EMD Uranium (Nuclear Minerals) Committee

2013 EMD Uranium (Nuclear Minerals and REE) Annual Committee Report

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May 2, 2013

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- **Steven S. Sibray, C.P.G., (Vice-Chair: University),** University of Nebraska, Lincoln, NE
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- **Bruce Rubin**, Senior Geological Consultant, Millers Mills, NY (Founding Member of EMD in 1977)
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- **Robert A. Arrington**, VP, Exploration, Texas Eastern Nuclear, Inc (retired), College Station, TX (Founding Member of EMD in 1977)
- **Jeffrey D. King, P.G.**, President, I2M Associates, LLC, Seattle, WA
- **Jay H. Lehr, Ph. D.,** Science Director, Heartland Institute, Chicago (on Nuclear Power)

Committee Activities

During the past six months, the Uranium Committee (UCOM) continued to monitor the expansion of the nuclear power industry and associated uranium exploration and development in the United States and overseas. Input has also been provided by Robert Odell, P.G., the Committee's Vice Chair (Industry) on industry activity worldwide, by Steven Sibray, C.P.G., Vice Chair (University) on university activities in uranium research, and by Robert Gregory, P.G., Vice Chair (Government) on governmental (State and Federal) activities in uranium research, with special input from Henry Wise, Sam Romberger, and James Conca of UCOM's Advisory Group and from Bruce Rubin, a Special Consultant to the UCOM.

Thorium activities are also updated in this annual report. Finally, the Committee continues to report on rare-earth activities, an activity approved by the UCOM in 2011. We provide information on current rare-earth exploration and mining, and associated geopolitical activities.

Committee Publications

The Uranium 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* the final 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* has been released as a text. For the Memoir 101's Press Release, Table of Contents, ordering information, and Book Preface with Front and Back Book Covers, see (here). Because the 2012 updates to Chapter 9 were omitted during final editing, these updates will be restored in a PDF version of the chapter. In the meantime, Chapter 9 is presented (here), along with author biographies.

Executive Summary of Industry, Government, and University Activities

- Research estimates that as many as 1.8 million human lives would be saved by replacing fossil-fuel sources with nuclear power. They also estimate the saving of up to 7 million lives in the next four decades, along with substantial reductions in carbon emissions, if nuclear power were to replace fossil fuel usage on a large scale.

- The designed age for nuclear reactors in the U.S. is 40 years. The average age of the 104 working plants is 32 years, according to the Energy Information Agency (EIA), a part of the U. S. Department of Energy. With age is sure to come more maintenance, more outages.

- The new requirements include emergency backup power and instrumentation to ensure spent-fuel pools operate adequately. All these reactors must also now have hardened vents for reactor containment structures to relieve pressure and discharge built-up hydrogen during a reactor vessel accident.

- As retirements near for many of these reactors, oversight by the Nuclear Regulatory Commission (NRC) of the trust funds becomes paramount. Last year, a review by the Government Accountability Office (GAO), the investigative arm of Congress, challenged NRC's formula for determining the size of funds.

- Immediately after the Fukushima tsunami disaster in 2011, nuclear power seemed doomed. Japan shut down all 54 of its reactors. Germany, Switzerland and other countries announced grand plans to phase nuclear out completely. And the price of uranium plummeted by more than 40%.

- ❖ But today, a shift back towards nuclear energy is underway in the U.S. and around the world. New reactors are in planning and more are beginning construction. Major export economies in Europe and Asia have energy-intensive industries that can't just dump nuclear energy overnight.

- ❖ Japan reverses course on nuclear power development and is re-starting most of it reactors and planning for more. When Japan promised to shut down its 54 nuclear power plants, they erased 20 million pounds of nuclear fuel demand, and exacerbated the pricing situation by simultaneously selling 15 million pounds into the market, primarily to China.

- ❖ Research shows that yellowcake is on the critical tipping point towards higher prices.

- ❖ China's renewed pledge to nuclear power means they could be adding as many as 100 nuclear reactors over the next two decades, considering that China currently operates only 15 reactors.

- ❖ And it's not just China and Russia that are re-committing to nuclear power. Other nations such as India, South Korea, and the United Arab Emirates (UAE) are contemplating new nuclear power plants as well that would add to the 435 nuclear reactors already providing base-load power worldwide.

- ❖ Although the 2012 total world uranium (yellowcake) output was 135 million pounds, that's an annual deficit of roughly 40 million pounds. Altogether, by 2020, the world demand would be short by 400 million pounds.

- ❖ Resource estimates typically rise as frontier and trend exploration discover new ore bodies. Such activities require time to unfold, and production from a new ore body may require up to 10 years before the first yellowcake can be produced for further processing into nuclear fuel pellets and rods.

- ❖ If the Russians decide not to renew the Megatons to Megawatts agreement later this year - and that's the general consensus in the U.S. - there will be an additional uranium shortfall of 50-65 million pounds U_3O_8 annually worldwide.

- ❖ Spot yellowcake prices need to reach and remain around $70 - $80/ pound U_3O_8 before mining companies will be prepared to bring on new projects to reach that 180 million pound level. The current yellowcake spot price is around $ 42/ pound U_3O_8.

- ❖ Quarterly U.S. production of uranium in the fourth quarter 2012 was 961,062 pounds U_3O_8, **down 8%** from the previous quarter and **up 8%** from the fourth quarter 2011. During the fourth quarter 2012, U.S. uranium was produced at six U.S. uranium facilities.

- ❖ Combined, total uranium drilling was 10,597 holes covering 6.3 million feet, **47% more holes than in 2010**. Expenditures for uranium drilling in the U.S. were $54 million in 2011, **an increase of 20% compared with 2010** (2012 data not available from EIA until May, 2013).

- Annual U.S. uranium mines produced 4.2 million pounds U_3O_8 in 2012, **some 200,000 pounds more than 2011**, from 10 mines (underground and in-situ-leach) and one other source.

- Data on employment for 2012 will be released in the EIA Annual Report for 2012 in May, 2013, and will be included in the UCOM Mid-Year Report of 2013.

- Total employment in the U.S. uranium production industry was 1,191 person-years in 2011, **an increase of 11% from the 2010** total. Exploration employment was 208 person-years, about the same as in 2010. Milling and processing employment was 419 person-years in 2011, and **increased the most from 2010 (24%)**. Uranium mining employment was 462 person-years and **increased 16%**, while reclamation employment **decreased 18 %** to 102 person-years from 2010 to 2011.

- Total expenditures for land, exploration, drilling, production, and reclamation were $319 million in 2011, **15% more than in 2010**.

- Expenditures for U.S. uranium production, including facility expenses, were the largest category of expenditures at $169 million in 2011 and were **up by 27% from the 2010 level**.

- Uranium exploration expenditures were $44 million and **increased 26% from 2010** to 2011.

- Expenditures for land were $20 million in 2011, **a 3% decrease compared with 2010**.

- Reclamation expenditures were $34 million, **a 25% decrease** compared with 2010.

- At the end of 2008, U.S. uranium reserves totaled 1,227 million pounds of U_3O_8 at a maximum forward cost (MFC) of up to $100 per pound U_3O_8.

- Wyoming led the Nation in total uranium reserves, in both the $50 and $100 per pound U_3O_8 categories, with New Mexico second. Taken together, these two States constitute about two-thirds of the estimated reserves in the country available at up to $100 per pound U_3O_8, and three-quarters of the reserves available at less than $50 per pound U_3O_8.

- Potential uranium resources are likely to increase substantially over this decade as discoveries are made in frontier areas. Extensions to areas in Texas that are favorable for uranium occurrence are likely, both along trend and at greater depths.

- Uranium mine development is active in Wyoming, slow in Colorado, and moving forward in Texas and Arizona.

- Drilling is underway in Nebraska, New Mexico, Colorado, Wyoming, and Texas.

- Virginia Energy has not received the go ahead in the Coles Hill project in Virginia, and has been put on hold temporarily by the Virginia Legislature.

- Annual Federal claim rental fees and a royalty from mining on Federal lands of not less than 5% of gross proceeds were recommended by a U.S. Department of Interior's Budget Appropriations Bill of November, 2012 to generate Treasury fees of $80 million over ten years.

- Canada continues to have numerous operations, both drilling, development and mining operations.

- Greenland Minerals and Energy is moving ahead on their new discovery in south eastern Greenland of uranium and REE mineralization, which appears to be shallow and mineable.

- University research on uranium and REE topics in the U.S. is underway at the Colorado School of Mines, University of Nebraska and University of Wyoming.

- University research is also underway in Australia, especially in South Australia, and New South Wales. Queensland is now open to uranium exploration and mining.

- In government research, the Wyoming Geological Survey has been active in uranium and more recently on REE, and the U.S. Geological Survey continues to make valuable contributions regarding uranium and other minerals and associated environmental research.

- The Geological Survey of Canada and the various Provinces have very active research programs underway on uranium in support of industry.

- In Australia, *Geoscience Australia* and other federal agencies have numerous activities underway on uranium, also in support of the industry.

- U.S. Department of Energy Secretary Steven Chu (March 11, 2013), concerning design and certification of small modular reactors, announced a funding opportunity for help with small modular reactor's design and certification. Secondary funding is likely.

- China has used older American research to pursue a safer reactor designs based on thorium.

- A Norwegian company is breaking with convention and switching to an alternative energy it hopes will be safer, cleaner and more efficient. This involves the switch from uranium to thorium in their nuclear power program.

- United Kingdom research is currently directed to considering a range of advanced reactor systems and fuel cycles, to offering insight into their potential advantages and disadvantages of thorium and to highlight some of the challenges to developing thorium nuclear reactor systems.

- Many energy scientists indicate that there must be a paradigm shift away from uranium-fueled reactors to other nuclear technologies, such as the Liquid Fluoride Thorium Reactor.

The literature is increasing and numerous blogs are now calling for thorium as a sustainable fuel.

- ❖ Although the first quarter of 2013 was challenging for the rare-earth sector as a whole, there have been some notable developments, especially across the junior companies.

- ❖ The U.S. Geological Survey has generated a webpage offering information on mineral deposits containing rare earth elements (REE) and yttrium from around the world with grade, tonnage, and mineralogy.

Nuclear Power Industry Activities

Nuclear power is often promoted as a low-carbon source that mitigates fossil-fuel emissions and the resulting health damage and deaths caused by air pollution. But is it possible to provide estimates and actually quantify these effects? Kharecha and Hansen (2013), the latter a well-known proponent of global-warming, estimate that as many as 1.8 million human lives would be saved by replacing fossil-fuel sources with nuclear power. They also estimate the saving of up to 7 million lives in the next four decades, along with substantial reductions in carbon emissions, if nuclear power were to replace fossil fuel usage on a large scale. In addition, their study finds that the proposed expansion of natural gas would not be as effective in saving lives and preventing carbon emissions. In general, the paper provides optimistic reasons for the responsible and widespread use of nuclear technologies in the near future. It also emphasizes the point that nuclear energy has prevented many more deaths than accidents related to production from coal, oil and gas, geothermal energy, wind, and solar, except hydropower.

