404 which states:

35-11-404. Drill holes to be capped, sealed or plugged.

(a) All drill holes sunk in the exploration for locatable or leasable minerals on all lands within the state of Wyoming shall be capped, sealed or plugged in the manner described hereinafter by or on behalf of the discoverer, locator or owner who drilled the hole. Prospecting and exploration drill holes shall include all drill holes except those drilled in conjunction with the expansion of an existing mine operation or wells or holes regulated pursuant to W.S. 30-5-101 through 30-5-204.
And also states:

(iii) "Surface Cap". Each drill hole is to be completely filled to the collar of the hole or securely capped at a minimum depth of two (2) feet below either the original land surface or the collar of the hole, whichever is at the lower elevation. If capped, the cap is to be made of concrete or other material satisfactory for such capping. The hole shall be backfilled above the cap to the original land surface;

The Department is raising issues regarding fall back of plugging material into legacy boreholes as well as potential hydrologic impacts of legacy bore holes on in-situ recovery well fields, specifically the impacts to water-bearing sands above and below the resource-bearing sands.

On Monday, October 17, 2011, the Land Quality Division (LQD) posted proposed revisions to Chapters 8, 9 and 10 of the Non-Coal Rules and Regulations. These proposed revisions address, among other items, plugging of boreholes. The Land Quality Advisory Board will be meeting to discuss the proposed revisions to Chapters 8, 9 and 10 of the Non-Coal Rules and Regulations. The meeting was scheduled to begin at 9:00 a.m. on Monday November 14, 2011 in the Hearing Room at the Oil and Gas Commission Building located at 2211 King Boulevard, Casper, Wyoming.
Additional information may be found at:

http://deq.state.wy.us/lqd/currentevents.asp

State of Wyoming Uranium-Leasing Form

The Office of State Lands and Investments is revising the State's Uranium Lease Form and proposing new leasing rates. The Wyoming Mining Association (WMA) provided a response in the form of a proposed draft lease agreement by the end of July 2011. Additional meetings between members of the uranium recovery industry and Harold Kemp of the Office of State Lands and Investments are planned.

NRC REGULATORY ISSUE SUMMARY 2011-11 REGARDING LONG-TERM SURVEILLANCE CHARGE FOR CONVENTIONAL OR HEAP-LEACH URANIUM RECOVERY FACILITIES LICENSED UNDER 10 CFR PART 40

The Nuclear Regulatory Commission (NRC) has issued a Regulatory Issues Summary (RIS) dated September 29, 2011 entitled *NRC REGULATORY ISSUE SUMMARY 2011-11 REGARDING LONG-TERM SURVEILLANCE CHARGE FOR CONVENTIONAL OR HEAP LEACH URANIUM RECOVERY FACILITIES LICENSED UNDER 10 CFR PART 40.*

This document *"...discusses existing NRC policy regarding the scope and corresponding dollar amount of the LTSC to be paid to the general treasury of the United States, or to an appropriate State agency, prior to the transfer of title to the long-term custodian for long-term care and license termination. It also further clarifies matters discussed in an NRC letter to the U.S. Department of Energy (DOE) dated June 17, 2010, regarding increases in the LTSC (Agency wide Documents Access and Management System (ADAMS) accession number ML100670337)."*

The document may be found in ADAMS under Accession Number: ML111290381.

Policy Regarding Submittal of Amendments for Processing of Equivalent Feed at Licensed Uranium Recovery Facilities

A draft policy entitled *Policy Regarding Submittal of Amendments for Processing of Equivalent Feed at Licensed Uranium Recovery Facilities* has been placed in the Federal Register (Federal Register /Vol. 76, No. 190 / Friday, September 30, 2011 /Notices pages 60941 to 60945). The policy is outlined in the notice. The comment period has been extended. Comments were due by November 14, 2011. Apparently Commission staff is planning to issue a Regulatory Issue Summary (RIS) following receipt and evaluation of comments. This draft document is being pre-pared *"…to inform addressees of the NRC's policy regarding receipt and processing, without a license amendment, of equivalent feed at an NRC and Agreement State-licensed uranium recovery site, either conventional, heap leach, or in situ recovery.*"

Staff Interim Guidance: Evaluations of Uranium Recovery Facility Surveys of Radon and Radon Progeny in Air and Demonstrations of Compliance with 10 CFR 20.1301

A draft of the document entitled Staff Interim Guidance: Evaluations of Uranium Recovery Facility Surveys of Radon and Radon Progeny in Air and Demonstrations of Compliance with 10 CFR 20.1301 is being issued for comment. The document states:

The NRC staff is publishing the present guidance as a draft for public comment. Members of the public, licensees, and other interested parties are encouraged to submit comments. The NRC staff plans to publish a Federal Register Notice to formally notice the opportunity for public comment. The Federal Register Notice will provide a date for expiration of the public comment period; at this time, staff anticipates the public comment period to be 60 days. Interested parties are encouraged to contact the NRC staff (contact listed below) with questions about the comment period or about the technical content of this draft guidance.

NRC Staff Contact:

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Given the above statement and absent a Federal Register notice, comments will probably be due by the beginning of January 2012. The document may be found on ADAMS. The ML number for the document is ML112720481. On Thursday, October 27, 2011, James Webb of the Decommissioning and Uranium Recovery Licensing Directorate informed me that to the best of his knowledge, this draft interim guidance has not been noticed for comment in the Federal register yet.

