

State of the Uranium Industry in the U.S. & the World: 2011

Another Report by the AAPG EMD Uranium (Nuclear Minerals) Committee

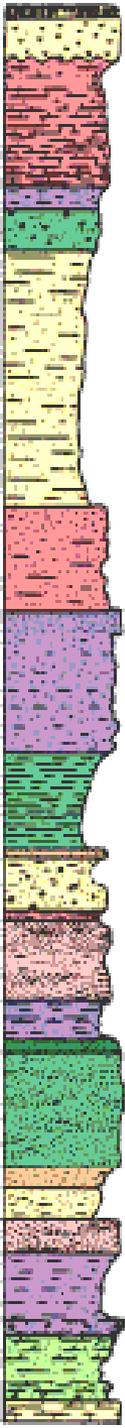
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Presentation to the Ohio Geological Society
Ramada Plaza Hotel & Conference Center 4900 Sinclair Rd.,
Columbus, Ohio



AAPG, Energy Minerals Division
April 21, 2011

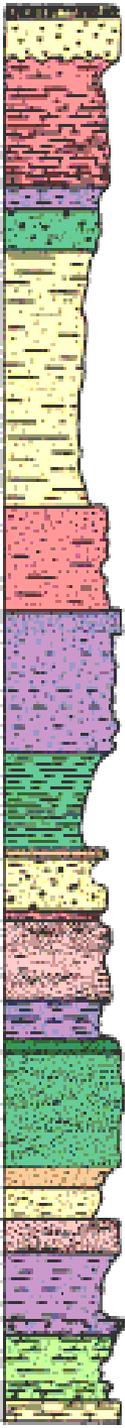


Introduction

In this presentation, I will first briefly discuss the recent activities of the Energy Minerals Division of AAPG and of its various commodity committees. I will then discuss a range of topics involving uranium exploration and nuclear power. This will range from the pros & cons of nuclear power to public concerns, and to exploration, development and production practices and anticipated yellowcake prices. I will then discuss the typical concerns still expressed by many anti-nuclear groups and by the media serving them, including various unrealistic expectations they hold, various forms of mis-information they believe, and various half-truths they circulate.

With the above as background, I'll summarize current conditions and our expectations on the energy picture over the next 30 years, specifically to generate electricity in the U.S., in terms of both small- and large-scale nuclear plants, and in terms of the future source of nuclear fuel (yellowcake as precursor to the fuel) produced in the U.S. and overseas, where new deposits are being discovered at an increasing rate, and perhaps even on the Moon in the foreseeable future.

Interest in nuclear power continues to grow in the U.S. with more than 50 permit applications now under review for building new plants. Nations around the world are looking to increasing their use of nuclear energy to generate greenhouse gas emission-free electricity because it is the cleanest technology available that is capable of producing the amount of electricity required at a competitive cost. With this increase in interest, there has been an increase in uranium exploration and production, with new exploration targets and new and old mines being opened as the market price of yellowcake begins to increase.



Introduction (Cont.)

The renewed activity has also encountered an equally increased resistance from a few adversarial groups, especially in Texas, New Mexico, and Colorado. These groups base their objections on exploration and mining techniques and mining laws that were in effect 30 years ago and more. Unfortunately, many in the news media have been reporting on these complaints without regard to important improvements in exploration and uranium recovery techniques, and environmental protection laws. This has led the general public to believe that uranium exploration and recovery will poison both land surface and underlying aquifers over vast areas. Typical concerns by environmental advocacy groups and associated media often claim that no in-situ uranium recovery operations ever remediated the mined area to its original condition and that the companies all had to amend their permits. None of this is true, of course.

The disaster in Japan involving major earthquakes, and followed by major tsunamis that took away even the back-up power supplies that operated the pumps that normally keep the spent fuel rods cooling, has even damaged the Fukushima Daiichi Nuclear Power Plant, which has leaked some radioisotopes into the air and the ocean nearby. All indications suggest that this too will pass without many casualties, and that the nuclear industry will learn from this and return to a renewed construction program on the large base of nuclear power plants that will be needed in the U.S. over the next 30 years.

They also claim that there are health risks living around in situ uranium facilities and release radiation into the air, which increases human cancer rates. In addition, they also claim that nuclear power isn't really carbon-free because the associated environmental costs of in-situ uranium recovery operations are not being fully assessed, such as energy/water/chemicals consumption, greenhouse gas emissions, and social issues, claiming that significant gaps remain in complete sustainability reporting and accounting. None of this is true, of course. I will evaluate these misconceptions in some detail.

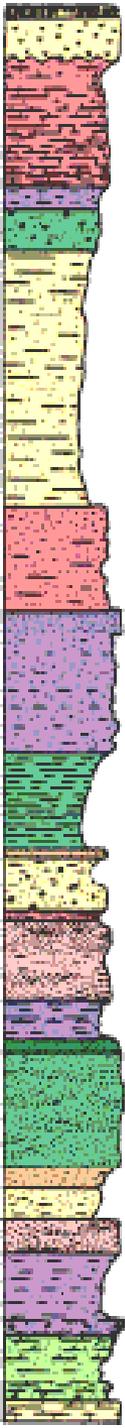
Presentation Coverage



- ❖ But first... a few words from our sponsor...

The Energy Minerals Division ([EMD](#)) of the AAPG is pleased to underwrite this presentation as part of your benefits as an Affiliate Society of The American Association of Petroleum Geologists (AAPG) and the Eastern Section of the AAPG.

- ❖ Pros & Cons of nuclear power
- ❖ How to treat public concerns, well meaning or otherwise biased.
- ❖ The current state of exploration, development and production practices and anticipated yellowcake prices.
- ❖ What's in the future for Energy Resources?



EMD Support of AAPG ACE & ICE:

❖ Houston ACE - 2011

- 20 EMD-Sponsored Sessions,
- 6 Short Courses- Ranging from Shale Gas, Geothermal in the O&G Industry, to Hydrofracturing, and others.
- 1 Field Trip – Growth Faulting at the Surface in the Houston Area.
- Recent meeting in Houston broke attendance records for the past 20 years (~ 8,200).

❖ Milan ICE - 2011

❖ Singapore ICE - 2012

❖ Long Beach - 2012

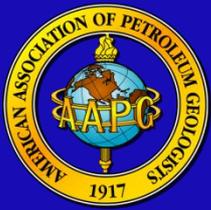
❖ Pittsburg - 2013





EMD Publications:

- ❖ ***Energy Resources for Human Settlement in the Solar System and Earth's Future in Space***
AAPG Special Publication - Print or CD – In Press: Early 2012
- ❖ ***Shale Petroleum Reservoirs***
AAPG Memoir 97 – Print and CD – In Press: 2011
- ❖ ***Heavy Oil/Bitumen Petroleum Systems in Alberta & Beyond***
AAPG Memoir -CD – In Press: 2011
- ❖ ***Coal Assessment of the Gulf Coast***
AAPG Studies in Geology- CD – In Press: 2011
- ❖ ***Atlas of Coal Geology***
AAPG Studies in Coal – 2nd Edition- CD - In Press: 2011
- ❖ ***Update on Unconventional Energy & Alternative Energy Resources***
(Paper in *Journal of Natural Resources Research* – Print – In Press: 2011)
- ❖ [Planning Stage:](#) *Geothermal Energy in the Oil & Gas Industry*



EMD Commodity Committees on:

Oil Shale

Gas Shales

Coalbed
Methane

Oil Sands



Gas
Hydrates

Tight Gas Sands

Uranium

Geothermal

Coal

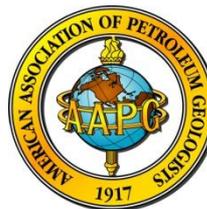
Energy
Economics &
Technology

Renewables

Enhancing contributions through an Energy Resource Specific organization

2010-2011 EMD Executive Committee

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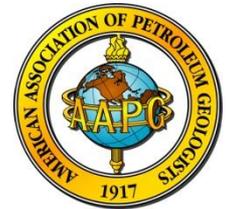


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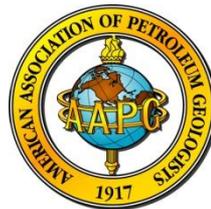
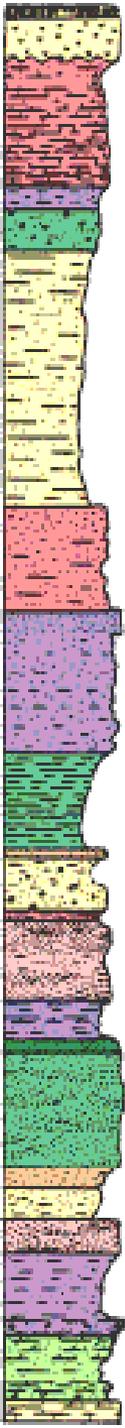
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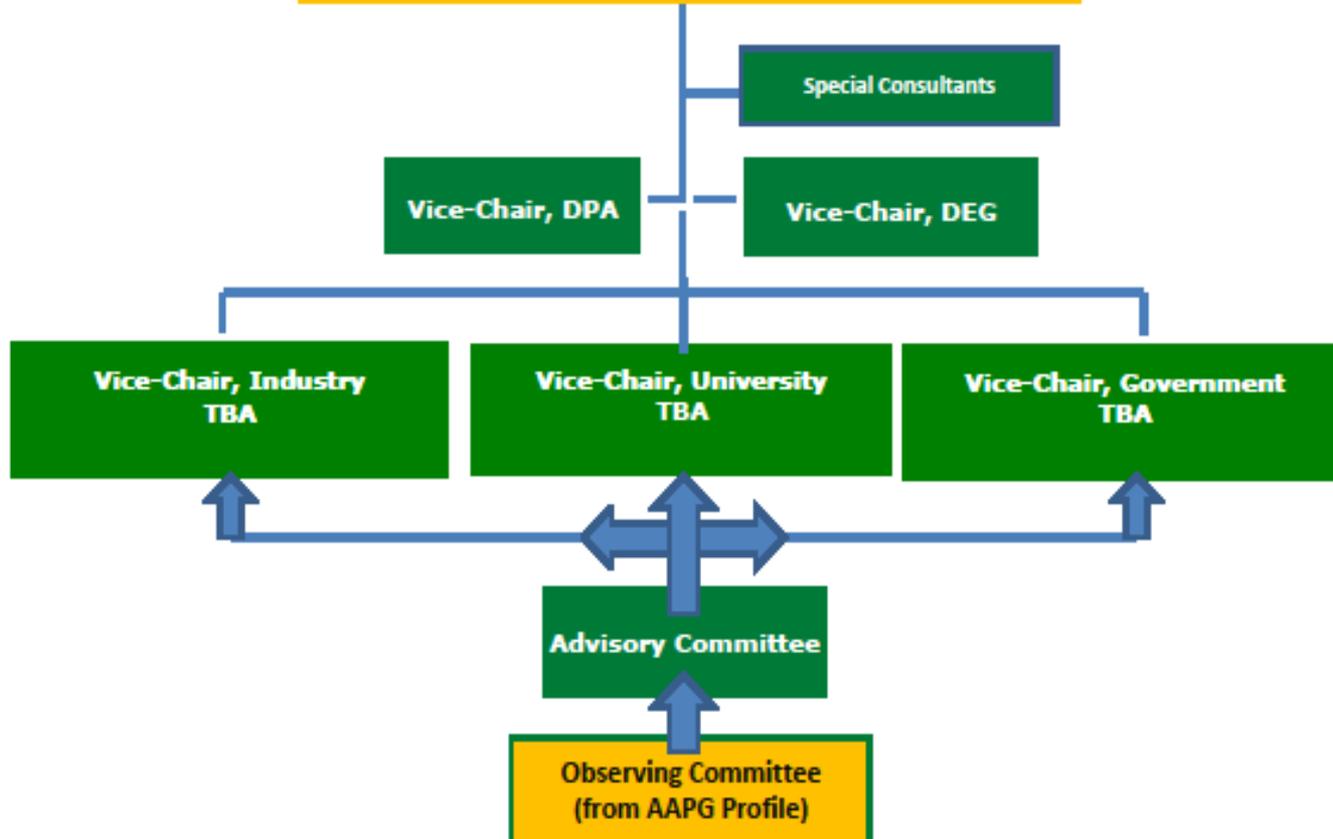
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Gas (Tight) Sands Committee