The Aging of the Fleet: The designed age for nuclear reactors in the U.S. is 40 years. The average age of the 104 working plants is 32 years, according to the EIA **(more)**, a part of the U. S. Department of Energy. With age is sure to come more maintenance and more outages. Other operators are likely to take the path chosen by the Kewaunee plant in Wisconsin and by the Crystal River Plant in Florida and begin the lengthy, complex, and expensive process of shutting down, cleaning up, and decommissioning **(more).**

New Safety Requirements: The new requirements include emergency backup power and instrumentation to ensure spent-fuel pools operate adequately. All these reactors must also now have hardened vents for reactor containment structures to relieve pressure and discharge built-up hydrogen during a reactor vessel accident. NRC is also contemplating requiring filters to capture vented radioactive material.

As retirements near for many of these reactors, NRC's oversight of the trust funds becomes paramount. Last year, a review by the Government Accountability Office (GAO), the investigative arm of Congress, challenged NRC's formula for determining the size of funds (more). The GAO report charges that the formula lacks detail and transparency, and in a sample of power plant savings programs, the report found NRC's formula may underestimate cleanup costs (more).

GAO investigated 12 reactors' trust funds, comparing company-prepared site-specific decommissioning cost estimates to NRC's formula. For nine reactors, NRC's formula resulted in funds below the companies' estimates. In one case, a company believed it needed $836 million, which was $362 million more than NRC's formula figure. GAO also noted NRC's funding formula was more than 30 years old, (more).

In new construction, the Vogtie Nuclear Plant in South Carolina has commenced construction of a new reactor, the second AP 1000 in America to start construction early 2013, (more). WNN also reported pouring of special basement concrete in South Carolina at the VC Summer Nuclear Plant. The site is the first reactor construction in 30 years. In addition, a second round of funding by the U.S. Government to encourage the development of Small Modular Reactors has begun, (more).

Immediately after the Fukushima tsunami disaster in 2011, nuclear power seemed doomed. Japan shut down all 54 of its reactors. Germany, Switzerland and other countries announced grand plans to phase nuclear out completely. And the price of uranium plummeted by more than 40%.

But today, a shift back towards nuclear energy is underway. New reactors are in planning and more are beginning construction in the U.S. and around the world. Major export economies in Europe and Asia have energy-intensive industries that can't just dump nuclear energy overnight. Research shows that uranium is on the critical tipping point towards higher prices.

According to global resource experts at *Money Morning* (2013) four factors could come into play to cause a major increase in the current price of uranium in the short-term. They are summarized and expanded in the following:

Factor 1: Increasing Developing World Demand

The growth in nuclear power is centered on the emerging markets, especially China. Last summer, the Chinese cabinet reconfirmed the country's commitment to its nuclear program, saying it would begin issuing new reactor licenses again after temporarily suspending them post-Fukushima.

China's renewed pledge to nuclear power means they could be adding as many as 100 nuclear reactors over the next two decades, considering that China currently operates only 15 reactors. Its capacity is likely to climb to 40 million kilowatts from nuclear by 2015, compared to 12.54 million at the close of 2011. Clearly, China will need to acquire substantial uranium fuel, which they've apparently been doing in the spot market recently.

For instance, earlier this month Russia's state owned *Atomredmetzoloto* and its *Effective Energy N.V.* affiliate, otherwise known together as *ARMZ*, announced they would buy the remaining 48.6% of *Uranium One* (TSX:UUU) which they didn't already own at a premium. This effectively solidifies them as the world's fourth largest uranium producer, concentrating uranium production even further into Russian control.

And it's not just China and Russia that are re-committing to nuclear power. Other nations such as India, South Korea, and the UAE are contemplating new nuclear power plants as well that would add to the 435 nuclear reactors already providing base-load power worldwide.

Today, 65 nuclear power plants are under construction in the world, another 160 new reactors are currently in the planning stages and 340 more have been proposed. Given this activity, the demand for uranium will increase but there is already a uranium-supply (yellowcake) deficit.

Factor 2: Growing Supply Deficit

Because of the post-Fukushima fallout, and the severely depressed yellowcake prices that followed, many uranium explorers and producers were forced to shelve development and expansion projects. This has led to a sizeable supply deficit. According to the World Nuclear Association, total consumption of uranium was 176.7 million pounds in 2011 and growing, while the 2012 total uranium output was 135 million pounds. That's an annual deficit of roughly 40 million pounds. Altogether, by 2020, the world demand would be short by 400 million pounds. Of course, as discussed in a previous paper (Campbell and Wiley, 2011, especially pp. 317-323), resource estimates typically rise as frontier exploration discovers new ore bodies. Such activities require time to unfold and production from a new ore body may require up to 10 years before the first yellowcake can be produced for further processing into nuclear fuel pellets and rods. However, in-situ development projects often require less time to go on-line than open-pit operations. In the interim, yellowcake prices are likely to rise and fuel alternatives will emerge, which includes thorium.

Factor 3: Japan Reverses Course

As a result of considerably higher energy costs, Japan is now shifting its stance on nuclear power. Japan's current power grid, without nuclear power, has been experiencing rolling blackouts. Natural gas imports have risen 17%, and even coal imports are up 21%. According to *Japan Today*, newly elected Prime Minister Shinzo Abe indicates that he is willing to build new nuclear reactors, which is a dramatic shift from the previous government's pledge to phase out all of the country's 50 working reactors by 2040. This reality is likely to spread to Germany and other countries that panicked after the tsunami in Japan a few years ago.

When Japan promised to shut down its 54 nuclear power plants, they erased 20 million pounds of nuclear fuel demand, and exacerbated the pricing situation by simultaneously selling 15 million pounds into the market, primarily to China.

Factor 4: Megatons to Megawatts

With the end of a program called **Megatons to Megawatts** this year**,** the fuel-supply deficit will increase. The program was created in the wake of the cold war, the **Megatons to Megawatts** program is an agreement between the U.S. and Russia to convert highly-enriched uranium (HEU) taken from dismantled Russian nuclear weapons into low-enriched-uranium (LEU) for nuclear fuel. The existence of this program alone covers a large portion of the worldwide annual deficit, with 24 million pounds of uranium going to American utilities. In years past, up to 10% of the electricity produced in the United States has been generated by fuel fabricated using LEU from the Megatons to Megawatts program. The program will expire toward the end of 2013 and, if the Russians decide not to renew the agreement - and that's the general consensus at least here in the West - there will be a uranium yellowcake shortfall of 50-65 million pounds annually worldwide.

The impact is substantial but can be offset. However, just counting the reactors currently under construction, it's expected that demand will increase by 13%, pushing up annual consumption to 200 million pounds, and that's not accounting for any reactors in the planning stages. The problem is that some experts think we may only see as much as 180 million pounds of annual uranium output by 2020. And it's estimated that spot prices need to reach and remain around \$70 - \$80/ pound U_3O_8 before mining companies will be prepared to bring on new projects to reach that 180 million pound level. The current yellowcake spot price is around \$ 42/ pound U_3O_8. Campbell and Wise, 2010, made some preliminary calculations on the likely development of production within the U.S. over the next 15 years and considered the impact of fuel additives, such as BeO and thorium to improve fuel-burn efficiency and the arrival of fast-breeder reactors by 2030 on yellowcake production levels.

U.S. Department of Energy Secretary Steven Chu (March 11), concerning design and certification of small modular reactors, announced a funding opportunity for help with small modular reactor's design and certification. "DOE will consider proposals with 50% private funding for projects with potential to begin commercial operation around 2025".

On March 5, 2013, *World Nuclear News* reported MIT's Ernest Moniz is President Obama's choice for Energy Secretary. Dr. Moniz, in the November 2011 "Foreign Affairs" magazine, has stated "the government and industry need to advance new designs that lower the financial risk of constructing nuclear power plants." Moniz favors development of small, modular reactors for economy of manufacturing.

STATUS OF U.S. URANIUM INDUSTRY

4TH QUARTER 2012 STATISTICS

U.S. EIA (2012) reported on U.S. production of uranium in the fourth quarter 2012 was 961,062 pounds U_3O_8, down 8% from the previous quarter and up 8% from the fourth quarter 2011. During the fourth quarter 2012, U.S. uranium was produced at six facilities.

U.S. URANIUM MILL IN PRODUCTION

1. White Mesa Mill (Utah)

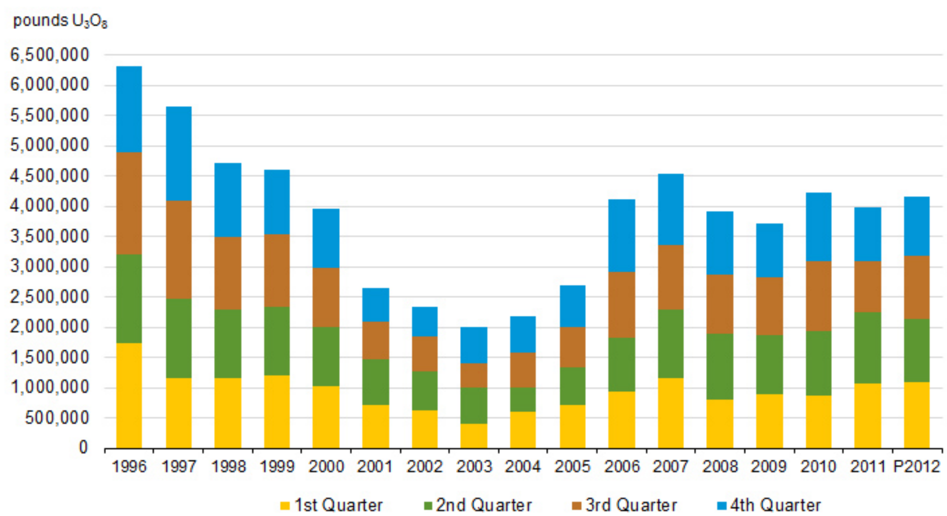
U.S. URANIUM IN-SITU-LEACH PLANTS IN PRODUCTION

1. Alta Mesa Project (Texas)
2. Crow Butte Operation (Nebraska)
3. Hobson ISR Plant/La Palangana (Texas)

4. Smith Ranch-Highland Operation (Wyoming)
5. Willow Creek Project (Wyoming)

As of December 31, 2012, U.S. uranium concentrate production totaled 4,148,773 pounds. This amount is 4% higher than the 3,990,767 pounds produced in 2011. The recent history is shown in the figure below.