If you have any questions please contact Duane Schmidt.

Environmental Protection Agency Review and Potential Revision of Health and Environmental Standards for Uranium and Thorium Milling Facilities

The EPA will be reviewing and potentially revising its regulations for uranium and thorium milling to bring them up-to-date. For additional information, see:

http://www.epa.gov/radiation/docs/tenorm/40cfr192-063009-announcement.pdf

The Agency has established a discussion blog regarding the revision of 40 CFR Part 192. It may be found at: http://blog.epa.gov/milltailingblog/

This regulation covers inactive uranium processing sites and includes control of residual radioactive material and remediation of land and buildings. It addresses the management of byproduct materials including uranium processing and thorium processing wastes. It covers specific areas including byproduct materials and uranium processing. It addresses construction of impoundments and incorporates the double liner requirement in 40 CFR Part 264.92, effluent limitations in 40 CFR Part 440 and radiation protection standards in 40 CFR Part 190. It addresses reclamation including remediation of buildings, supplemental standards, alternate concentration limits (ACLs), radon releases following radon barrier emplacement and soil remediation standards (5/15 rule).

On Tuesday, July 27, 2010, Tony Nesky of the Environmental Protection Agency (EPA) sent an e-mail to various stakeholders requesting input on their blog at:
http://blog.epa.gov/milltailingblog/

If you have questions please contact Tony Nesky at: Nesky.Tony@epamail.epa.gov

In the Federal Register Volume 75, Number 226 dated Wednesday, November 24, 2010, the EPA issued a notice entitled Science Advisory Board Staff Office; Request for Nominations of Experts for Review of EPA's Draft Technical Report Pertaining to Uranium and Thorium In-Situ Leach Recovery and Post-Closure Stability Monitoring. This notice requests nominations for technical experts to review and provide advice on the planned draft scientific and technical report on Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40 CFR part 192). The deadline for nominations was December 15, 2010. The NMA submitted a list of nominees on behalf of the uranium recovery industry. Please contact Katie Sweeney of the National Mining Association (NMA) at KSweeney@nma.org if you require a copy of the list.

The draft technical report is available at:

http://www.epa.gov/radiation/docs/tenorm/post-closure-monitoring.pdf

This review will directly impact the Nuclear Regulatory Commission's (NRC's) proposed revision of Appendix A of 10 CFR Part 40. These revisions will be delayed until the review of 40 CFR Part 192 is complete. A nationwide public teleconference regarding the draft technical report was held at 1 p.m. (Eastern) on Tuesday, July 12, 2011. It was followed by a public meeting in Washington, D.C., on Monday to Tuesday July 18 to 19, 2011.

Hematite Stained Sand Channel in the Powder River Basin.

Pine Ridge Ft Union outcrop in the SW Powder River Basin.
R. Sydow photo taken on Casper College geology field trip in September, 2011.

2011-2012 Meeting Calendar

Nov 7th
4th Annual Nuclear New Build Forum
One Whitehall Place
London, UK
http://www.marketforce.eu.com/newbuild

Jan 2012
NEI Fuel Supply Forum
Nuclear Energy Institute W Washington D.C., USA
http://www.nei.org/newsandevents/

Jan 30 EUEC
Phoenix Convention Center
Phoenix Arizona, USA
http://euec.com/index.aspx

Feb 6, 2012
African Mining Indaba 2012
International Investment conference
Cape Town International Convention Centre,
Cape Town South Africa
http://www.miningdaba.com/

April
17th World Nuclear Fuel cycle
NEI/WNA
Helsinki, Finland

http://www.nei.org/newsandevents/

For more information on upcoming events visit http://www.uranium.info

VOLUME 2011 ISSUE 11 STATUS OF THE THORIUM INDUSTRY

Thorium activity

Due to increased demand of carbon-free energy, accelerated growth of global nuclear power is foreseen in future, which has in turn made the sustainable use of fuel resources such as uranium and thorium important. Uranium though is the main-stay of the present generation of Nuclear Power Plants, with the anticipated steep growth in nuclear energy it will be necessary to introduce thorium too as a fuel. Thorium fuel cycle offers several potential advantages over a uranium fuel cycle, including greater abundance, superior physical and nuclear properties of fuel, enhanced proliferation resistance, and reduced plutonium and actinide production. Technically thorium has been well established and it behaves remarkably well in Light Water Reactors, High Temperature Reactors and Liquid Fluoride Thorium Reactors. Recognizing the potential contribution of thorium fuel cycle in nuclear energy, renewed R&D efforts are seen in many Member States.

Geochemically thorium is four times more abundant than uranium on the crust of earth and economical concentrations of thorium are found in a number of countries. Geologically thorium deposits are found in varies setups such as alkaline complexes, pegmatites, carbonatites and heavy mineral sands with wide geographic distribution. Worldwide thorium resources are estimated to total about 6 million tonnes. Major resources of thorium are seen in Australia, Brazil, Canada, India, Norway, South Africa and USA. Thorium exploration is presently ongoing in some countries such as India and USA. The present production of thorium is mainly as a by-product of processing of heavy mineral sand deposits for titanium, zirconium and tin.

II. Uranium-Related University Research Activity

By Steven N. Sibray, P.G., (Vice-Chair: University), University of Nebraska, Lincoln, NE

To be submitted for Annual 2012 Report.