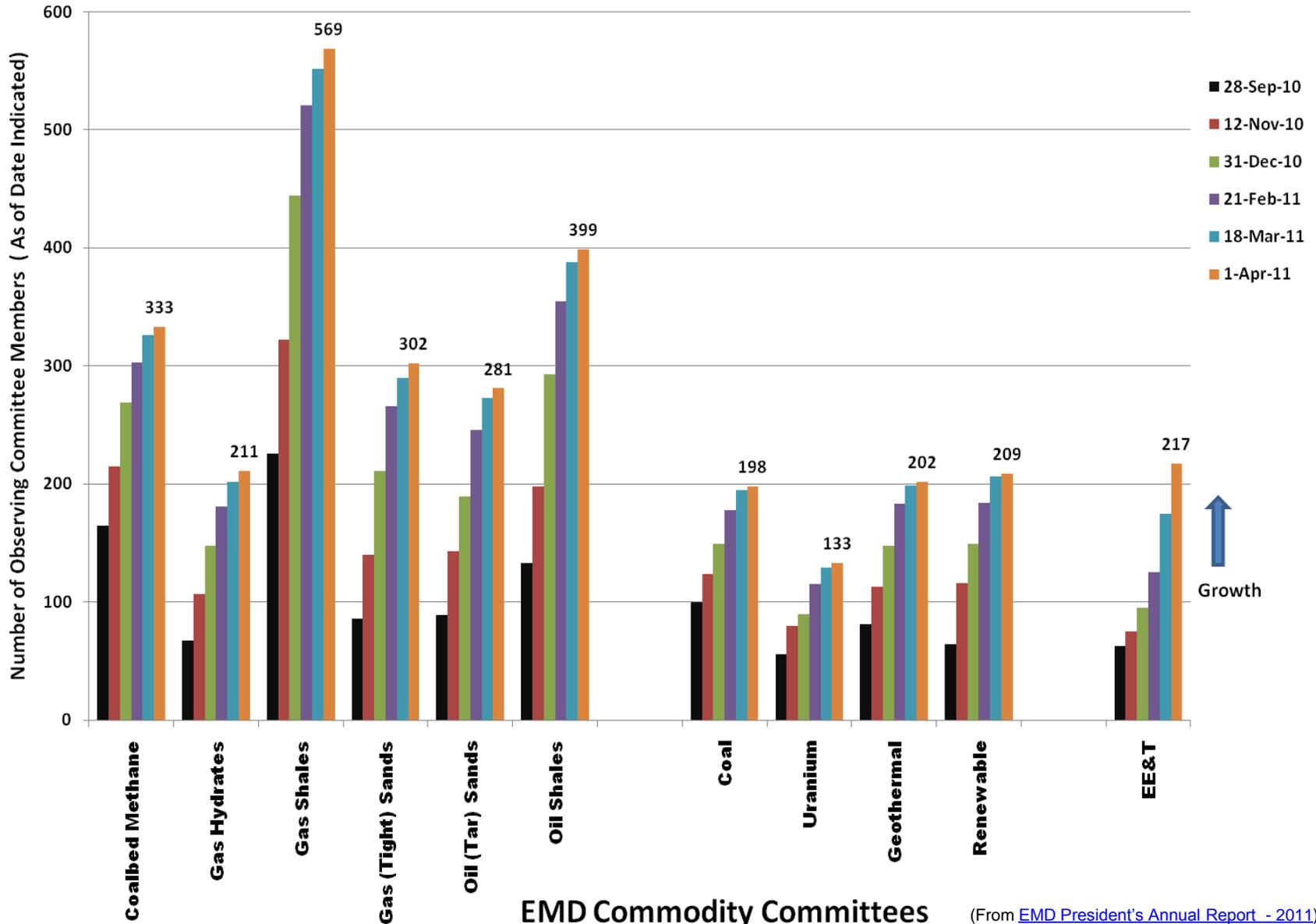


Creties Jenkins, P.E., P.G.
Chair





EMD Commodity Observing Committee Membership Growth



Current EMD Commodity Committees (SEE [EMD HOME PAGE](#))

Scroll down within one or more of the rectangular boxes below across from the EMD Committee in which you may have a general interest. See [Explanation to the right](#). Each of the eleven (11) EMD Committees is linked to its Public webpage. Once there, you may go on to the Members' Only webpage to review the wealth of technical information available for each of the EMD Commodities as an EMD member benefit.

TECHNICAL COMMITTEES

[Unconventional Energy Resources Committee](#)

None at this time	Coalbed Methane
Observing Committee	Gas Hydrates
Active Committee	Gas Shales
None at this time	Tight Gas Sands
Observing Committee	Oil (Tar) Sands
None at this time	Oil Shale

[Alternative Energy Resources Committee](#)

None at this time	Coal
Active Committee	Uranium (Nuclear Minerals)
Active Committee	Geothermal Energy
None at this time	Renewable Energy

SUPPORTING COMMITTEE

None at this time	Energy Economics & Technology
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Explanation

You will note that each box offers three options: 1) None at this Time, 2) Active Committee, and 3) Observing Committee.

Active Committee:

The last two options inquire about your specific level of interest in a particular Committee. If you would like to be considered as a candidate for appointment to the Active Committee for one of the Committees, select "Active Committee." If appointed by the Chair of the Committee, you will be expected to "actively" participate in the Committee activities. The Chair will contact you by e-mail in due course to further assess your candidacy. Please keep in mind that the Active Committee is limited to 15 members so if you are deemed qualified by the Chair, but the Committee is fully constituted at present, you will be placed on the Active Waiting List and notified by the Chair for further consideration when a position becomes available.

Observing Committee:

If you are only somewhat interested in the particular Commodity Committee but would be interested in monitoring its activities, select "Observing Committee" and you will then be placed on the Observing Committee list found on the Members' Only webpage. If you wish to become more active at some stage, you can request the Chair to be considered for appointment to the Active Committee, if a position is available. To change your relative interest, you may also return to this Profile web page and select "Active Committee," which would also begin the process.

EMD Membership History / Month: 2000 to 2011

Note: June Adjustment/Yr:



(From [EMD President's Annual Report - 2011](#))