Figure 1. Uranium concentrate production in the United States, 1996 - 4th Quarter 2012



P = Preliminary data.
Source: U.S. Energy Information Administration: Form EIA-851A and Form EIA-851Q, "Domestic Uranium Production Report."

Drilling Statistics in Uranium Exploration

U.S. EIA (2012) reports that U.S. uranium exploration drilling in 2011 was 5,441 holes covering 3.3 million feet. Development drilling was 5,156 holes and 3.0 million feet. Combined, total uranium drilling was 10,597 holes covering 6.3 million feet, 47% more holes than in 2010. Expenditures for uranium drilling in the United States were $54 million in 2011, an increase of 20 % compared with 2010. For historical activity, see (here). For current drilling activity, see the Uranium Industry Vice-Chair Report later in this presentation beginning on Page 12.

Mining, Production, Shipments, and Yellowcake Sales Statistics

EIA has added new information in Table 4 and Table 5 that now include County and State location of existing and planned mills and in-situ-leach (ISL) plants. EIA (2012) produced their final report on 2011 production in May, 2012, which is summarized here for the first time. The EIA report for 2012 activities will be available in May, 2013.

U.S. uranium mines produced 4.2 million pounds U_3O_8 in 2012, some 200,000 pounds more than 2011, from 10 mines (underground and in-situ-leach) and one other source. Five underground mines produced ore containing uranium during 2011, one more than during 2010. Uranium ore is stockpiled and shipped to a mill, to be milled into uranium concentrate (a yellow or brown powder). Additionally, five ISL mining operations produced solutions containing uranium in 2011 that was processed into uranium concentrate at ISL plants. The data for 2012 will be produced in the EIA Annual Report in May, 2013 on production.

An indication that the nuclear industry is anticipating price increases for yellowcake is presented in the marketing report for 2011, which was released in May, 2012 (see here). The marketing report for 2012 will be released in May, 2013.

Employment in the Uranium Industry

Total employment in the U.S. uranium production industry was 1,191 person-years in 2011, an increase of 11% from the 2010 total. Exploration employment was 208 person-years, about the same as in 2010. Milling and processing employment was 419 person-years in 2011, and increased the most from 2010 (24%). Uranium mining employment was 462 person-years and increased 16 %, while reclamation employment decreased 18% to 102 person-years from 2010 to 2011. Five States (Colorado, Nebraska, New Mexico, Texas, and Wyoming) accounted for 74% of total employment in the uranium production industry in 14 States: Arizona, Colorado, Nebraska, New Mexico, Nevada, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Virginia, Washington, and Wyoming. See additional EIOA 2011 data on employment (here). Data on employment for 2012 will be released in the EIA Annual Report for 2012 in May, 2013, and will be included in the UCOM Mid-Year Report of 2013.

Expenditures in the Uranium Industry

Total expenditures for land, exploration, drilling, production, and reclamation were $319 million in 2011, 15% more than in 2010. Expenditures for U.S. uranium production, including facility expenses, were the largest category of expenditures at $169 million in 2011 and were up by 27 % from the 2010 level. Uranium exploration expenditures were $44 million and increased 26% from 2010 to 2011. Expenditures for land were $20 million in 2011, a 3% decrease compared with 2010. Reclamation expenditures were $34 million, a 25% decrease compared with 2010. For EIA data on 2011 activities, see (here).

U.S. Department of interior's Budget Appropriations Bill of November, 2012 recommended reforming Hardrock Mining on Federal Lands to a leasing program, including gold, silver, lead, zinc, copper, uranium and molybdenum. Annual claim rental fees and a royalty not less than 5% of gross proceeds were recommended to generate Treasury fees of $80 million over ten years.

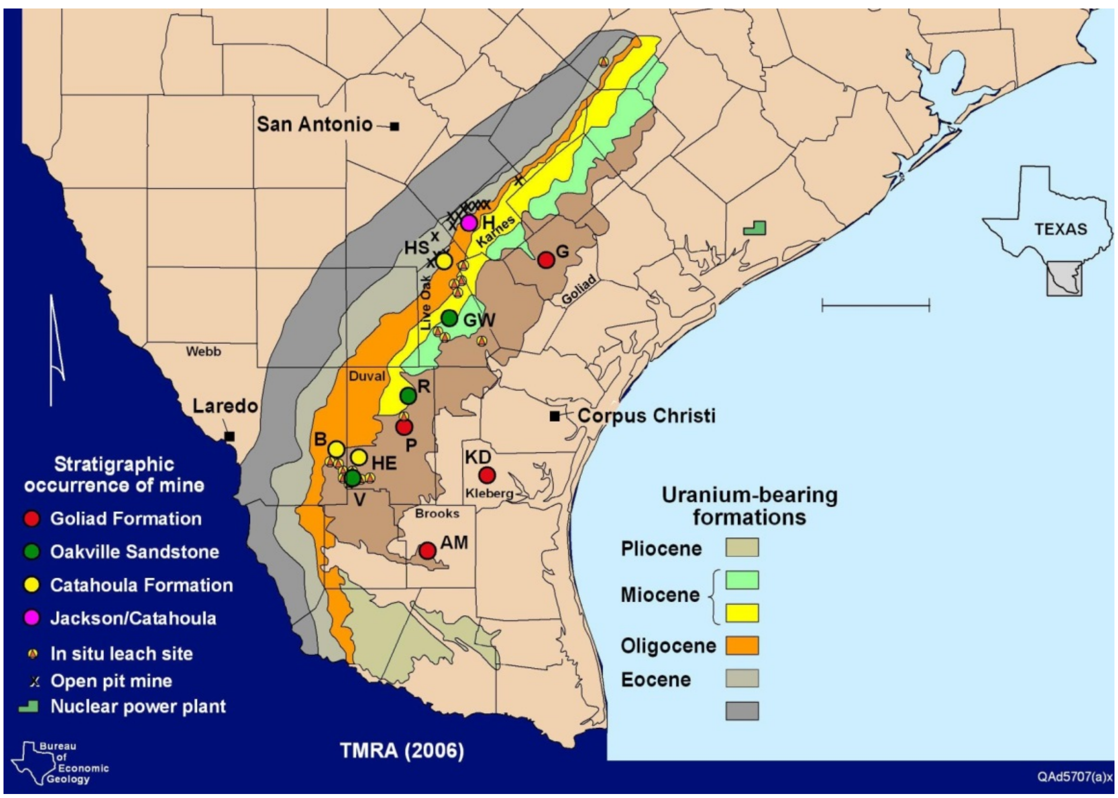
Uranium Reserves

EIA (2010) has updated its estimates of uranium reserves for year-end 2008. This represents the first revision of the estimates since 2004. The update is based on analysis of company annual reports, any additional information reported by companies at conferences and in news releases, personal contacts, and expert judgment. The next update is expected in 2012 but this has not been released to date.

At the end of 2008, U.S. uranium reserves totaled 1,227 million pounds of U_3O_8 at a maximum forward cost (MFC) of up to $100 per pound U_3O_8 (Table 1, see left margin for link to Table 1). In 2008, Wyoming led the Nation in total uranium reserves, in both the $50 and $100 per pound U_3O_8 categories, with New Mexico second. Taken together, these two States constituted about two-thirds of the estimated reserves in the country available at up to $100 per pound U_3O_8, and three-quarters of the reserves available at less than $50 per pound U_3O_8.

By mining method, uranium reserves in underground mines constituted just under half of the available product at up to $100 per pound of U_3O_8 (Table 2). At up to $50 per pound U_3O_8, however, uranium available through in-situ leaching (ISL) was about 40% of total reserves, somewhat higher than uranium in underground mines in that cost category. ISL is the dominant mining method for U.S. production today. See Table 3 for more estimates from 1993 through 2003 and 2008. The EIA report on reserves is apparently overdue. That last available report is for 2008 (more).

Potential uranium resources are likely to increase substantially over this decade as discoveries are made in frontier areas, see (Campbell and Biddle, 1977). The known areas in Texas that are favorable for uranium occurrence are shown in the figure below. Extensions to these trends are likely, both along trend and at greater depths.



Uranium Trends in South Texas From Ambrose (**2007**)

Vice-Chair Reports:

I. Uranium-Related Industry Activity

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

NORTH AMERICAN URANIUM REVIEW
as of: April 1, 2013

UNITED STATES ACTIVITIES

ARIZONA

Energy Fuels has shifted focus to mining low-cost, high grade breccia pipes. Dick White, VP, indicated on March 21, 2013 that his firm has not conducted exploration drilling on sandstone-hosted deposits this year in Colorado or Utah but underground mining development of breccia pipe deposits continues in the north and south Grand Canyon area. At White Mesa, milling of uranium and vanadium ores continues from stockpiles.

COLORADO

Energy Fuels reported on March 1, 2013 reaffirmed that the PINION RIDGE uranium mill has won the approval of the Colorado Department of Health and Environment, following an appeal by non-government entities. A new license for mill construction is anticipated in April, 2013.

Cotter Corporation at the Schwartzwalder Mine area will attempt a molasses and alcohol mix in Ralston Creek above the mine in a bioremediation exercise to treat a 24,000 ppb heavy contamination level. Chemically treating the water to remove or reduce uranium levels above 30 ppb for down-stream and is becoming a financial burden for miners in the area. *ASARCO* is also conducting similar tests at its smelter in Denver, according to an Associated Press release to the *Casper Star Tribune*, March 4, 2013.

The Colorado Department of Natural Resources in late 2012 was poised to propose a listing decision for the Greater Sage Grouse under the Endangered Species Act by 2015. The report was scheduled for release soon from Colorado's Office of the Executive Director.

NEBRASKA

Cameco continued exploration drilling at Crow Butte with two drills, according to Chief Geologist Bob Blackstone of the Casper office, March 21, 2013.

NEW MEXICO

Strathmore Minerals announced in March (2013) that the three-year Roca Honda Mine area study by *Mangi Environmental Group*'s Draft Environmental Statement (DEIS) managed by the U.S.

Forestry Service has been published. Open house public meetings are scheduled for Grants and Gallup for local review mid-April, 2013. A Final Environmental Impact Statement and Roca Honda Mine Permit Record of Decision are expected later this year. *UX Weekly (UXW*) reported in mid-March that the project is funded 60% by *Strathmore* and 40% by *Sumitomo*, under terms of the RHR LLC Joint Venture.

Uranium Resources Inc.'s feasibility studies at its Section 8 property in the Grants Mineral Belt reported 6.5 million pounds of 0.11% U_3O_8. Studies were performed by BEHRE DOLBEAR, TREK and WESTERN STATES MINING CONSULTANTS. ISR recovery could result in a 67% recovery of the deposit, calculating to total 4.4 million pounds over 6 years. Direct production costs have been estimated at US$20 to $23 per pound U_3O_8. Terence J. Cryan, CEO of URI released the report in *UXW*, January 17, 2013.