III. Uranium-Related Government Research Activity

By Robert W. Gregory, P.G., (Vice-Chair: Government), Wyoming State Geological Survey, Laramie, WY

To be submitted for Annual 2012 Report.

STATUS OF THE RARE EARTH INDUSTRY

Introduction to Rare Earths

As the initial report by the Committee, we have included below introductory information on rare earths that have been adapted from *Wikipedia*.

As defined by IUPAC, **rare earth elements** or **rare earth metals** are a set of seventeen chemical elements in the periodic table, specifically the fifteen lanthanides plus scandium and yttrium.[2] Scandium and yttrium are considered rare earth elements since they tend to occur in the same ore deposits as the lanthanides and exhibit similar chemical properties.

Despite their name, rare earth elements (with the exception of the radioactive promethium) are relatively plentiful in the Earth's crust, with cerium being the 25th most abundant element at 68 parts per million (similar to copper). However, because of their geochemical properties, rare earth elements are typically dispersed and not often found in concentrated and economically exploitable forms. The few economically exploitable deposits are known as rare earth minerals.[3] It was the very scarcity of these minerals (previously called "earths") that led to the term "rare earth". The first such mineral discovered was gadolinite, a compound of cerium, yttrium, iron, silicon and other elements. This mineral was extracted from a mine in the village of Ytterby in Sweden; many of the rare earth elements bear names derived from this location.

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A table listing the seventeen rare earth elements, their atomic number and symbol, the etymology of their names, and their main usages (see also Lanthanide#Technological_applications) is provided here. Some of the rare earths are named for the scientists who discovered or elucidated their elemental properties, and some for their geographical discovery.

Z	Symbol	Name	Etymology	Selected applications
21	Sc	Scandium	from Latin *Scandia* (Scandinavia), where the first rare earth ore was discovered.	Light aluminium-scandium alloy for aerospace components, additive in Mercury-vapor lamps.[4]
39	Y	Yttrium	for the village of Ytterby, Sweden, where the first rare earth ore was discovered.	Yttrium-aluminum garnet (YAG) laser, yttrium vanadate (YVO4) as host for europium in TV red phosphor YBCO high-temperature superconductors, yttrium iron garnet (YIG) microwave filters.[4]
57	La	Lanthanum	from the Greek "lanthanein", meaning *to be hidden*.	High refractive index glass, flint, hydrogen storage, battery-electrodes, camera lenses, fluid catalytic cracking catalyst for oil refineries
58	Ce	Cerium	for the dwarf planet Ceres.	Chemical oxidizing agent, polishing powder, yellow colors in glass and ceramics, catalyst for self-cleaning ovens, fluid catalytic cracking catalyst for oil refineries, ferrocerium flints for lighters
59	Pr	Praseodymium	from the Greek "prasios", meaning *leek-green*, and "didymos", meaning *twin*.	Rare-earth magnets, lasers, core material for carbon arc lighting, colorant in glasses and enamels, additive in didymium glass used in welding goggles,[4] ferrocerium firesteel (flint) products.
60	Nd	Neodymium	from the Greek "neos", meaning *new*, and "didymos", meaning *twin*.	Rare-earth magnets, lasers, violet colors in glass and ceramics, ceramic capacitors
61	Pm	Promethium	for the Titan Prometheus, who brought fire to mortals.	Nuclear batteries
62	Sm	Samarium	for Vasili Samarsky-Bykhovets, who discovered the rare earth ore samarskite.	Rare-earth magnets, lasers, neutron capture, masers
63	Eu	Europium	for the continent of Europe.	Red and blue phosphors, lasers, mercury-vapor lamps, NMR relaxation agent
64	Gd	Gadolinium	for Johan Gadolin (1760–1852), to honor his investigation of rare earths.	Rare-earth magnets, high refractive index glass or garnets, lasers, X-ray tubes, computer memories, neutron capture, MRI contrast agent, NMR relaxation agent
65	Tb	Terbium	for the village of Ytterby, Sweden.	Green phosphors, lasers, fluorescent lamps
66	Dy	Dysprosium	from the Greek "dysprositos", meaning *hard to get*.	Rare-earth magnets, lasers

Z	Symbol	Name	Etymology	Selected applications
67	Ho	Holmium	for Stockholm (in Latin, "Holmia"), native city of one of its discoverers.	Lasers
68	Er	Erbium	for the village of Ytterby, Sweden.	Lasers, vanadium steel
69	Tm	Thulium	for the mythological northern land of Thule.	Portable X-ray machines
70	Yb	Ytterbium	for the village of Ytterby, Sweden.	Infrared lasers, chemical reducing agent
71	Lu	Lutetium	for Lutetia, the city which later became Paris.	PET Scan detectors, high refractive index glass

ABBREVIATIONS

The following abbreviations are often used:

- RE = rare earth
- REM = rare earth metals
- REE = rare earth elements
- REO = rare earth oxides
- REY = rare earth elements and yttrium
- LREE = light rare earth elements (La-Eu)
- HREE = heavy rare earth elements (Gd-Lu and Y)

DISCOVERY AND EARLY HISTORY

Rare earth elements became known to the world with the discovery of the black mineral "ytterbite" (renamed to gadolinite in 1800) by Lieutenant Carl Axel Arrhenius in 1787, at a quarry in the village of Ytterby, Sweden.[5]

Arrhenius' "ytterbite" reached Johan Gadolin, a Royal Academy of Turku professor, and his analysis yielded an unknown oxide (earth) which he called Ytteria. Anders Gustav Ekeberg isolated beryllium from the gadolinite but failed to recognize other elements which the ore contained. After this discovery in 1794 a mineral from Bastnäs near Riddarhyttan, Sweden, which was believed to be an iron-tungsten mineral, was re-examined by Jöns Jacob Berzelius and Wilhelm Hisinger. In 1803 they obtained a white oxide and called it *ceria*. Martin Heinrich Klaproth independently discovered the same oxide and called it *ochroia*.