Total EMD Members

4,000

3,000

2,000

1,000

2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011

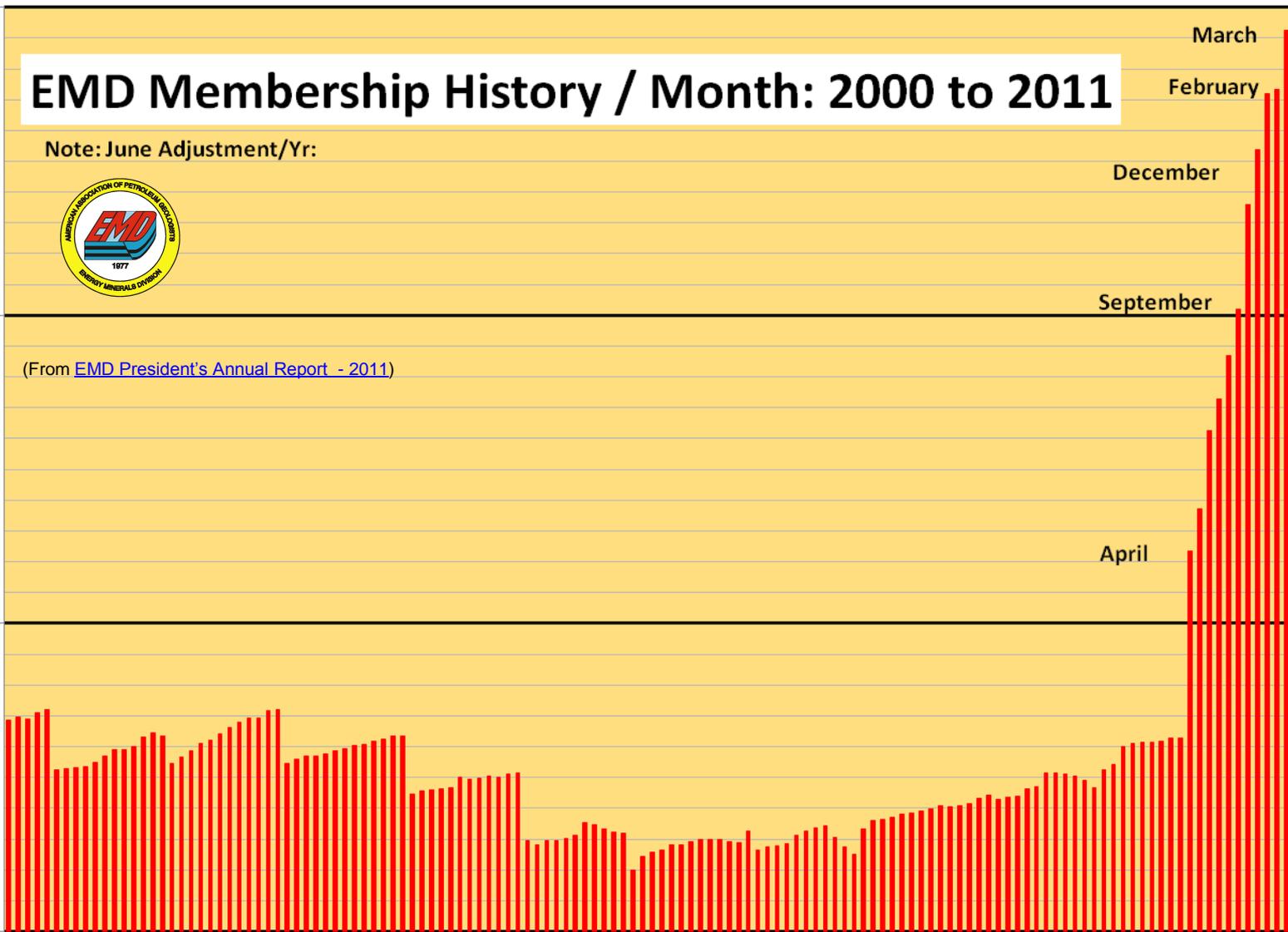
March

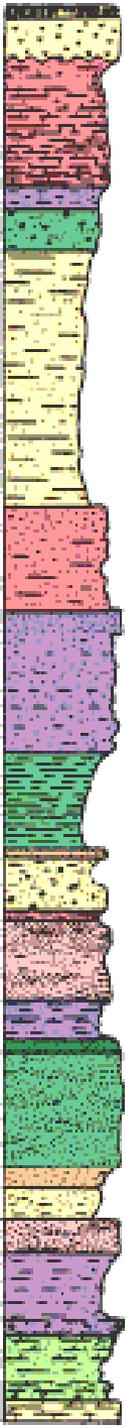
February

December

September

April

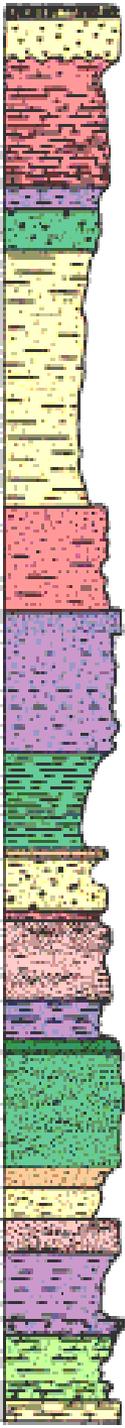




Nuclear Power for Electrical Generation Pros and Cons

❑ Pros

- Excellent for use as base-load electrical generation.
- Minimal greenhouse-gas emissions during production of electricity.
- Plants very inexpensive to operate (to boil water) in generating electricity.
- Fuel costs are the lowest of all forms of fuels used to generate electricity.
- The DOE estimates nuclear energy, factoring in the present value of building and operating appropriate facilities, is approximately 20%, 38%, 70% and 1% cheaper than onshore wind, offshore wind, solar photovoltaic and hydro-energy, respectively.
- New designs are more efficient with even greater number of safety features.



Nuclear Power for Electrical Generation Pros and Cons

❑ Cons

- Expensive to build, amongst the highest of all forms of electrical generation plants, although this expense tends to be offset by the inexpensive fuel costs.
- Creates high-level waste (future fuel?) that must be managed, although high-level waste is a resource that can be reprocessed; storage alternatives are available.
- Total high-level waste produced since the 1950's would fill a football field or two to a depth of about 14 feet.
- Only 5% of fissionable material is consumed. Reprocessing of waste would extend current uranium supplies & reduce waste volume.
- New plant designs burn uranium more efficiently w/Be & Th, thereby reducing waste.
- Many Americans are of the opinion that if the U.S. stops using nuclear power, the rest of the world will follow, although the rest of the world is going to expand nuclear use regardless what the U.S. does. U.S. needs to remain a leader in the nuclear industry.

Nuclear Power for Electrical Generation Pros and Cons

❑ Cons

- Then the earthquake and tsunami hit Japan ... and the Fukushima Daiichi Nuclear Power Plants.....



A Forbes Photo

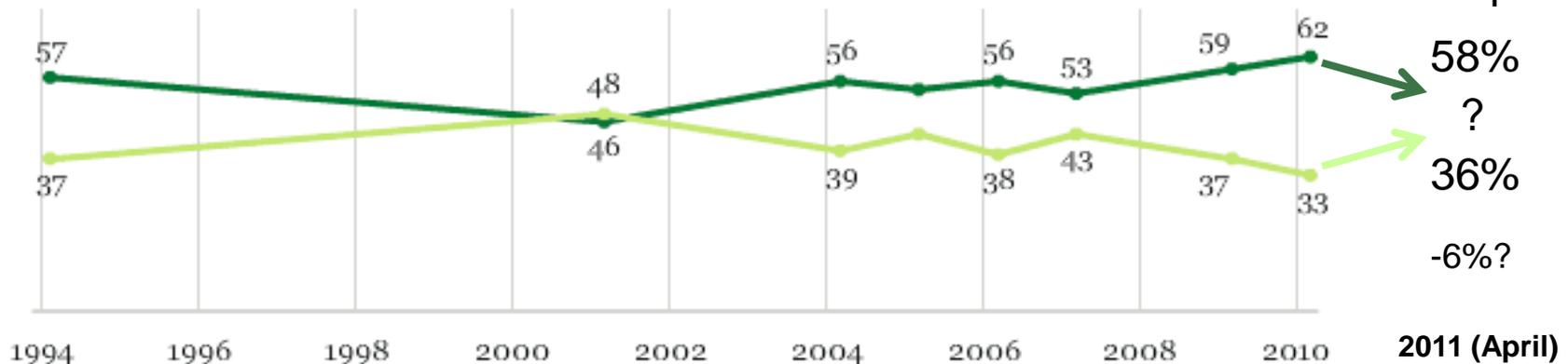
Nuclear Concerns Treated by News Media

- Billions of dollars in subsidies needed for all alternate-energy resources, including nuclear.
- Biodiesel is subsidized \$1.00 per gallon; others subsidizations seldom mentioned.
- **And then the Big Story....**

Nuclear power was continuing to rise in popularity. Jones ([2010](#)) of Gallup reported that Americans' support for nuclear power had increased to 62%, establishing a new high, but then the earthquake and tsunami hit Japan and Fukushima Daiichi Nuclear Power Plants lost secondary power (see graph below).

Overall, do you strongly favor, somewhat favor, somewhat oppose, or strongly oppose the use of nuclear energy as one of the ways to provide electricity for the U.S.?

■ Total % favor ■ Total % oppose



Nuclear Concerns Treated by News Media

- Fukushima Daiichi Power Plants - 30 years of safe operation; not without regulatory issues.
- The Media reports on day-to day rumors.
- Why didn't the geologists speak up in Japan 40 years ago recommending re-siting of the plants? These plants were built to withstand the average 100-year earthquake/tsunami, rather than the worst-case scenario, which occurred during the 9th Century.
- A Case of Management Expediency?
- Lessons to Learn....Again! Build to withstand the likely maximum threat.
- Impact on U.S. building program? Probably a brief slowdown as safety and construction of U.S. nuclear power plants are re-examined (West Coast, and Memphis areas).
- New power plants have already taken into account additional safety concerns and are more efficient in electricity production than ever.



A Forbes Photo

Nuclear Power in the Future

- Fukushima Daiichi Power Plants
- The [Global X Uranium ETF \(URA\)](#), which tracks uranium-mining companies, has fallen 21 % since March 10, the day before the major earthquake and tsunami occurred.



- This too will pass...because the lessons learned far out weigh the dangers of Nuclear Power to generate electricity in the U.S., and elsewhere.
- Any slow-down on current construction of new plants will force yellowcake prices to rise significantly. The world will continue to build nuclear power plants even if the U.S. were to stop construction.