TEXAS

URANIUM ENERGY CORP (UEC) announced on February 28, 2013 receipt of a NI 43-101 resource estimates for 2.9 million pounds grading 0.047% U_3O_8 at its BURKE HOLLOW, TEXAS exploration site, where two rigs have drilled 266 holes and are installing baseline monitor wells. On March 18, 2013, UEC reported their GOLIAD ISR site now has a 3-phase power system and the caliche site pad for the main complex and disposal well are in place. The BURKE HOLLOW ISR environmental data collection will continue through 2014. The SALVO ISR review of historic and recent drilling study will help plan Production Area One. At the CHANNEN project, drilling has located two lower Goliad sub-rolls at a depth of between 700 and 860 feet.

VIRGINIA

VIRGINIA ENERGY announced December 28, 2012 a 6 million dollar plan to sell 14,285,714 common shares to ENERGY FUELS. Approximately 14 million shares at 42 cents per share will be acquired by ENERGY FUELS for approximately $6 million for the 9,439,857 shares of VE, which owns 100% of the COLES HILL deposit in south central Virginia. That deposit, the largest in the US, totals some 133 million pounds grading 0.056% uranium. The deal involves $250,000 cash from ENERGY FUELS and 21,851,411 shares of EF stock, according to the January 7, 2013 UX Weekly. The same report suggests progress for the Virginia Legislature to consider lifting the state's ban on uranium mining, which is imminent.

WYOMING

BAYSWATER URANIUM announced on March 13, 2013 at RENO CREEK, BU will receive $2.5 million investment funding from PACIFIC ROAD RESOURCES FUNDS, the first of a $7.5 million investment in the AUC LLC PROJECT, where commercial production is planned for 2016.

CAMECO reported through Tom Nicholson 16 production drills at the Christensen Ranch project in Powder River Basin, for March, 2013.

ENERGY FUELS this year continues base-line environmental monitoring of properties acquired from TITAN in the Great Divide Basin Sheep Mountain area. There is recent news on the LOST CREEK Project regarding the recent environmental legal injunction action to halt construction at the Great Divide Basin uranium plant. The Wyoming District Court upheld a comprehensive five-year multi-agency regulatory approval for the site. Foundation work at the site is complete and large equipment is in place with building exteriors fully enclosed. First production is planned later this year. Photos of construction progress are available at www.ur-energy.com, according to President and CEO Wayne Heili. Ten development drills were active mid-March, 2013.

UR-Energy Lost Creek Plant building 2012-13. Great Divide Basin, Wyoming.

URANERZ in Wyoming's Powder River Basin is also nearing completion of mill construction.

Nichols Ranch Aerial View as of September, 2012.

PENINSULA ENERGY Ltd has upgraded its east Wyoming LANCE resource estimates to 17.2 million pounds, measured and indicated resources. Total resources are now at 53.7 million pounds U_3O_8, reported in the January 28, 2013 UX Weekly. On March 25, 2013, PENINSULA completed an Optimization Study by TREC for the property, showing gross revenue of $187 million with a long-term contract price of US$62.33 per pound U_3O_8. Metallurgical recoveries of 64% were calculated for the ROSS, KENDRICK, and BARBER production units.

POWERTECH URANIUM has its final Safety Evaluation Report for DEWEY-BURDOCK, signaling the end of NRC's technical reviews and requiring only the Supplemental Environmental Impact Statement and NRC review. The 6.7 million pound indicated U_3O_8 deposit covers 17,800 acres located on the southwest flank of the Black Hills, SD. Another 4.5 million pounds U_3O_8 are inferred in two additional deposits.

STRATHMORE late in 2012 indicated *CROSSHAIR ENERGY* had returned all claims to the JUNIPER RIDGE uranium property in south central Wyoming, which is within shipping distance of STRATHMORE's Gas Hills proposed uranium mill, citing "continued deterioration of existing market conditions". CROSSHAIR drilled 549 drill holes and identified a new uranium trend and an NI 43-101 resource estimate of 5.2 million pounds, 4.14 million pounds of which ran 0.063% U_3O_8.

STAKEHOLDER and *URANIUM ONE* continue uranium reserves development in Wyoming.

CANADA ACTIVITIES

ASHBURTON VENTURES, as of March 13, 2013, has acquired two uranium properties in Saskatchewan's PATTERSON LAKE SOUTH (ALPHA MINERALS/FISSION ENERGY discovery area). Following review of all available exploration data, a 2013 uranium program design is planned for the East Athabasca Basin site, according to *UX Weekly*.

CAMECO as of late 2012 reduced long-term uranium plans due to the weak global economy, according to Tim Gitzel, CEO. *UX Weekly* and *Nuclear Mining Review* late last year indicated CAMECO will concentrate on projects presently in an advanced stage and anticipates production of 36 million pounds annually by 2018. CIGAR LAKE production will commence in 2013, with expansion of the KEY LAKE MILL and extension of RABBIT LAKE and ISL facilities.

DENISON as of March 14, 2013 reported WHEELER RIVER drilling involves two drill rigs on a 24-hole program, with 18 holes already completed in the Athabasca Basin. At the PHOENIX A deposit, four infill drill holes returned one occurrence of 3.5 meters grading 36.3% U_3O_8 and three lesser occurrences grading from 13.5% to 24.1% U_3O_8, 2.6 to 3.0 meters thick. MOORE LAKE exploration continues to encourage further drilling. Twelve holes there were reported March 18th through *UX Weekly*.

SKYHARBOR RESOURCES has picked up six uranium exploration properties in the Athabasca Basin totaling 209,000 acres in the Patterson Lake area. Uranium mineralization is associated with granitic plutons, stocks and felsic gneiss.

INNUIT government sources in NUNAVUT were indicated in www.wise-uranium.org to be changing earlier mining policy to encourage mining by reducing the 12% royalties on all minerals, including gold and uranium. No details were available.

BRITISH COLUMBIA has banned uranium and thorium exploration, for now.

ONTARIO's MINISTRY of NORTHERN DEVELOPMENT has modernized their Mining Act (April, 2013), allowing no staking on private lands and requiring private companies to consult with aboriginal groups.

SASKATCHEWAN will cut royalty rates, as of March 22, 2013. No details or rates were mentioned by WISE via www.wise-uranium.org. AREVA was reported to have won a royalty-calculating methodology law suit against the provisional government which must repay AREVA millions of dollars in overage charges.

Overseas Activities of Particular Note

GREENLAND MINERALS and ENERGY will evaluate potential for an "offsite refinery" for its KVANEFJELD uranium/rare earths project projected to offer a potential production rate of three million ton per year. The firm claims inferred uranium reserves of 512 million pounds U_3O_8. The reserves of rare earth and other metals have not been announced but are considered to be substantial.

Publications of Historical Interest

Historical publications related to the nuclear industry from the personal library of Roger Conarty (deceased), are now available through library loan from the Casper College Historical Librarian, Vince Carolla. E-mail: vcrolla@caspercollege.edu. Phone: (307) 268-2131.

> "Roger Conarty studied under some powerful men in their field, Hans Wigner, and Enrico Fermi, guest lecturers at the Einstein Institute, Princeton N.J., where Conarty received his Master's Degree, in 1952, went on to teach Physics at the US Military Academy, West Point. These may be dated, but are of historical interest."

1. Glossary of Nuclear terms, Atomic Energy Commission,
2. Study of Nuclear as an alternative energy-U.S, Supply Prospects, to 2010-National Academy of Sciences, Washington D.C.
3. The Science and Engineering of Nuclear Power, Princeton University, Princeton, N.J. Dept. of Physics, Wigner, Weisenkopf, Freidman, Giuliland and Feld
4. Radiological Health, U.S. Dept. of Health Education and Welfare-Environmental Control Agency, Washington, D.C.
5. Atomic Energy Legislation through the 85th Congress, U.S. Committee on Atomic Energy
6. The Man Made Elements beyond Uranium, Dr. Glenn Seaborg Chairman Atomic Energy Commission, Washington D.C. 1960
7. Nuclear Power and the Environment, American Nuclear Society, 1978, Question and Answer Manual
8. Gas Fundamentals, Kopper Company, Inc. Pittsburgh, Pennsylvania
9. Biological Effects of Atomic Radiation, National Academy of Science, Washington D.C.
10. Industrial Survival of Nuclear, and Summit Plan, Journal, Academy of Sciences
11. An Introduction to Controlled Thermonuclear Fusion, Hagler and Kristenson, Library of Congress Washington D.C.
12. Future role of the Atomic Energy Commission, Joint Committee on Atomic Energy, Manual
13. Nuclear Physics, Enrico Fermi, Master of the Atomic Bomb- World War !!, University of Chicago Press.
14. Radiation Protection Standards, Federal Radiation Council.
15. Enrico Fermi lectures from Technical Information Branch, Oak Ridge, Tennessee.
16. Fundamentals of a Nuclear Reactor, Oak Ridge National Lab.
17. Nuclear Radiation Detection, Second edition, William Price
18. Ionization Chambers and counters-Experimental techniques, MIT Bruno Rossi and Stanford University, Hans Staub, both formerly from the Los Alamos Laboratories

19. The Army gas cooled Reactor Systems Program using a Mobile Low Power Plant, U.S. Atomic Energy Commission

20. National Council of Radiation Measurements, Washington D.C. Manual, Natural Background Radiation.

Miscellaneous

WHO (World Health Organization) http://www.world-nuclear-news.org/RS 3/25/2013 reported "Clear cases of health damage from radiation generally occur only following exposure of 1,000 mSU" – which is far more radiation than the reported Fukushima doses of 10 to 50 mSu.

SYMPOSIUM CALENDAR, 2013

April 16-17, 2013 SMALL MODULAR REACTOR CONGRESS: Nuclear Energy Insider. Marriot Downtown Hotel, Columbia, South Carolina: http://www.nuclearenergyinsider.com/

May 23-24, 2013 4th ANNUAL SUPPLY CHAIN CONF: Nuclear Energy Insider. Hilton City Centre, Charlotte, North Carolina: http://www.nuclearenergyinsider.com/

June 11-12, 2013 AUSIMM INTERNATIONAL URANIUM CONFERENCE 2013 Holiday Inn Esplanade Darwin, Darwin, Australia: http://www.ausimm.com.au/uranium2013/

July 30, 2013 NEI NUCLEAR FUEL SUPPLY FORUM, NUCLEAR ENERGY INSTITUTE: Westin Georgetown Hotel, Washington, D.C.: http://www.nei.org/

Sept. 29 to Oct. 3, 2013 U2013 GLOBAL URANIUM SYMPOSIUM Omni Bayfront Hotel Corpus Christi, TX http://www.u-2013.org/

II. Uranium-Related University Research Activity

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

Annual Report, 2013

The EMD Uranium (Nuclear Minerals) Committee is pleased to remind readers of the Jay M. McMurray Memorial Grant which is awarded annually to a deserving student whose research involves uranium or nuclear fuel energy. This grant is made available through the AAPG Grants-In-Aid Program, and is endowed by the AAPG Foundation with contributions from his wife, Katherine McMurray, and several colleagues and friends. Those students having an interest in applying for the grant should contact the UCOM Chairman for further information and guidance. The biography of Mr. McMurray's outstanding contribution to the uranium industry in the U.S. and overseas is presented here. He passed away in 2008 and only one grant has been made to date to Chiara Mazzoni of the University of Strathclyde, Glasgow, United Kingdom.