Thus by 1803 there were two known rare earth elements, *yttrium* and *cerium*, although it took another 30 years for researchers to determine that other elements were contained in the two ores ceria and ytteria (the similarity of the rare earth metals' chemical properties made their separation difficult).

In 1839 Carl Gustav Mosander, an assistant of Berzelius, separated ceria by heating the nitrate and dissolving the product in nitric acid. He called the oxide of the soluble salt *lanthana*. It took him three more years to separate the lanthana further into *didymia* and pure lanthana. Didymia, although not further separable by Mosander's techniques was a mixture of oxides.

In 1842 Mosander also separated the ytteria into three oxides: pure ytteria, terbia and erbia (all the names are derived from the town name "Ytterby"). The earth giving pink salts he called *terbium*; the one which yielded yellow peroxide he called *erbium*.

So in 1842 the number of rare earth elements had reached six: *yttrium*, *cerium*, *lanthanum*, *didymium*, *erbium* and *terbium*.

Nils Johan Berlin and Marc Delafontaine tried also to separate the crude ytteria and found the same substances that Mosander obtained, but Berlin named (1860) the substance giving pink salts *erbium* and Delafontaine named the substance with the yellow peroxide *terbium*. This confusion led to several false claims of new elements, such as the *mosandrium* of J. Lawrence Smith, or the *philippium* and *decipium* of Delafontaine.

SPECTROSCOPY

There were no further discoveries for 30 years, and the element didymium was listed in the periodic table of elements with a molecular mass of 138. In 1879 Delafontaine used the new physical process of optical-flame spectroscopy, and he found several new spectral lines in didymia. Also in 1879, the new element *samarium* was isolated by Paul Émile Lecoq de Boisbaudran from the mineral samarskite.

The samaria earth was further separated by Lecoq de Boisbaudran in 1886 and a similar result was obtained by Jean Charles Galissard de Marignac by direct isolation from samarskite. They named the element *gadolinium* after Johan Gadolin, and its oxide was named "gadolinia".

Further spectroscopic analysis between 1886 and 1901 of samaria, ytteria, and samarskite by William Crookes, Lecoq de Boisbaudran and Eugène-Anatole Demarçay yielded several new spectroscopic lines that indicated the existence of an unknown element. The fractional crystallization of the oxides then yielded *europium* in 1901.

In 1839 the third source for rare earths became available. This is a mineral similar to gadolinite, *uranotantalum* (now called "samarskite"). This mineral from Miass in the southern Ural Mountains was documented by Gustave Rose. The Russian chemist R. Harmann proposed that a new element he called "ilmenium" should be present in this mineral, but later, Christian Wilhelm Blomstrand, Galissard de Marignac, and Heinrich Rose found only tantalum and niobium (columbium) in it.

The exact number of rare earth elements that existed was highly unclear, and a maximum number of 25 was estimated. The use of X-ray spectra (obtained by X-ray crystallography) by Henry Gwyn Jeffreys Moseley made it possible to assign atomic numbers to the elements. Moseley found that the exact number of lanthanides had to be 15 and that element 61 had yet to be discovered.

Using these facts about atomic numbers from X-ray crystallography, Moseley also showed that *hafnium* (element 72) would not be a rare earth element. Moseley was killed in World War I in 1915, years before hafnium was discovered. Hence, the claim of Georges Urbain that he had discovered element 72 was untrue. Hafnium is an element that lies in the periodic table immediately below zirconium, and hafnium and zirconium are very similar in their chemical and physical properties.