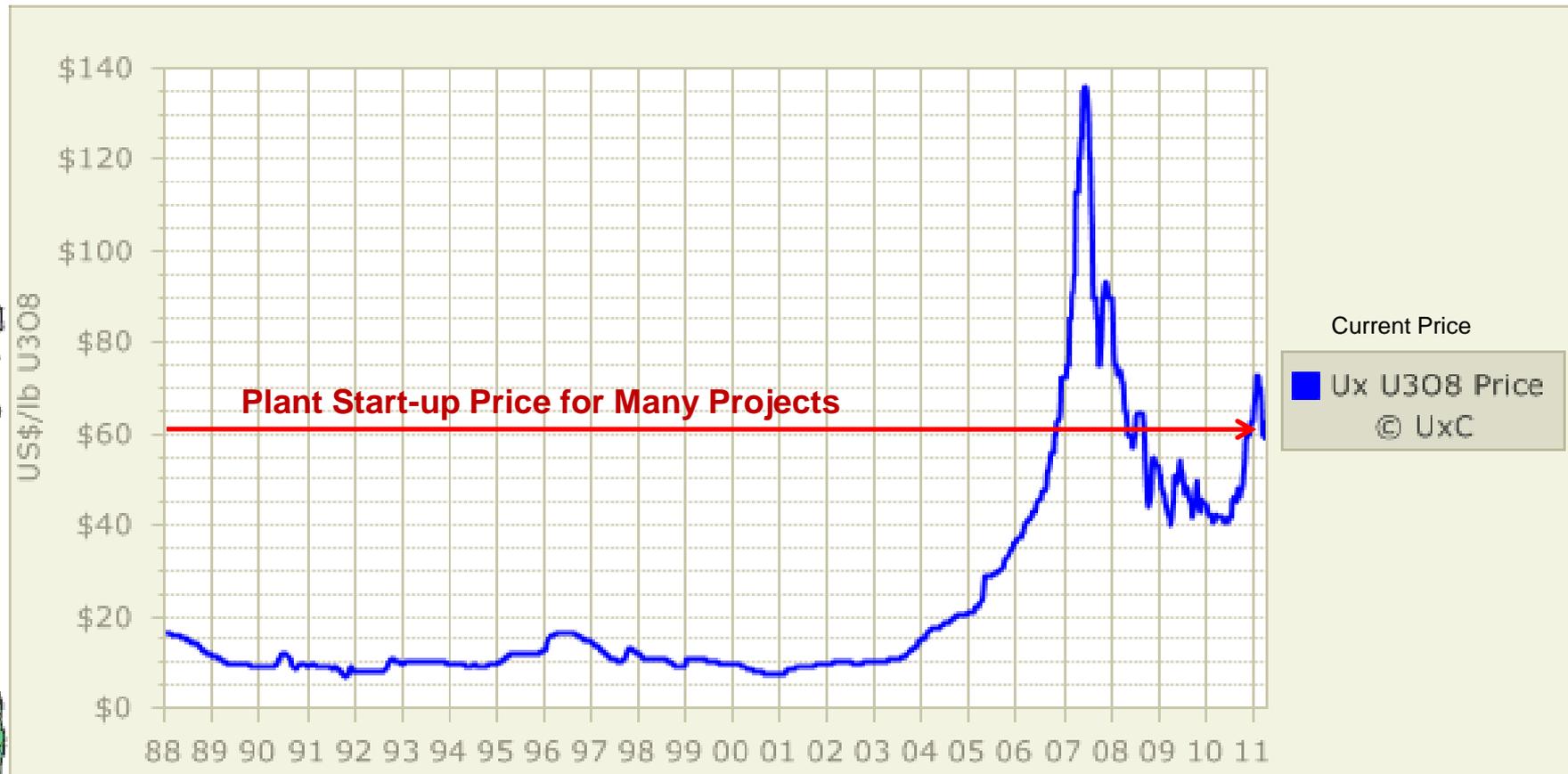
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Yellowcake Price History & Projections

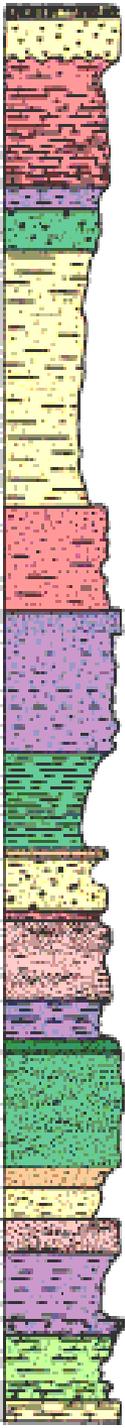


Historical Spot Price of U₃O₈ (after UXC.com) and Projected Price, see [C&A News Release](#)

Yellowcake Price History & Projections



Current Spot Price of U₃O₈ (after UXC.com)



Uranium Recovery Techniques: Past & Present

❑ Underground

- Problems with radiation exposure to miners who smoke tobacco, etc.
- What to do with tailings from the old mines? Environmental remediation?
- Prior to the environmental movement there were insufficient regulations to address health, safety, closure, and remediation concerns.

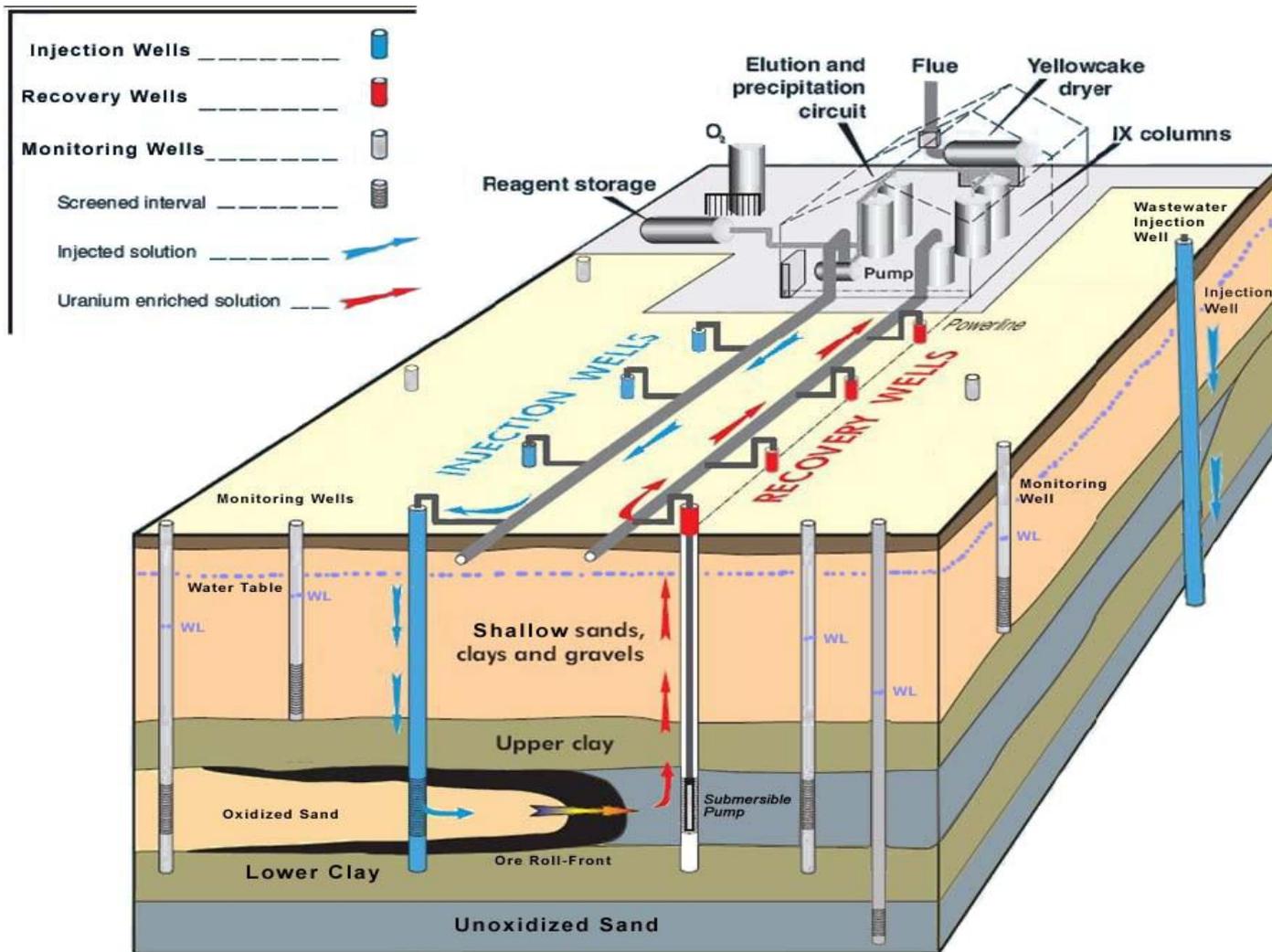
❑ Open Pit Mining

- Fewer problems with radiation exposure to miners.
- Left the ground surface disturbed because of a lack of effective closure.
- There were insufficient regulations to address health, safety, closure, and remediation concerns during the 1970's and 80's.