Uranium-related research activities at the major American universities were limited in scope in 2012. Funding was primarily from private sources, usually uranium mining companies. The Society of Economic Geologists [SEG] provided two student grants related to uranium ore deposits. One of the uranium related grants was for study of U-REE mid-crustal systems and their links to Iron Oxide Copper Gold [IOCG] deposits while the other grant was for a study of a deposit in British Guyana. In contrast, a total of 4 SEG grants were for the study of REE. The SEG grants relating to uranium and REE are listed are as follows:

2012

Jim Renaud, CAN$2,000 [CAN] University of Western Ontario, Canada, Ph.D.; "Aricheng uranium deposit. Roraima Basin, British Guyana, South America."

Matt McGloin, US$3,250 Monash University, Australia,, Ph.D. "The Genesis of U-REE mid-crustal systems and their links to IOCG deposits."

Laurie Christine O'Neill, US$1,000 University of Texas at Austin (USA) M.Sc. "Rare Earth Element Mineralisation associated with the Paleogene Round Top Laccolith (West Texas, USA)."

Andrew Peter George Fowler, US$ 2,000 University of California, Davis (USA) M.Sc., "Detrital rutile in the Au-bearing Moeda Formation, Minas Gerais, Brazil, Rare Earth Element concentrations in geothermal fluids from Icelandic geothermal systems (Iceland)."

Erik Hanson, US$3,250 Southern Illinois University (USA) M.Sc., "The origin and REE investigation of the Sparks Hill and Chamberlain diatremes near Hick's Dome (Southeastern Illinois, USA)."

2011

Luisa Ashworth-Broccardo US$2,000 University of Witwatersrand (South Africa) Ph.D. "Rare metal and abyssal pegmatites (Damara Belt, Namibia)."

Benjamin Snook US$2,000 Camborne School of Mines (UK) Ph.D. "High purity quartz and rare metals, Bamble-Evje pegmatite belt (Norway)."

Jim Renaud, CAN$2,000 [CAN] University of Western Ontario, Canada, Ph.D.; "Aricheng uranium deposit. Roraima Basin, British Guyana, South America."

Two faculty members of the Colorado School of Mines had active research projects related to uranium ore deposits. Dr. Thomas Monecke and a Ph.D. graduate student (Julie Leibold) were investigating the mineralogy and geochemistry of the Three Crows roll front uranium deposit in Nebraska. Dr. Monecke was also conducting research on the mineralogy and geochemistry of the

Lost Creek roll front deposit in Wyoming. Funding for the Three Crows study was provided by Cameco while the Lost Creek study was funded by UR Energy and the U.S. Geological Survey. Dr. Moenke and a new M.Sc. student have a new project, Roll-front mineralization at the Buss Pit, Gas Hills, Wyoming (sponsored by Cameco). Dr. Murray Hitzman and Sophie Hancock (PhD graduate student) finished up the study of the hydrogeology of the Lost Creek deposit that was funded by UR Energy.

Steven Sibray [University of Nebraska Lincoln] presented a talk on "Exploring for Roll Front Uranium Deposits and Groundwater Using Airborne Electromagnetic Surveys in the Nebraska Panhandle" at the Rocky Mountain section of AAPG in Grand Junction, Colorado. Recent advances in application of airborne electromagnetic [AEM] surveys to groundwater management programs can also be utilized to map aquifers that host uranium deposits. The US Geological Survey and the Nebraska Geological Survey have collected AEM data as part of an ongoing project to define the hydrogeologic framework of the principal shallow aquifer in the Nebraska Panhandle. Additional interpretation of these data sets has identified areas where the deeper confined aquifer of the Tertiary White River Group may contain economic deposits of uranium.

At the 244th meeting of the American Chemical Society in Philadelphia in August 2012, scientists reported on new technology that could extract uranium from seawater. It is estimated that seawater contains at least 4 billion tons of uranium. Dr Erich Schneider, University of Texas, said that the current goal is not to make seawater extraction as economical as terrestrial mining. Instead, scientists are trying to establish uranium from the ocean can act as a sort of "economic backstop" that will ensure there will be enough uranium to sustain nuclear power through the 21st Century and beyond.

The standard extraction technique uses mats of braided plastic fibers embedded with compounds that capture uranium atoms. Each mat is 50 to 100 yards long and suspended 100 to 200 yards under the water. After being brought back to the surface, the mats are rinsed with a mild acid solution to recover the uranium. DOE-funded technology now can extract about twice as much uranium from seawater as the first approaches developed in Japan in the late 1990s. That improvement reduces production costs down to around $300 per pound of uranium, from a cost of $560 per pound.

In contrast to the limited scope of uranium research in the United States, there is a great deal of research being conducted in the Athabasca region of Canada. The following information on research being conducted in that region was found on the website of the Province of Saskatchewan (more).

Research Activities at Canadian Universities and Government Agencies

Canada was the world's largest uranium producer for many years, accounting for about 22% of world output, but in 2009 was overtaken by Kazakhstan. Production comes mainly from the McArthur River mine in northern Saskatchewan province, which is the largest in the world (more). Production is expected to increase significantly from 2013 as the new Cigar Lake mine returns to operation. With known uranium resources of 572,000 tons of U_3O_8 (or 485,000 tU), as well as continuing exploration, Canada will have a significant role in meeting future world demand. The country has a very vigorous research program underway at the federal, provincial, and university levels, with considerable funding provided by industry.

Research Projects in the Athabasca Region of Saskatchewan

Nancy Université , Michel Cuney, colleagues and students: Fluid history of the Athabasca Basin proximal to ore deposits.

Queen's University

1) Uravan Minerals/NSERC: Exploration geochemistry for deep uranium deposits
Uravan Minerals, Queen's University, U. Wisconsin involving PDF, Ph.D., M.Sc. and 4 B.Sc.

- Exploration geochemistry using core and surface samples in the Outer Ring, Johannsen Lake, Halliday Lake and Stevenson areas of the Athabasca Basin.

2) Raven Minerals/NSERC: Basin-related uranium systems
Raven Minerals, Queen's University, involving 2 PDF, 2 Ph.D., M.Sc., 4 B.Sc.

- Identify the critical factors that control uranium mobility and precipitation in sedimentary basins, including specific areas in the Athabasca Basin

3) Cameco Corp/NSERC: Iron Oxidation State study
Cameco Corp., Queens University (Kyser), U. Manitoba Fayek), involving Ph.D. & M.Sc.

- Distribution of iron oxidation state using well-characterized clay minerals to trace preferential pathways for uraniferous paleofluids.

4) Cameco Corp/NSERC: Uranium Deposits in Successor Basins
Cameco Corp., Queens University, involving PDF and PhD Thesis

- Re-evaluate the character and formation of vein type deposits in successor basins in Canada (Beaverlodge area) and Australia (South Alligator River area) and compare them to those in the younger U-rich basins with which they are associated, using structural settings, mineral paragenesis and crystal chemistry, character of fluids involved, the nature of the paleohydrologic system and critical factors in deposit formation. Goal is to relate significance of deposits in successor basins to more significant deposits younger basins.

University of Regina

1) "Geological, petrographic and geochemical characterization of the west zone of the Roughrider U deposit" (Thesis defended in May 2012). **Participants:** Rachel Boulanger (U of Regina, M.Sc. student), Guoxiang Chi (U of Regina), Alistair McCready (Hathor/Rio Tinto), Mostafa Fayek (U of Manitoba) detailed petrographic studies of alteration and mineralization, paragenesis, and 3D distribution; whole-rock geochemistry; U-Pb geochronology with SIMS

2) "A petrographic, fluid-inclusion and clay mineralogy study of the Athabasca Group from the Rumpel Lake drill core" (In progress). **Participants:** Ryan Scott (U of Regina, M.Sc. student), Guoxiang Chi (U of Regina), Sean Bosman (SER) detailed petrographic studies of Athabasca

Group sedimentary rocks; fluid inclusion microthermometry, Raman spectroscopy, and SEM-EDS, and EMP study of clay minerals. The aim is to reconstruct the paleo-geothermal gradient in the Athabasca Basin and estimate the thickness of eroded strata.

3) "Numerical modeling of fluid pressure regime in sedimentation history of the Athabasca basin: implications for fluid flow models related to unconformity-type uranium mineralization (In progress; paper in review). **Participants:** Guoxiang Chi (U of Regina), Sean Bosman and Colin Card (SER) 2D numerical modeling of fluid overpressure caused by disequilibrium compaction in the history of the Athabasca Basin, using the software Basin2.

4) "Diagenetic studies of the Athabasca basin and implications for uranium mineralization" (In progress). **Participants:** Haixia Chu (U of Regina, Ph.D. student), Guoxiang Chi (U of Regina) Detailed petrographic studies of sedimentary rocks of the Athabasca Group, mainly from deep drill cores away from known mineralization; analysis of fluid inclusions in authigenic quartz; major and trace element analysis of sedimentary rocks by affected by different diagenetic processes and mass balance calculation; establishment of background fluid temperature and composition to be compared with those in mineralized areas.

5) "Genetic relationship between episyenite and vein-type uranium mineralization in the Beaverlodge area" (started in 2012 summer). **Participants:** Rong Liang (U of Regina, M.Sc. student), Guoxiang Chi (U of Regina), and Kenneth Ashton (SER) Detailed petrographic studies of episynite; analysis of fluid inclusions in related hydrothermal minerals; major and trace element analysis of episynite and protoliths and mass balance calculation.

6) "Characterization of mineralizing fluids associated with vein-type uranium deposits in the Beaverlodge area: relationships with structures and the Martin Group." **Participants:** Student to be identified (U of Regina, M.Sc. student), Guoxiang Chi (U of Regina), Charles Normand and Kenneth Ashton (SER) Detailed studies of fluid inclusions in vein minerals associated with uranium mineralization and in quartz overgrowths in the Martin Group; fluid-inclusion plane studies in oriented samples.