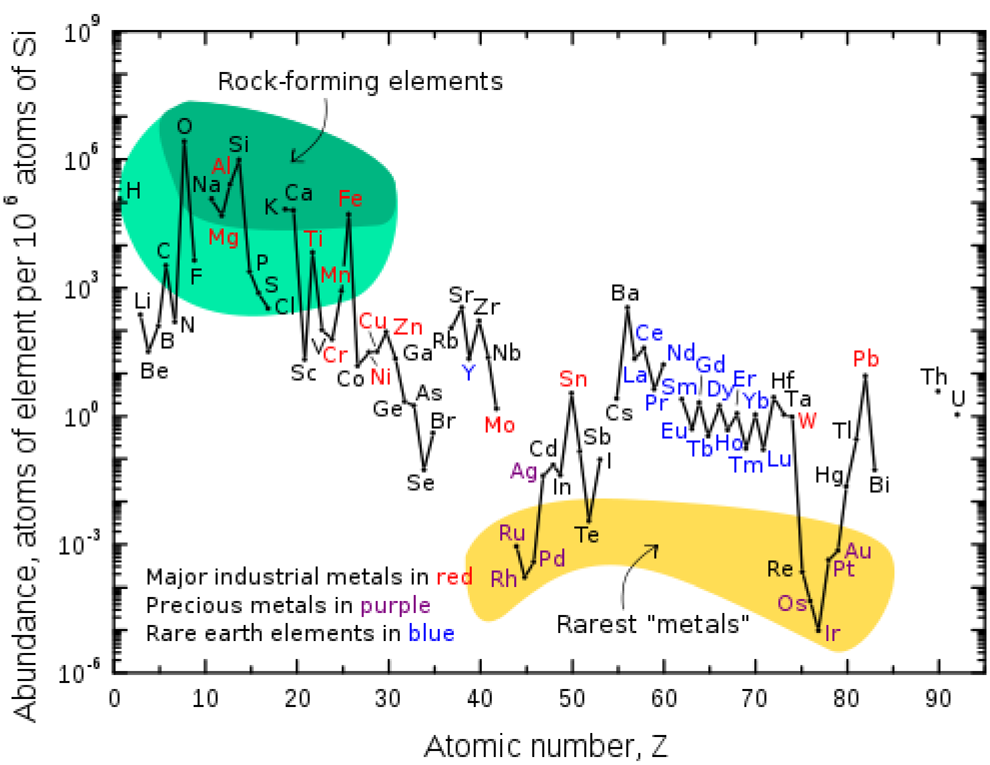
During the 1940s, Frank Spedding and others in the United States (during the Manhattan Project) developed the chemical ion exchange procedures for separating and purifying the rare earth elements. This method was first applied to the actinides for separating plutonium-239 and neptunium, from uranium, thorium, actinium, and the other actinide rare earths in the materials produced in nuclear reactors. The plutonium-239 was very desirable because it is a fissile material.

The principal sources of rare earth elements are the minerals bastnäsite, monazite, and loparite and the lateritic ion-adsorption clays. Despite their high relative abundance, rare earth minerals are more difficult to mine and extract than equivalent sources of transition metals (due in part to their similar chemical properties), making the rare earth elements relatively expensive. Their industrial use was very limited until efficient separation techniques were developed, such as ion exchange, fractional crystallization and liquid-liquid extraction during the late 1950s and early 1960s.[6]

ORIGIN OF RARE EARTHS

Rare earth elements are heavier than iron and thus are produced by supernova nucleosynthesis or the s-process in asymptotic giant branch stars. In nature, spontaneous fission of uranium-238 produces trace amounts of radioactive promethium, but most promethium is synthetically produced in nuclear reactors.

GEOLOGICAL DISTRIBUTION



Abundance of elements in the Earth crust per million of Si atoms

Rare earth cerium is actually the 25th most abundant element in the Earth's crust, having 68 parts per million (about as common as copper). Only the highly unstable and radioactive promethium "rare earth" is quite scarce.

The rare earth elements are often found together. The longest-lived isotope of promethium has a half life of 17.7 years, so the element only exists in nature in negligible amounts (approximately 572 g in the entire Earth's crust).[7] Promethium is one of the two elements that do not have stable (non-radioactive) isotopes and are followed by (i.e. with higher atomic number) stable elements.

Due to lanthanide contraction, yttrium, which is trivalent, is of similar ionic size to dysprosium and its lanthanide neighbors. Due to the relatively gradual decrease in ionic size with increasing atomic number, the rare earth elements have always been difficult to separate. Even with eons of geological time, geochemical separation of the lanthanides has only rarely progressed much farther than a broad separation between light versus heavy lanthanides, otherwise known as the cerium and yttrium earths. This geochemical divide is reflected in the first two rare earths that were discovered, yttria in 1794 and ceria in 1803.

As originally found, each comprised the entire mixture of the associated earths. Rare earth minerals, as found, usually are dominated by one group or the other, depending upon which size-range best fits the structural lattice. Thus, among the anhydrous rare earth phosphates, it is the tetragonal mineral xenotime that incorporates yttrium and the yttrium earths, whereas the monoclinic monazite phase incorporates cerium and the cerium earths preferentially. The smaller size of the yttrium group allows it a greater solid solubility in the rock-forming minerals that comprise the Earth's mantle, and thus yttrium and the yttrium earths show less enrichment in the Earth's crust relative to chondritic abundance, than does cerium and the cerium earths. This has economic consequences: large ore bodies of the cerium earths are known around the world, and are being developed.

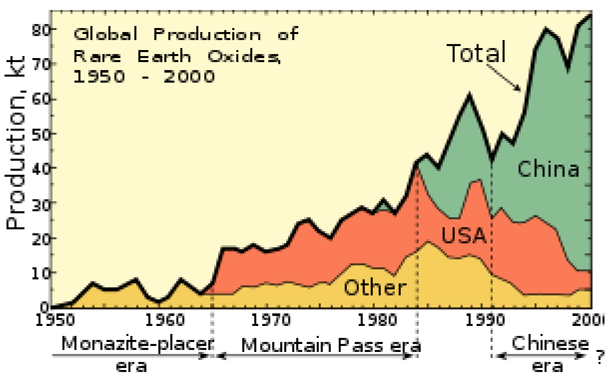
Corresponding ore bodies for yttrium tend to be rarer, smaller, and less concentrated. Most of the current supply of yttrium originates in the "ion adsorption clay" ores of Southern China. Some versions provide concentrates containing about 65% yttrium oxide, with the heavy lanthanides being present in ratios reflecting the Oddo-Harkins rule: even-numbered heavy lanthanides at abundances of about 5% each, and odd-numbered lanthanides at abundances of about 1% each. Similar compositions are found in xenotime or gadolinite.