❑ In-situ Uranium Recovery

- Radiation exposure to plant workers very low.
- No tailings or surface pits to manage.
- Ground-water remediation of conditions within the original mineralized zone prior to mining is required after production is complete, usually about 5 to 7 years of additional operations. This does not involve restoration to regional water-quality levels, only reduction in oxidizing conditions within the zone to precipitate all metals currently in solution.

Uranium Recovery Techniques: Past & Present



Typical In Situ Uranium Recovery System

After Heathgate Resources Pty Ltd
(After Campbell, *et al.*, 2007)

Uranium Recovery Techniques: Past & Present

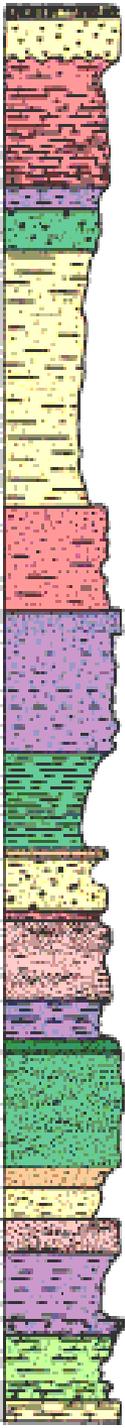


Typical In Situ Uranium Recovery System Surface Installation of Well Field

Uranium Recovery Techniques: Past & Present



Wells Being Installed for In Situ Uranium Recovery System



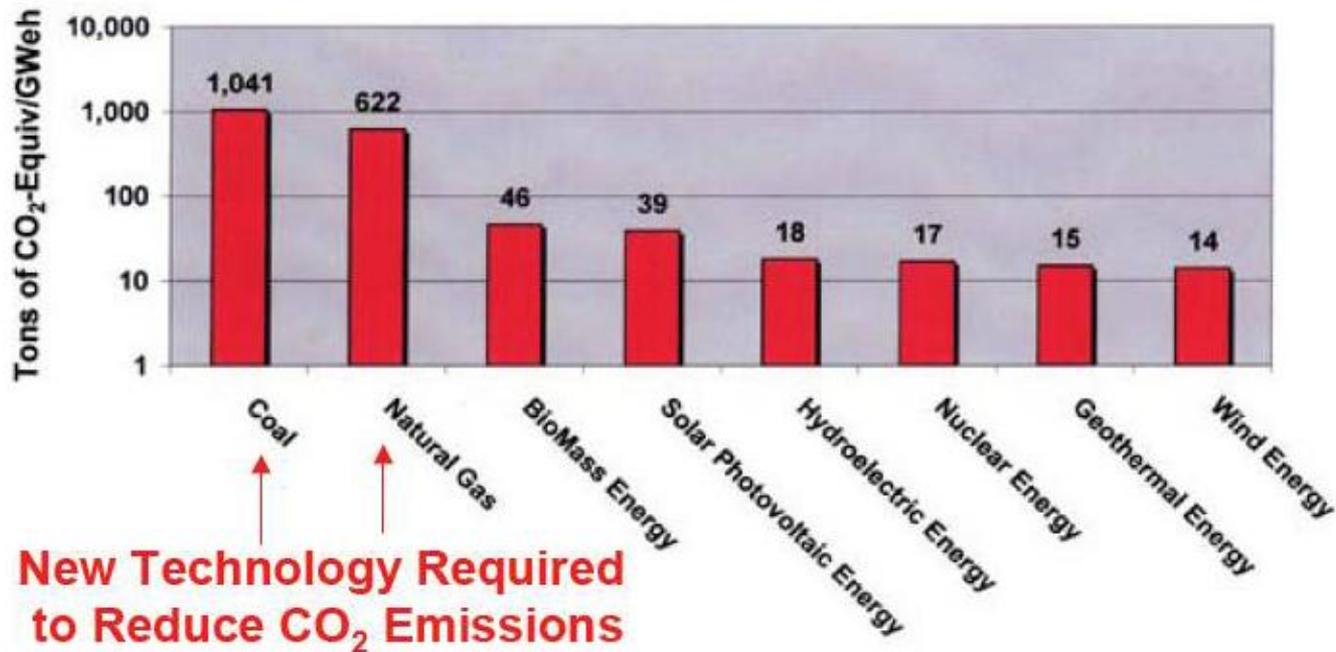
Typical Concerns of Environmental Advocacy Groups & Associated Media

- ❖ “Previous ISR mines didn’t close using the original cleanup levels”, see (Hall, 2009)
- ❖ “Mines release radiation into the air.”
- ❖ “Living around uranium mines show increased cancer rates,” see (Boice, 2003; USNIH, 2008)
- ❖ “Groups want aquifer baseline studies prior to any exploration drilling.”
- ❖ “In-situ Recovery operations should never be performed in drinking water aquifers.”
- ❖ “Mining activities will destroy the aquifer by pumping all available water and causing pollution.”
- ❖ “Homeowner reported a change in their drinking water from their well.”
- ❖ “Mining companies generally don’t care about the environment or health and safety of the workers.”
- ❖ “Persons who worked in a mine or served on Groundwater Conservation Boards are often presented by the news media as experts, but are practicing geology and/or hydrogeology in public with no training or experience in the fields.”
- ❖ “The government has a vested interest in allowing exploration and mining permits because that is how the governmental agencies are funded.”
- ❖ “The news media almost always portrays anti-nuclear advocates in a positive light.”
- ❖ “The news media often portrays governmental agencies as good only when they obstruct mining or nuclear energy and side with environmental advocacy groups.”
- ❖ “The news media makes no distinction between the three forms of mining.”
- ❖ “Uranium produced in the U.S. gets exported overseas.”

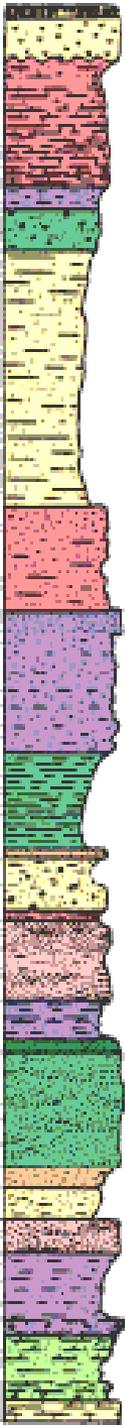
Typical Concerns of Environmental Advocacy Groups & Associated Media

- ❖ “Nuclear Power isn’t really carbon-free,” (see type of claims by Mudd and Diesendorf, 2008), but minor compared to conventional energy sources, i.e., coal, oil & gas, etc.

**CO₂ Generated After Producing
One GigaWatt-Hour of Electricity By Indicated
Energy Source (U.S. EIA)**



EIA studies illustrate current understanding of CO₂ production, (see [USEIA](#)).