7) "3-D geological characterization of the southeastern part of the Athabasca basin and modeling of fluid flow related to uranium mineralization" (Will be carried out under TGI-4 program of the Geological Survey of Canada, Started in spring, 2012 and will continue until spring, 2015).
Participants: Zenghua Li (U of Regina, Ph.D. student), Kathryn Bethune, Guoxiang Chi (U of Regina), Sean Bosman and Colin Card (SER) Regional analysis of the surface/subsurface geology and construction of a 3-dimensional model that will image fundamental lithological, structural and alteration features of the Key Lake–Russell Lake structural corridor of the eastern Athabasca Basin. Structural modeling will be accompanied by fluid flow modeling to determine fluid pathways and structural-fluid factors affecting mineralization.

8) "Deposit-scale study of structures and their relationship to alteration and fluids in the eastern Athabasca Basin" (Will be carried out under TGI-4 program of the Geological Survey of Canada. Project to be initiated in January, 2013 and will continue until 2015). **Participants:** (U of Regina, M.Sc. student), Kathryn Bethune, Guoxiang Chi (U of Regina), Sean Bosman and Colin Card (SER) Detailed structural/microstructural, alteration and fluid inclusion study of an unconformity-style uranium deposit (to be determined) in the Key Lake–Russell Lake structural corridor of the eastern Athabasca Basin. This project aims to determine, at a detailed level, if mineralizing fluids were focused at particular structural/microstructural sites (e.g., faults intersections, jogs and/or dilatant zones) in the deposit area/volume. It will also investigate the types, sources and fracture pathways of fluids and if/how changes in fluid pressure promoted faulting. The project is intended to complement the regional-scale modeling project described above.

9) "Regional basement geology to the Athabasca Basin: the role of inherited structures in post-Athabasca fault reactivation and uranium mineralization". **Participants:** Colin Card (U of Regina, Ph.D. student), Kathryn Bethune (U of Regina). Investigation of geological relationships in the basement of the Athabasca Basin, their tectonic development and controls, and their influence on the nature and location/distribution of uranium mineralization. Investigation will involve a combination of targeted field study and analysis of legacy geological maps, satellite imagery and radiometric and geophysical data.

University of Saskatchewan (see GSC and CMIC projects) Seismic Laboratory (Hajnal) and Industry:

1) Seismic investigations in the eastern Athabasca Basin. Study of full wave response properties of the sandstone and basement rocks utilizing a number of in situ measurements. Influences of alterations zones on intrinsic properties of the seismic signals. Determination of unique structural and attribute properties of mineralized zones in the Athabasca Basin

2) Geology, geochemistry and origin of the Fraser Lakes U-Th-REE pegmatites, Wollaston Domain (M.Sc.); Christine Austman, Kevin Ansdell, Irv Annesley (JNR Resources); supported by JNR Resources and NSERC

3) B, Li and Th-U-Pb analytical techniques and application to uranium mineralization (M.Sc); Rob Millar, Kevin Ansdell, Irv Annesley (JNR Resources); supported by SRC and NSERC

4) BSc students have been involved in numerous projects over the last few years, e.g. 2 last year - Geochemistry of mafic dykes in the Dufferin Lake area (complete), petrology of basement rocks, West Key Lake area (incomplete); Kevin Ansdell and students

University of Windsor

Jianwen Yang and colleagues' research continues on integrated numerical investigation of hydrothermal fluid flow in sedimentary basins: Implications for the formation of unconformity-type uranium deposits.

Recent publications include:

Cui, T., Yang, J., and Samson, I.M., 2012, "Uranium transport across basement/cover interfaces by buoyancy-driven thermohaline convection: implications for the formation of unconformity-related uranium deposits," submitted to *American Journal of Science*.

In review; and Cui, T., Yang, J., and Samson, I.M., 2012, “Tectonic deformation and fluid flow: implications for the formation of unconformity-related uranium deposits,” *Economic Geology*, 107, 147-163.

AREVA

1) Iron Oxides; Georges Beaudoin (Laval University); (being organized)
- Characterize iron oxides present in and around uranium deposits - Shea Creek and Kiggavik;

2) Project Wollaston; Philippe Goncalves and Pauline Jeanneret (Université de Franche-Comté; Ph.D thesis)
- Role of metamorphism, partial melting, and transpressive deformation on U (re)mobilization in the Mudjatik-western Wollaston Domains boundary region

3) Alteration systems; Daniel Beaufort and Freddy Uri (Université de Poitiers; Ph.D thesis)
- Clay alteration and uranium mineralization in the Shea Creek area

4) Alteration systems; Daniel Beaufort and Thomas Riegler (Université de Poitiers; Ph.D thesis)
- Uranium mineralization and alteration systems along the Kiggavik and Andrew Lake trend (NU), with comparisons to Athabasca alteration systems

5) Quaternary indicator minerals; Dan Layton-Matthews & Scott Robinson (Queen's University; MSc thesis)
- Drift prospecting indicator mineral technology to be developed for the eastern Thelon Basin unconformity-type uranium deposits; possible applications to Athabasca exploration

6) Geochronology; Mostafa Fayek and Dan Hrabok (University of Manitoba; B.Sc thesis)
- Uranium mineralization and geochronology of the Sue D deposit

7) Geochronology; Mostafa Fayek and Ryan Sharpe (University of Manitoba; B.Sc thesis; Ph.D thesis TBD)
- The Kiggavik (Thelon Basin) and Shea Creek (Western Athabasca Basin) Uranium Deposits: A Comparative Study

Cameco Corporation (See also GSC projects and Queen’s University)

1) Uranium Deposit Speciation study (Unconformity only) University of Manitoba - Dr Mostafa Fayek - joint with Laurentian University as well. PhD project student Jennifer Durocher
- To geochemically "map" alteration and ore minerals at McArthur River. This speciation study is using VESPERS beamline technology at the CLS facility in Saskatoon. This new technology has XRF, XRD and XAS components and has the capability of determining trace element contents to PPM levels in mineral grains of only several microns in size.
- 2012 is year 4 of 4.

2) B.Sc. Theses

University of Saskatchewan to date but all are welcome.

• A budgeted amount has been set aside to support BSc thesis students/projects, to date exclusively at the University of Saskatchewan.

• Recently completed projects include “Petrography and Geochemistry of the Key Lake Trend Basement Stratigraphy” and “The petrology and geochemistry of diabase dykes from the Centennial deposit and area, Northern Saskatchewan”.

CanAlaska Uranium

No specific research but continuously investigating the relationships between the responses of the various geophysical methods (mainly ground EM and DC) and the drill-core lithology and down-hole probing techniques.

JNR Resources

See University of Saskatchewan.

Uravan Minerals (See Queen’s University)

OTHER NON-PROFIT ORGANIZATIONS

Canadian Mining Innovation Council (CMIC)

University of Saskatchewan (Kevin Ansdell), 15 Industry Participants (Cameco is the project host), Geological Survey of Canada, Saskatchewan Geological Survey: Footprints Project – Uranium

• Develop a profile of the mineralizing system focused along the Millennium-McArthur trend.

• Develop quantitative multi-parameter models and tools that combine a wide range of different data types in order to derive the most sensitive indicators of the ore-system “footprint” and thereby enhance our ability to detect and navigate from their most distal margins to their high-grade cores.

Research Activities at Australian Universities and Government Agencies

Australia has the world’s largest Reasonably Assured Resources (RAR) of uranium and currently is the world’s third largest producer of uranium after Kazakhstan and Canada. There are three operating uranium mines, at Olympic Dam and Beverley in South Australia and Ranger in the Northern Territory, plus three additional operations are scheduled to begin production in the near future. Australia’s uranium production is forecast to more than double by 2030. Australia is a dominant supplier to the world and has been so for the past 30 years (more). The country has a vigorous research program underway at the federal, province, and university levels.

Australian National University:

Precise Timing of Ore Formation Project
Dr. Y. Amelin and Dr. Ian Campbell.

This project is aimed at dating the giant Olympic Dam Cu-Au-REE-U deposit and its host rocks using modern high-precision geochronology. Precise knowledge of the age relationships between ore formation and related magmatism, metamorphism and fluid migration is necessary for understanding the conditions of ore formation. The age of the Olympic Dam deposit is currently known with precision of ca. ±10 million years, which is insufficient for resolving the ages of individual components in the Olympic Dam Breccia Complex.

The objective is to date zircon and other uranium-bearing accessory minerals from the key rocks in the Olympic Dam Breccia Complex, with precision by 10-30 times higher than before, using high-precision U-Pb isotopic analyses. The project will involve developing better constrained models of formation of this unique deposit, using the determined isotopic ages.

CSIRO [Commonwealth Scientific and Industrial Research Organization – Australia's National Science Agency] published the following:

Geology, geochemistry and mineralogy of the lignite-hosted Ambassador palaeochannel uranium and multi-element deposit, Gunbarrel Basin, Western Australia. Author(s): Douglas, Grant; Butt, Charles; Gray, David *Mineralium Deposita*; October, 2011, Vol. 46, Issue 7, p. 761

Macquarie University, GEMOC, Department of Earth and Planetary Sciences:

Dr. Simon Turner, Dr. Bruce Schaefer and Dr. Anthony Dosseto and graduate student Melissa Murphy are evaluating the viability of using U-series isotopes as an exploration tool for U mineralisation, characterize the uranium minerals, and to improve understanding of the behavior of U and its decay products during transport and solid-fluid interactions in an environment where both known and potential U ore deposits are located.

Current research is focused on the Beverley sedimentary uranium system, South Australia, which is currently being exploited by in-situ leaching (ISL), and the adjacent Four Mile prospect which is presently the subject of intense exploration drilling but have not yet been modified by mining activities. Groundwater sample will be collected along the groundwater flow and analyzed for U and Th concentrations, (^{234}U/^{238}U), (230Th/234U) and (^{230}Th/^{232}Th) activity ratios. Results will be used to assess the viability of using combined variations in concentrations and isotopic ratios to identify the location of the high-grade U deposit, and subsequently the use of U-series isotopes as a vector for U mineralisation. Rock samples containing uranium minerals will also be analyzed for U and Th concentrations, (^{234}U/^{238}U), (^{230}Th/^{234}U) and (^{230}Th/^{232}Th) activity ratios in order to constrain the age of the mineralization in order to gain an improved understanding of the timing and conditions of formation and the evolution of the Beverley/ Four Mile uranium deposits.