Well-known minerals containing yttrium include gadolinite, xenotime, samarskite, euxenite, fergusonite, yttrotantalite, yttrotungstite, yttrofluorite (a variety of fluorite), thalenite, yttrialite. Small amounts occur in zircon, which derives its typical yellow fluorescence from some of the accompanying heavy lanthanides. The zirconium mineral eudialyte, such as is found in southern Greenland, contains small but potentially useful amounts of yttrium. Of the above yttrium minerals, most played a part in providing research quantities of lanthanides during the discovery days. Xenotime is occasionally recovered as a byproduct of heavy sand processing, but is not as abundant as the similarly recovered monazite (which typically contains a few percent of yttrium). Uranium ores from Ontario have occasionally yielded yttrium as a byproduct.

Well-known minerals containing cerium and the light lanthanides include bastnaesite, monazite, allanite, loparite, ancylite, parisite, lanthanite, chevkinite, cerite, stillwellite, britholite, fluocerite, and cerianite. Monazite (marine sands from Brazil, India, or Australia; rock from South Africa), bastnaesite (from Mountain Pass, California, or several localities in China), and loparite (Kola Peninsula, Russia) have been the principal ores of cerium and the light lanthanides.

In 2011, Yasuhiro Kato, a geologist at the University of Tokyo who led a study of Pacific Ocean seabed mud, published results indicating the mud could hold rich concentrations of rare earth minerals. The deposits, studied at 78 sites, came from "hot plumes from hydrothermal vents pulling these materials out of seawater and depositing them on the seafloor, bit by bit, over tens of millions of years. One square patch of metal-rich mud 2.3 kilometers wide might contain enough rare earths to meet most of the global demand for a year, Japanese geologists report July 3 in *Nature Geoscience*." "I believe that rare earth resources undersea are much more promising than on-land resources," said Kato. "Concentrations of rare earths were comparable to those found in clays mined in China. Some deposits contained twice as much heavy rare earths such as dysprosium, a component of magnets in hybrid car motors."[8]

GLOBAL RARE EARTH PRODUCTION



Global production 1950–2000

Until 1948, most of the world's rare earths were developed from placer sand deposits in India and Brazil.[9] Through the 1950s, South Africa took the status as the world's principal rare earth source, after large veins of rare-earth bearing monazite were discovered there.[9] Through the 1960s until the 1980s, the Mountain Pass rare earth mine in California was the leading producer. Today, the Indian and South African deposits still produce some rare earth concentrates, but they are dwarfed by the scale of Chinese production. China now produces over 97% of the world's rare earth supply, mostly in Inner Mongolia,[10][11] even though it has only 37% of proven reserves.[12] All of the world's heavy rare earths (such as dysprosium) come from Chinese rare earth resources such as the polymetallic Bayan Obo deposit.[11][13] In 2010, the USGS released a study which found that the United States had 13 million metric tons of rare earth elements.[14]

New demand has recently strained supply, and there is growing concern that the world may soon face a shortage of the rare earths.[15] In several years from 2009 worldwide demand for rare earth elements is expected to exceed supply by 40,000 tonnes annually unless major new sources are developed.[16]

CHINA

These concerns have intensified due to the actions of China, the predominant supplier. Specifically, China has announced regulations on exports and a crackdown on smuggling.[17] On September 1, 2009, China announced plans to reduce its export quota to 35,000 tons per year in 2010–2015, ostensibly to conserve scarce resources and protect the environment.[18] On October 19, 2010 *China Daily*, citing an unnamed Ministry of Commerce official, reported that China will "further reduce quotas for rare earth exports by 30 percent at most next year to protect the precious metals from over-exploitation".[19]

At the end of 2010 China announced that the first round of export quotas in 2011 for rare earths would be 14,446 tons which was a 35% decrease from the previous first round of quotas in 2010.[20] China announced further export quotas on 14 July 2011 for the second half of the year with total allocation at 30,184 tons with total production capped at 93,800 tonnes.[21] In September 2011 China announced the halt in production of three of its eight major rare earth mines, responsible for almost 40% of China's total rare earth production.[22]

As a result of the increased demand and tightening restrictions on exports of the metals from China, some countries are stockpiling rare earth resources.[23] Searches for alternative sources in Australia, Brazil, Canada, South Africa, Greenland, and the United States are ongoing.[24] Mines in these countries were closed when China undercut world prices in the 1990s, and it will take a few years to restart production as there are many barriers to entry.[17] One example is the Mountain Pass mine in California, which is projected to reopen in 2011.[11][25] Other significant sites under development outside of China include the Nolans Project in Central Australia, the remote Hoidas Lake project in northern Canada,[26] and the Mount Weld project in Australia.[11][25][27] The Hoidas Lake project has the potential to supply about 10% of the $1 billion of REE consumption that occurs in North America every year.[28] Vietnam signed an agreement in October 2010 to supply Japan with rare earths[29] from its northwestern Lai Châu Province.[30]

Also under consideration for mining are sites such as Thor Lake in the Northwest Territories, various locations in Vietnam,[11][16] and a site in southeast Nebraska in the US, where Quantum Rare Earth Development, a Canadian company, is currently conducting test drilling and economic feasibility studies toward opening a niobium mine.[31] Additionally, a large deposit of rare earth minerals was recently discovered in Kvanefjeld in southern Greenland.[32] Pre-feasibility drilling at this site has confirmed significant quantities of black lujavrite, which contains about 1% rare earth oxides (REO).[33]