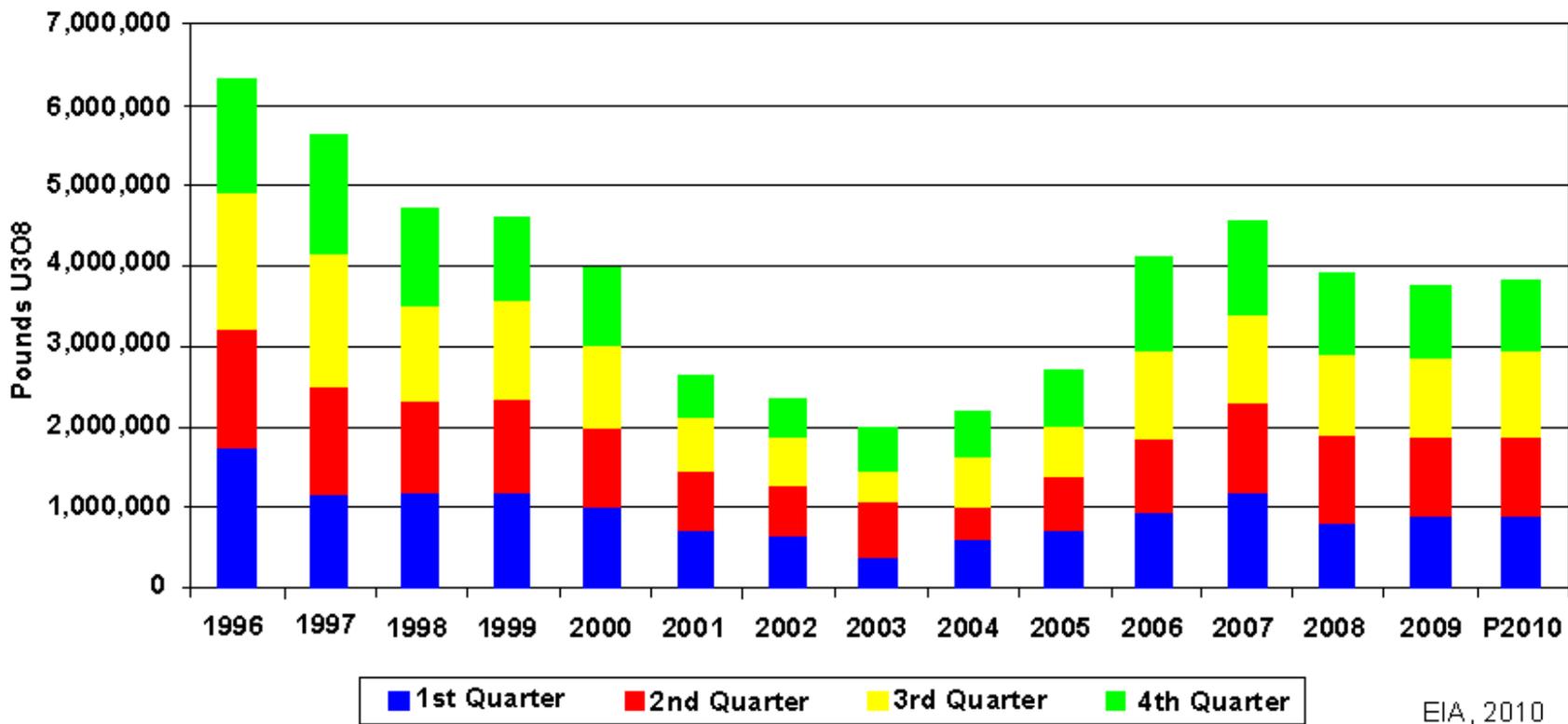
Community Outreach Programs

- ❖ **Company personnel should talk with community about technical issues:**
- ✓ **Talk issues, dispel rumors & falsehoods and provide supporting information concerning:**
 - 1) the unlikely occurrence of ground-water contamination by exploration drilling and in-situ recovery operations, and
 - 2) the need for local owners to provide regular maintenance by a Certified Water Well Contractor on their water wells to avoid or eliminate iron, manganese, and sulfate-reducing bacteria from fouling their wells, i.e. red water, etc., a condition that is entirely unrelated to nearby uranium drilling or development activities.
- ✓ **Explore or identify conflicting agendi, such as:**
 - 1) envy of nearby land owners who do not have uranium below their lands,
 - 2) fear expressed by local real-estate agents that property values may fall because of the presence of uranium exploration & development activities in the area, and
 - 3) opposition of local residents to nuclear power development in general.
- ✓ **Point out positive features of uranium development & recovery, like oil & gas, i.e., local employment & spending, community funding (schools, etc.).**
- ✓ **Combat media bias programming with objections to treatment by local and national news media, e.g. <http://mdcampbell.com/CARreviewszz/I2MARreviews.htm>**

Current Conditions/Expectations of the U.S. Nuclear Industry:

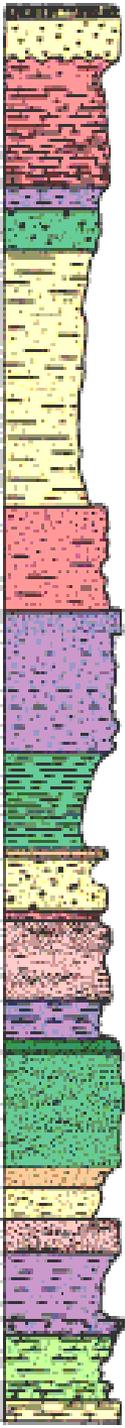
- ❖ 4 million lbs / year U_3O_8 (Yellowcake) recovered in U.S. (2010).
- ❖ 25 million lbs / year U_3O_8 from Decommissioned Nuclear Weapons Program ends in 2013.
- ❖ 29 million lbs / year U_3O_8 current capacity in U.S. (per EIA and Nuclear Regulatory Commission (NRC) data)
- ❖ 104 nuclear power plants in U.S. (441 plants in world as of 2010).
- ❖ 52 million lbs / year U_3O_8 required to Load 104 U.S. reactors in U.S. (3-5 Year Fuel Cycle) – BeO & other modifications would increase fuel burn life and reduce load requirements.
- ❖ Available waste storage site: **WIPP site** in New Mexico is presently licensed for defense transuranic nuclear waste including significant reprocessed spent fuel waste from old defense reactors. The site would be ideal for storing all nuclear waste at modest cost, at a cost of ten times less than cost projections for **Yucca Mountain**. Space is already set aside, and the infrastructure and work force are in place. Selection is a political problem, not technical !
- ❖ Globally (including U.S.) there are 441 plants in operation (less those damaged in Japan), 59 plants currently under construction, 439 planned and proposed, some of which may now be postponed until after a new round of safety reviews have been completed, although many plants have been running for decades without serious incident.
- ❖ China is planning more than 150 new nuclear reactors by itself over the next 15 years.
- ❖ NEI estimates that 1,000 to 1,200 reactors globally will be in operation by 2030.

Historical / Current Production of the U.S. Uranium Mining Industry



- 4 Mines Operating Today in U.S. = About 4 million lbs/year U_3O_8
- U.S. will need about 20 Mines in production to meet 2021 Requirements. See Campbell and Wise (2010) for discussions on estimated fuel needs through 2030.