Dr. Mark C. Pirlo, also at Macquarie University, published the following abstract:

> **Geochemical Modeling of Wastewater Disposal at the Honeymoon In-Situ Leach Uranium Mine, South Australia.**
>
> *The Honeymoon Uranium Project in South Australia will use an acid in-situ leach (ISL) mining technique to recover uranium from mineralized sand aquifers in Tertiary paleochannels. The geochemical modeling code REACT has been used to study wastewater arising from the uranium leaching and extraction plant operations. The preferred disposal option for the wastewater is re-injection into local aquifers. Mixing reactions involving this wastewater and natural groundwater have been examined with the model to estimate the potential for adverse mineral precipitation and environmental problems. Total mineral precipitation is estimated to be less than* $4x10^{-2}$*g/L, based on a groundwater: wastewater mixing ratio of 10:1. These results lend support to the preferred disposal technique.*

University of Sydney:

Dr. Adiana Dutki's interests are in the role of hydrocarbons the genesis of ores and ore-forming systems in sedimentary basin hosted mineral deposits. Her work to date has included uranium deposits at Elliot Lake in Canada and the natural fission reactors at Oklo in Gabon.

The University of Queensland:

Dr. Gordon Southam co-authored the following publication:

Structural and biological control of the Cenozoic epithermal uranium concentrations from the Sierra Peña Blanca, Mexico, Angiboust, S., Fayek M., Power I. M., Camacho A., Calas G., and Southam Gordon , *Mineralium Deposita*, Volume 12, p.859-874, (2012)

University of Adelaide:

Dr. Steven Hill's interests are in silcretes, specifically their characteristics, evolution and mineral exploration significance. The chemical and morphological characterization of silcretes can be used to develop models for their evolution, and these models can be used to develop mineral exploration programs for resources such as sedimentary hosted uranium deposits.

His uranium related publications include:

Hore, S. B. & Hill, S. M. (2010). Palaeoredox fronts: setting and associated alteration exposed within a key section for understanding uranium mineralisation at the Four Mile West deposit. *MESA JOURNAL*, 55, 34-39.

Hill, S. M. & Hore, S. B., 2009. Northern Flinders Ranges – Lake Frome Plains uranium exploration under cover: new geological insights through collaboration. *MESA JOURNAL* 53, 28-31.

Hore, S. B. & Hill, S. M., 2009. Four Mile Creek uranium: basement to cover. In: Korsch, R.J., editor, Broken Hill Exploration Initiative: Abstracts for the 2009 Conference. *GEOSCIENCE AUSTRALIA RECORD*, 2009/28, 79-82.

He is supervising graduate student Byron Dietman (commenced 2010) whose project is:

> REGOLITH EXPRESSION OF IRON OXIDE COPPER GOLD URANIUM (IOCGU) MINERALISATION IN THE SOUTHERN OLYMPIC DOMAIN, GAWLER CRATON, SOUTH AUSTRALIA.

III. Uranium-Related Government Research Activity

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

Uranium related research at government agencies in 2012 was mostly limited to the USGS and the Wyoming State Geological Survey (WSGS) in cooperation with the University of Wyoming Department of Geology and Geophysics (UW-GG). The USGS continues its research into the uranium ore forming processes and the geology and geochemical changes that take place during extraction and processing.

The aim is to develop environmentally sustainable methods that will benefit the recovery and restoration processes associated with in-situ recovery (ISR) of uranium. Dr. Tanya Gallegos of the USGS in Denver, leads a study entitled "Impacts of Uranium Mining/ Milling on Groundwater and Remediation with Mackinawite." Certain sulfides, either natural or introduced, can aid the groundwater restoration process by hastening the necessary reduction required to stabilize minerals such as uraninite. The iron sulfide mackinawite, and possibly similar minerals, may prove useful in precipitating uranium and other metals in order to return the groundwater to pre-mining conditions.

In future research, Dr. Gallegos hopes to explore other areas such as 1) characterizing core samples from an ISR operation to determine elemental associations with uranium, 2) laboratory simulation of ISR to extract uranium and characterize solids in the system, and 3) simulated remediation using mackinawite and its effectiveness on fixing uranium and other metals. For more information visit: http://geology.usgs.gov/postdoc/profiles/gallegos/.

In cooperation with active Wyoming uranium mining operators, the WSGS and the UW-GG have acquired well-controlled samples of pre-mineralized, mineralized, and post-mineralized host sandstones and also plan to study associated native waters. Investigators on this project are Susan M. Swapp, Robert W. Gregory, B. Ronald Frost, Carol D. Frost, Jonathan F. McLaughlin, Davin Bagdonas, Charles Nye, and William White. They are using field emission scanning electron microscopy (FESEM), powder x-ray diffraction (XRD), and wavelength dispersive x-ray analysis (WDS) on an electron probe micro analyzer (EPMA), x-ray fluorescence (XRF), stable isotope mass spectrometry, and traditional wet chemical analyses at UW-GG to characterize host rocks, native ground waters, and uranium minerals in these deposits.

These data, together with radiogenic isotopic data for accessory minerals acquired using instrumentation at Stanford University, will enable us to recognize potential source areas for the uranium in individual deposits. Identification of uranium mineralogy will hopefully facilitate more thorough and effective ISR mining processes, and a better understanding of uranium source rocks and controls on deposit formation will enhance prospecting and initial evaluation of new deposits. The study will end in June, 2014.

In September, 2012, I presented a talk at the Rocky Mountain Section of AAPG in Grand Junction entitled "Aspects of Ore Genesis at the Lost Creek Uranium Deposit, Sweetwater County, Wyoming." This was a brief update on the above mentioned study with WSGS and UW-GG presenting some of our preliminary findings, questions, and a summary of the direction in which we would like to proceed.

Also at the WSGS, Wayne M. Sutherland, Brett Worman, Jacob Carnes, and I are currently finalizing a reconnaissance survey of potential rare earth element (REE) deposits and anomalous occurrences. Follow-up studies on known sites with anomalous REE values were visited and resampled, not only for REE but also other potential minerals of potential economic value. Additionally, we sampled dozens of sites around Wyoming which may have potential for REE occurrences based on what is known about existing deposits in Wyoming and elsewhere.

The study also involved data mining at WSGS and beyond as well as testing of geologic samples collected in conjunction with past WSGS investigations but for which REE was not the focus. All field and geochemical data is being compiled into an interactive database which will be made available to the public upon the project's completion in June, 2013.

Geological Survey of Canada Managed Research (GSC)

GEM Program

1) Origin, transport and emplacement of uranium mineralization in different Paleoproterozoic Basins of Northern Canada.
<u>Proponents:</u> Mostafa Fayek (University of Manitoba) and graduate students.

Goals:

- Determination of the relative and absolute timing of primary and secondary uranium ore minerals and disseminated uraniferous phosphate minerals such as fluorapatite and xenotime;
- For both the Thelon and Athabasca basins: investigate the paragenetic, isotopic and spatial relationships of uranium-oxides and phosphates in a basinal context, and identify and evaluate the pathways most important for uranium deposition.

2) The Centennial unconformity-related uranium deposit, south-central Athabasca Basin, Saskatchewan. (Additional funding from Cameco Corp. and NSERC)

Proponents: Kevin Ansdell, Ph.D. student Kyle Reid, Colin Card (SGS), Dan Jiricka (Cameco), Gary Witt (Cameco) and Eric Potter (GSC).

Goals:

- Regional setting, geology and paragenesis of the Centennial unconformity-related uranium deposit, Athabasca Basin, Saskatchewan, Canada
- Compare basement geology of the immediate deposit area to nearby exposures of Virgin River domain to improve surface-subsurface correlations and predictions.
- Secondary processes tied to the MacKenzie Dykes

TGI4 Uranium Project

1) Alteration and radiogenic nuclides in various media along major faults in the Athabasca Basin, Saskatchewan.
Proponents: Keiko Hattori (U of O), M.Sc. student Jack Dann, M.Sc. student Michael Power, M.Sc. Student Erin Adlakha, Eric Potter and SGS

Goals:

- Investigate and characterize alteration along major faults associated with uranium mineralization and compare this to barren or "background" alteration; and
- Evaluate the surface expression of concealed uranium deposits by examining the chemistry of various surface media over deeply buried systems.
- Link surficial geochemical anomalies to alteration in bedrock and track vertical element mobility, forming the basis of a robust exploration vectoring tool.

2) Graphite loss associated with unconformity-related uranium mineralization in the Dufferin Lake area, Virgin River trend (Additional funding from Cameco Corp. and NSERC)
Proponents: Kevin Ansdell (U of S), MSc student Marjolaine Pascal, Irvine Annesley (JNR), Dan Jiricka, Gary Witt, and Aaron Brown (Cameco).

Goals:

- Characterize and compare the mineralogy, petrology and geochemistry of graphite-bearing basement rocks with texturally and lithologically similar rocks that appear to have lost their graphite content near uranium mineralization; and
- Understand the processes under which graphite forms or is destroyed, and the relationship, if any, to the formation of uranium mineralization.

3) Mg- and Fe-isotopic signatures of alteration associated with formation of unconformity-related U deposits, Athabasca Basin, Saskatchewan.
Proponents: Eric Potter, Simon Jackson, Isabelle Girard (GSC)

Goals:

- Quantify the Mg and Fe-isotopic signature associated with weathering, diagenetic alteration and hydrothermal alteration in the Athabasca Basin;

- Distinguish between fertile (redox evident) and barren (no redox signature) alteration systems; and
- Develop exploration criteria for critical examination of unconformity-related uranium alteration systems through a combination of Mg and Fe-isotopes. Update: Planning start of project in spring 2013.

Saskatchewan Geological Survey (SGS)

Proponents: Colin Card and Sean Bosman: Athabasca Uranium Ore Systems

Goals:

- 3D and 4D analysis of the Athabasca Basin and its ore systems to help define the geologic environment through time and the background conditions in the Athabasca Basin and it basement rocks.
- Project involves collaboration with the Geological Survey of South Australia, particularly on 3D modeling, geophysical interpretation and scientific direction.

STATUS OF THE THORIUM INDUSTRY

China has used older American research to pursue a safer reactor based on thorium (more). A Norwegian company is breaking with convention and switching to an alternative energy it hopes will be safer, cleaner and more efficient. This discusses the switch from uranium to thorium. Oslo based Thor Energy is pairing up with the Norwegian government and U.S.-based (but Japanese/ Toshiba owned) Westinghouse to begin a four-year test that they hope will dispel doubts and make thorium a viable addition to the nuclear fuels. Thorium will be used at a government reactor in Halden (more).

Most of the world's nuclear power reactors tend to run on uranium fuel, be cooled by water and, in order to sustain the heat-giving nuclear reaction in the reactor core, they must slow down the neutrons that the fuel emits. However, there are a range of reactor designs in various stages of development that differ from these and that may offer advantages over currently available reactor systems. Some of these also offer the possibility of using thorium, rather than uranium as a fuel, which also may offer desirable characteristics.

United Kingdom research is currently directed to consider a range of advanced reactor systems and fuel cycles, to offer insight into their potential advantages and disadvantages and to highlight some of the challenges to developing them (more).