In early 2011, Australian mining company, Lynas, was reported to be "hurrying to finish" a US$230 million rare earth refinery on the eastern coast of Malaysia's industrial port of Kuantan. The plant would refine "slightly radioactive" ore - Lanthanide concentrate from the Mount Weld mine in Australia. The ore would be trucked to Fremantle and transported by container ship to Kuantan. However, the Malaysian authorities confirmed that as of October 2011, Lynas was not given any permit to import any rare earth ore into Malaysia. Within two years, Lynas was said to expect the refinery to be able to meet nearly a third of the world's demand for rare earth materials, not counting China."[34]

The Kuantan development brought renewed attention to the Malaysian town of Bukit Merah in Perak, where a rare-earth mine operated by a Mitsubishi Chemical subsidiary, Asian Rare Earth, closed in 1992 and left continuing environmental and health concerns.[35] In mid-2011, after protests, Malaysian government restrictions on the Lynas plant were announced. At that time, citing subscription-only Dow Jones Newswire reports, a *Barrons* report said the Lynas investment was $730 million, and the projected share of the global market it would fill put at "about a sixth."[36] An independent review was initiated by Malaysian Government and UN and conducted by IAEA between 29 May and 3 June 2011 to address concerns of radioactive hazards. The IAEA team was not able to identify any non-compliance with international radiation safety standards.[37]

Another recently developed source of rare earths is electronic waste and other wastes that have significant rare earth components. New advances in recycling technology have made extraction of rare earths from these materials more feasible, and recycling plants are currently operating in Japan, where there is an estimated 300,000 tons of rare earths stored in unused electronics.[38]

Significant quantities of rare earth oxides are found in tailings accumulated from 50 years of uranium ore, shale and loparite mining at Sillamäe, Estonia.[39] Due to the rising prices of rare earths, extraction of these oxides has become economically viable. The country currently exports around 3,000 tonnes per year, representing around 2% of world production.[40]

Nuclear reprocessing is another potential source of rare earth or any other elements. Nuclear fission of uranium or plutonium produces a full range of elements, including all their isotopes. However, due to the radioactivity of many of these isotopes, it is unlikely that extracting them from the mixture can be done safely and economically.

ENVIRONMENTAL CONSIDERATIONS

Mining, refining, and recycling of rare earths have serious environmental consequences if not properly managed. A particular hazard is mildly radioactive slurry tailings resulting from the common occurrence of thorium and uranium in rare earth element ores.[41] Additionally, toxic acids are required during the refining process.[12] Improper handling of these substances can result in extensive environmental damage. In May 2010, China announced a major, five-month crackdown on illegal mining in order to protect the environment and its resources. This campaign is expected to be concentrated in the South,[42] where mines – commonly small, rural, and illegal operations – are particularly prone to releasing toxic wastes into the general water supply.[11][43] However, even the major operation in Baotou, in Inner Mongolia, where much of the world's rare earth supply is refined, has caused major environmental damage.[12]

The Bukit Merah mine in Malaysia has been the focus of a US$100 million cleanup which is proceeding in 2011. "Residents blamed a rare earth refinery for birth defects and eight leukemia cases within five years in a community of 11,000 — after many years with no leukemia cases." Seven of the leukemia victims died. After having accomplished the hilltop entombment of 11,000 truckloads of radioactively contaminated material, the project is expected to entail in summer, 2011, the removal of "more than 80,000 steel barrels of radioactive waste to the hilltop repository."

One of Mitsubishi's contractors for the cleanup is GeoSyntec, an Atlanta-based firm.[35] Osamu Shimizu, a director of Asian Rare Earth, "said the company might have sold a few bags of calcium phosphate fertilizer on a trial basis as it sought to market byproducts" in reply to a former resident of Bukit Merah who said, "The cows that ate the grass [grown with the fertilizer] all died."[44]

In May 2011, after the Fukushima Daiichi nuclear disaster, widespread protests took place in Kuantan over the Lynas refinery and radioactive waste from it. The ore to be processed has very low levels of thorium, and Lynas founder and chief executive Nicholas Curtis said "There is absolutely no risk to public health." T. Jayabalan, a doctor who says he has been monitoring and treating patients affected by the Mitsubishi plant, "is wary of Lynas's assurances. The argument that low levels of thorium in the ore make it safer doesn't make sense, he says, because radiation exposure is cumulative."[44] Construction of the facility has been halted until an independent United Nations IAEA panel investigation is completed, which is expected by the end of June 2011.[45] New restrictions were announced by the Malaysian government in late June.[36]

IAEA panel investigation is completed and no construction has been halted. Lynas is on budget and on schedule to start producing 2011. The IAEA report has concluded in a report issued by the nuclear watchdog Thursday June 2011 said it did not find any instance of "any non-compliance with international radiation safety standards" in the project. [46]

GEOPOLITICAL CONSIDERATIONS

China has officially cited resource depletion and environmental concerns as the reasons for a nationwide crackdown on its rare earth mineral production sector.[22] However, non-environmental motives have also been imputed to China's rare earth policy.[12] According to *The Economist*, "Slashing their exports of rare-earth metals...is all about moving Chinese manufacturers up the supply chain, so they can sell valuable finished goods to the world rather than lowly raw materials."[47] One possible example is the division of General Motors which deals with miniaturized magnet research, which shut down its US office and moved its entire staff to China in 2006.[48] (It should be noted that China's export quota only applies to the metal but not products made from these metals such as magnets.

It was reported,[49] but officially denied,[50] that China instituted an export ban on shipments of rare earth oxides (but not alloys) to Japan on 22 September 2010, in response to the detainment of a Chinese fishing boat captain by the Japanese Coast Guard.[51] On September 2, 2010, a few days before the fishing boat incident, *The Economist* reported that "China...in July announced the latest in a series of annual export reductions, this time by 40% to precisely 30,258 tonnes."[52]

The United States Department of Energy in its 2010 Critical Materials Strategy report identified dysprosium as the element that was most critical in terms of import reliance.[53]

A 2011 report issued by the U.S. Geological Survey and U.S. Department of the Interior, “China’s Rare-Earth Industry," outlines industry trends within China and examines national policies that may guide the future of the country's production. The report notes that China’s lead in the production of rare-earth minerals has accelerated over the past two decades. In 1990, China accounted for only 27% of such minerals. In 2009, world production was 132,000 metric tons; China produced 129,000 of those tons.

According to the report, recent patterns suggest that China will slow the export of such materials to the world: “Owing to the increase in domestic demand, the Government has gradually reduced the export quota during the past several years.” In 2006, China allowed 47 domestic rare-earth producers and traders and 12 Sino-foreign rare-earth producers to export. Controls have since tightened annually; by 2011, only 22 domestic rare-earth producers and traders and 9 Sino-foreign rare-earth producers were authorized. The government’s future policies will likely keep in place strict controls: “According to China’s draft rare-earth development plan, annual rare-earth production may be limited to between 130,000 and 140,000 [metric tons] during the period from 2009 to 2015. The export quota for rare-earth products may be about 35,000 [metric tons] and the Government may allow 20 domestic rare-earth producers and traders to export rare earths.” [54]

The U. S. Geological Survey is actively surveying southern Afghanistan for rare earth deposits under the protection of United States military forces. Since 2009, the USGS has conducted remote sensing surveys as well as fieldwork to verify Soviet claims that volcanic rocks containing rare earth metals exist in Helmand province near the village of Khanneshin. The USGS study team has located a sizable area of rocks in the center of an extinct volcano containing light rare earth elements including cerium and neodymium. It has mapped 1.3 million metric tons of desirable rock, or about 10 years of supply at current demand levels. The Pentagon has estimated its value at about $7.4 billion. [55]

RARE-EARTH PRICING

Rare earth elements are not exchange-traded in the same way that precious (for instance, gold and silver) or non-ferrous metals (such as nickel, tin, copper, and aluminum) are. Instead they are sold on the private market, which makes their prices difficult to monitor and track. However, prices are published periodically on websites such as mineralprices.com.[56] The 17 elements are not usually sold in their pure form, but instead are distributed in mixtures of varying purity, e.g. "Neodymium metal ≥ 99.5%".[56] As such, pricing can vary based on the quantity and quality required by the end user's application.

LUNAR KREEP

KREEP, an acronym built from the letters **K** (the atomic symbol for potassium), **REE** (**R**are **E**arth **E**lements) and **P** (for phosphorus), is a geochemical component of some lunar impact melt breccia and basalt rocks. Its most significant feature is somewhat enhanced concentration of a majority of so-called "incompatible" elements[1] (those that prefer a liquid state during magma crystallization) and the heat-producing elements potassium, uranium and thorium.[2]

Canonical composition of KREEP includes 1% (wt) of potassium and phosphorus oxides, 20-25 ppm of Rb, and concentrations of Lanthanum that are 300-350 times the concentrations found in chondrites.[3]

Indirectly, the origin of KREEP is a result of the Moon's origin, which is now commonly believed to be the result of a Mars-sized object that impacted the Earth 4.5 billion years ago.[4] This impact put a large amount of material into circum-terrestrial orbit that ultimately re-accreted to form the Moon.[5] Given the large amount of energy that was liberated in this event, it is predicted that a large portion of the Moon would have initially been molten, forming a near-global magma ocean.

As crystallization of this magma ocean proceeded, minerals such as olivine and pyroxene would have precipitated and sunk to form the lunar mantle.

After crystallization was about three-quarters complete, anorthositic plagioclase would have begun to crystallize, and because of its low density, float, forming an anorthositic crust. Importantly, elements that are incompatible (i.e., those that partition preferentially into the liquid phase) would have been progressively concentrated into the magma as crystallization progressed, forming a "KREEP"-rich magma that initially should have been sandwiched between the crust and mantle. Evidence for this scenario comes from the highly anorthositic composition of the lunar highland crust, as well as the existence of KREEP-rich materials.[6]

Before the Lunar Prospector mission, it was commonly thought that KREEP-rich materials would have formed a near global layer beneath the crust. However, results from the gamma ray spectrometer on this mission show that KREEP-containing rocks are primarily concentrated within the region of Oceanus Procellarum and Mare Imbrium, a unique geological province that is now known as the Procellarum KREEP Terrane. Basins far from this province that excavated deep into the crust (and possibly mantle) such as the Crisium, Orientale, and South Pole-Aitken show only modest, or no, enhancements of KREEP within their rims or ejecta. The enhancement of heat producing elements within the crust (and/or mantle) of the Procellarum KREEP Terrane is almost certainly responsible for the longevity and intensity of mare volcanism on the nearside of the Moon.[7]

We have reported on the apparent significance of KREEP in 2010 (more).

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