The research subjects suggested for U.K. research should be seen as a preliminary analysis of technological potential and are not intended as an exhaustive review. Additionally, they do not aim to include the influence of market and policy drivers in the future, which would determine whether the technological characteristics might deliver real-world advantages. These influences would include changes in demand for energy, the level of worldwide uptake of nuclear power, developments in nuclear waste disposal technology and the growth of other energy generation sources.

- Review of metrics relevant to reactor systems - the definition and selection of the characteristics being considered in these reports.

- Assessment of advanced reactor systems against UK performance metrics - an assessment of the reactor types against aggregated 'scorecards', offering a combined view of these characteristics. Advanced technologies are compared against the typical current reactor types.

- Comparison of thorium and uranium fuel cycles - an assessment of how the use of uranium and thorium fuels compare within these reactors.

- Addendum to NNL(11)11491: review of metrics relevant to reactor systems - a refinement of the original metrics in order to remove duplications of characteristics.

- Addendum to NNL(11)11620: assessment of advanced reactor systems against UK performance metrics - further reactor system assessment: an assessment of the reactor types using the metrics determined in Addendum 1, grouped to highlight how they deliver to individual objectives

Many energy scientists indicate that there must be a paradigm shift away from unsustainable energy to sustainable and affordable energy sources such as the Liquid Fluoride Thorium Reactor (LFTR). The literature is increasing and even blogs are now devoted to promoting thorium as a sustainable fuel (more).

The following is from *The Energy from Thorium* blog. LFTR is not a concept. LFTR is combination of proven technologies the Federal Government pursued in the 1950s and 1960s. The Thorium fuel cycle was abandoned, not because it was unsuccessful, it was abandoned because of political and military considerations. Other nuclear fuel cycles produce materials needed to make nuclear weapons and the Thorium fuel cycle does not produce materials suitable for making weapons.

A precursor to the LFTR reactor, the Molten Salt Reactor (MSR), was constructed at Oak Ridge National Laboratory in Oak Ridge, Tennessee. This pilot reactor ran flawlessly for four years and help proved the basic concepts of a LFTR reactor.

A traditional Light Water Reactor (LWR) is a solid-fuel design and the LFTR reactor is a liquid-fuel design. Today's LWR's run on uranium and needs to be enriched in order to be used in a reactor. During the fissioning process in a LWR, heat is produced that is used along with pressure and water to produce steam that in turn drives the turbines that produce electricity.

During the fissioning process "transuranics" are produced. Transuranics are a byproduct of the fissioning process that eventually contaminates uranium fuel and stops the fissioning process. LWRs consume less than 1% of their fuel and the rest is contaminated with transuranics making it unusable for further use and difficult to handle as a waste.

LFTRs are exactly the opposite of LWRs as they consume about 99% of their fuel. A LFTR can do this because its fuel is a liquid and the transuranics can be chemically removed in the normal course of operations. Transuranics materials such as xenon are a valuable material used in industry. The 1% of waste that remains in a LFTR is only radioactive for 300 years, compared to the 10,000 year waste produced by a LWR.

Because a LFTR's core is made of molten salt and thorium it cannot melt down, the core is already melted, and because of the physical design of a LFTR, it does not require human intervention or backup systems to shut the reaction down. The design and reaction of LFTR are passively safe.

LFTR does not use water as a coolant. It uses the molten salt as a coolant. This means a LFTR can be placed in areas with no water source and there is no potential for a massive cloud of radioactive steam forming if something would go wrong with the reactor. Because the reactors do not use water and run at near atmospheric pressures the reactor itself can be much smaller and be placed closer to energy consumers.

This also means a LFTR system improves the energy grid through distributive generation. The very high process temperatures of LFTR make it also a candidate for co-generation and to produce transportation fuels.

The second generation of LFTR will be manufactured with high-heat neutron-resistant materials that will allow higher process heat that can be used to crack carbon out of the atmosphere and produce carbon neutral transportation fuels.

Phase 1: LFTR could displace less environmentally friendly forms of electricity generation.

Phase 2: LFTR could recover oil from oil shale and help stabilize world-energy markets.

Phase 3: LFTR could be used to transform Coal and Natural Gas into Methanol and Compressed Natural Gas (CNG) in an affordable and environmentally friendly manner.

Phase 4: A Very High Temperature Liquid Fluoride Thorium Reactor (VHTLFTR) could be developed that will use atmospheric carbon to produce CO_2-neutral transportation fuels.

Geochemically, thorium is four times more abundant than uranium in the crust of the Earth and economic concentrations of thorium are found in a number of countries. Geologically, thorium deposits are found in various geological environments, such as alkaline complexes, pegmatites, carbonatites and heavy mineral sands with wide geographic distribution. Worldwide, current thorium resources are estimated to total about 6 million tons. Major resources of thorium are present in Australia, Brazil, Canada, India, Norway, South Africa and the U.S. Thorium exploration is presently ongoing in some countries, such as India and U.S. The present production of thorium is mainly as a by-product of processing of heavy mineral sand deposits for titanium, zirconium, tin and REEs.

Thorium is widely available in Australia from sands containing monazite in heavy-mineral beach sand deposits. A possible key factor is that thorium is three to five times more abundant than uranium, (more). Thorium (and REEs) have also been tentatively identified on the Moon (see summary (here).

STATUS OF THE RARE EARTH INDUSTRY

The EMD Mid-Year Report for 2011 (2011) offers the uninitiated an introduction to the rare earth commodities. That report covers the list of 17 rare-earth elements (REEs), their geological origins and distribution, production, prices, and explores some of the geopolitical issues involved, with a brief description of the REEs on the Moon. That report also contains numerous references on REE deposits.

ALEC (American Legislative Exchange Council) reports that Consultant Tom Tanton (of T2 & Associates, Inc.) estimates the U.S. must import 96% of the rare earths consumed and 92% of uranium consumed, while $40 billion in increased economic development are lost and nearly 9,000 jobs not filled due to bureaucratic and political demands impacting mine permitting. He recommends trade missions to Australia and Canada where mine permitting is often completed in one quarter of the time while meeting all appropriate environmental and mine-safety concerns, which eliminates mining opponents from using faulty science to delay or deny mining projects. See www.alec.org for the report and news of a May 2-3, 2013 Task Force Summit in Oklahoma City, OK.

For this 2013 Annual Report, although the first quarter of 2013 was challenging for the rare-earth sector as a whole because a lack of development funding, there have been some notable developments, especially with a few junior REE mining companies. China continues to acquire properties and companies in various parts of the world. Here is a list of some of the sector's main highlights over the first quarter, 2013. The following is a summary of the report by Currie (2013).

1. Greenland Minerals and Energy (ASX:GGG) conducted studies that show that the costs and risks associated with its Kvanefjeld project can be lowered and its financial returns increased if it establishes the refinery for the project outside of Greenland. The company had originally considered establishing the refinery for uranium and heavy and light REEs in Southern Greenland, in proximity to the mine and concentrator.

2. Search Minerals (TSXV:SMY) announced a revised preliminary economic assessment (PEA) for its Foxtrot REE project, which is located in Labrador, Canada. Highlights include a reduction in capital costs from $469 million to $221 million, with a 3.8-year payback period. Further, net revenue for the project has increased by $110 per MT milled and operating expenditures have increased by $38 per MT. The revised project will now focus on higher-grade REE material of "0.89% total REE … on average, which compares to the 0.58% TREE on average for the original bulk open pit concept," according to a press release.

3. Peak Resources (ASX:PEK) announced further improvements to beneficiation process for its Ngualla rare earth project in Tanzania. It confirmed that the ability to concentrate mineralization at an early stage prior to acid-leach recovery is likely to have a "significant impact" on costs. One improvement is that the optimization of the beneficiation process reduces by 43% the mass of feed to be treated by the acid-leach recovery process. The latest test work also indicates that conventional magnetic separation and flotation techniques will reduce the mass of the feed mineralization by 78% through the rejection of relatively mineralized barite and iron oxides. The cost reductions will be quantified in a revision of the scoping study, and an economic assessment is scheduled for completion in the second quarter of 2013.

4. Rare Element Resources (TSX:RES,AMEX:REE) announced a 65% increase to its total measured and indicated (M&I) REE resource estimate for the Bear Lodge project. The increase saw a rise from 571 to 944 million pounds of REO. The updated NI 43-101 compliant resource estimate includes the first indicated resource at the heavy rare earth element (HREE)-enriched Whitetail Ridge deposit and high grades of critical rare earth oxides (CREOs) in all deposits. CREOs are rare earth oxides that have the highest values and the strongest projected future growth.

5. Great Western Minerals Group (TSXV:GWG) released a PEA for its Steenkampskraal REE project that indicates strong potential for its integrated business model. Project highlights include a $555-million after-tax net present value when applying a 10% discount rate, a 28% South African corporate tax rate and a 66% after-tax internal rate of return. On an after-tax basis, the project has a 4.3-year estimated payback period from the start of underground mining production. It also has an 11-year potential mine life.

6. Tasman Metals (TSXV:TSM) announced the first NI 43-101 compliant independent resource estimate for its 100%-owned Olserum HREE project in Sweden. Its press release notes that highlights include a 0.4% total rare earth oxide (TREO) cut off, an indicated resource of 4.5 million MT at 0.60% TREO and an inferred resource of 3.3 million MT at 0.63% TREO. It adds that "higher value" HREEs comprise 34% of the total REE content at Olserum, with the five critical REEs (dysprosium, terbium, europium, neodymium and yttrium) comprising approximately 40% of the REE content.

7. Ucore Rare Metals (TSXV:UCU) confirmed that United States senators Lisa Murkowski and Mark Begich jointly introduced a bill in Washington, DC to authorize construction of a road to the Niblack and Bokan Mountain projects on Prince of Wales Island. Ucore also highlighted the introduction of Senate Joint Resolution No. 8 in the Legislature of the State of Alaska by senators Lesil McGuire, Berta Gardner and Johnny Ellis. The resolution supports the continued and increased exploration, extraction, processing and production of REEs in the state. It is positive news for the project as it supports a number of initiatives and urges state agencies that administer the permits required for the development of REE projects in Alaska to expedite the consideration and issuance of permits for the development of REE deposits.

8. Quest Rare Minerals (TSXV:QRM,AMEX:QRM) provided an update on the preparation of a PFS for the B-Zone deposit at its Strange Lake HREE deposit, located in Quebec. It confirmed that significant development work demonstrates that Strange Lake is a "very large rare earth project" with high concentrations of HREEs, as well as by-products such as zirconium and niobium.

9. The U.S. Geological Survey has generated a webpage offering information on mineral deposits containing REE and yttrium from around the world with geographical locations, grade, tonnage, and mineralogy, where available (more).

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