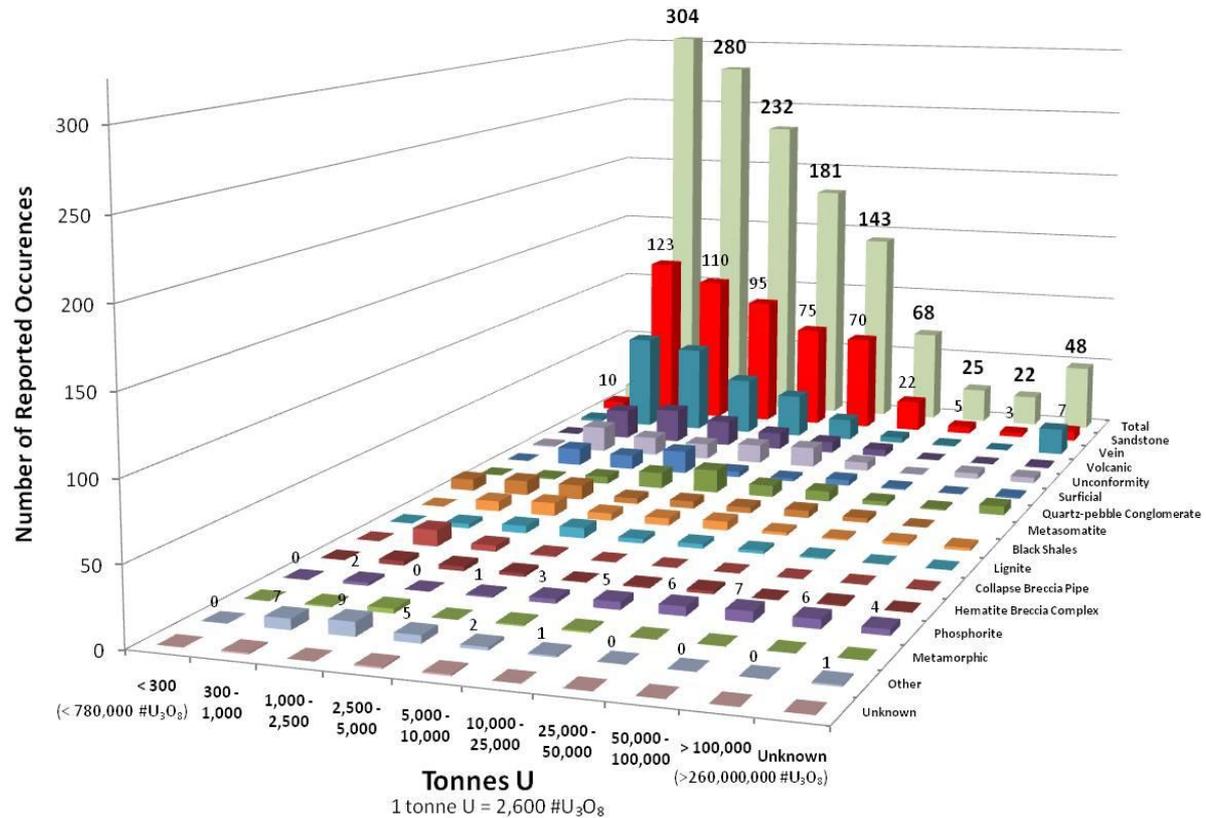
Current Conditions / Expectations of the U.S. Nuclear Industry

- 
- Estimated U.S. Resources: ~ 900 million lbs. Assume 50% as Reserves: Through 2025?
 - After about 2025, additional yellowcake production must come from the overseas sources (i.e., high-grade deposits in Canada, Australia, Gabon, Argentina, and from lower-grade deposits in Kazakhstan, Niger, Zambia , Columbia, Guyana, etc.
 - Re-processing of nuclear waste with Type IV Reactors (Breeder Reactors) by 2030 or before.
 - Public will support nuclear development because coal mining and use are no longer acceptable in view of current climate-change issues. Current technology will be phased out over coming 15 years. Domestic natural gas will likely contribute to the U.S. for decades to come.
 - A new energy-and-climate bill emerges in Congress: \$54 billion in federal-loan guarantees for new nuclear projects. Plus 10% tax credit for nuclear construction costs and use of tax-exempt bonds for joint ventures for advanced nuclear facilities. This will be used to encourage new construction after current slowdown.
 - The World Nuclear Association (WNA) projects possible world expansion of nuclear generating capability from current base of 387 GWe (441 plants rated @ 880 MWe (Ave) to 1,200-3,000 GWe by 2050 (see Campbell and Wise (2010).

Current Uranium Resources Available in the World

(IAEA-UDEPO Data, 2009)

Reported Uranium Occurrences According to Deposit Reserves and Type of Mineralization



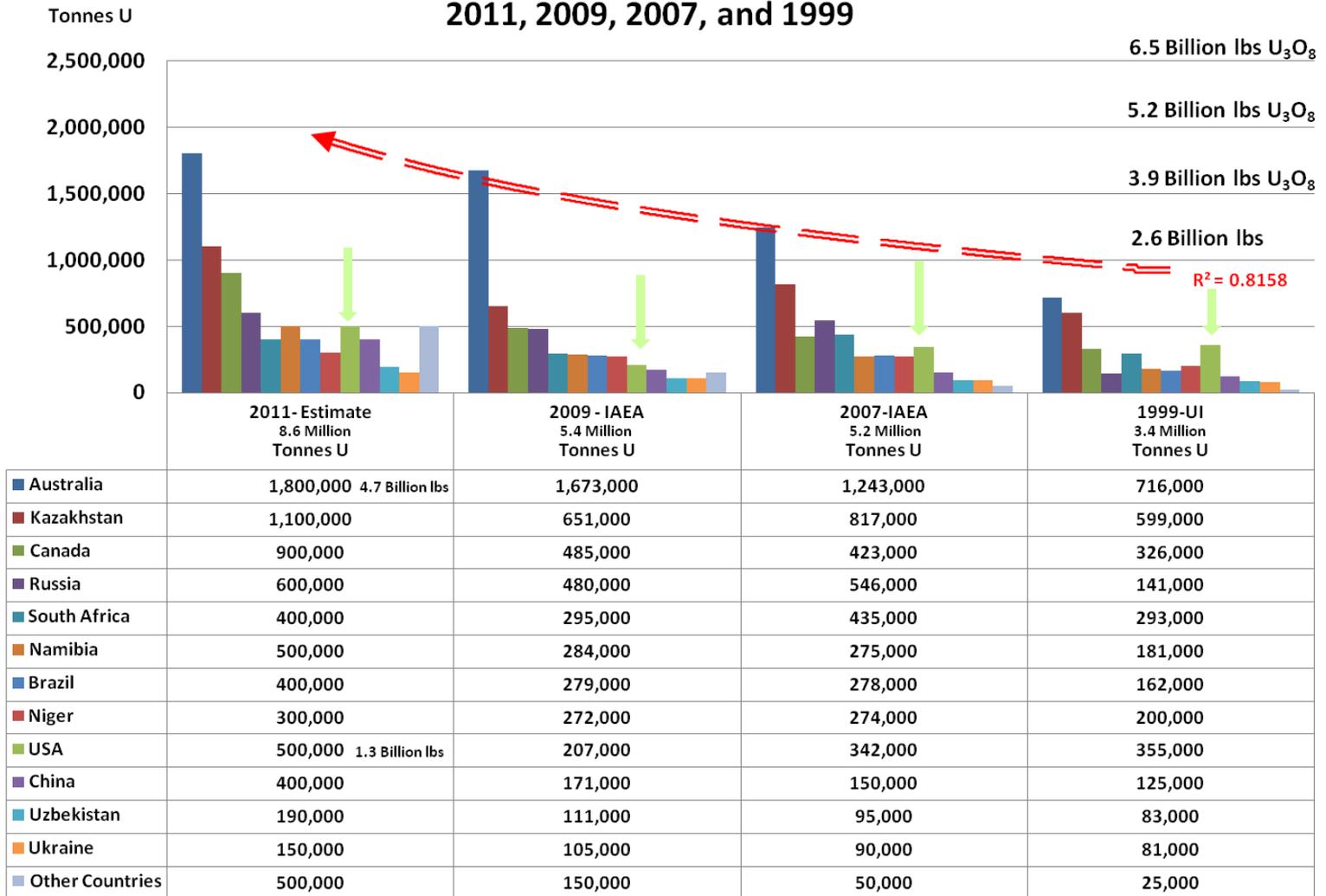
- Unknown
- Other
- Metamorphic
- Phosphorite
- Hematite Breccia Complex
- Collapse Breccia Pipe
- Lignite
- Black Shales
- Metasomatite
- Quartz-pebble Conglomerate
- Surficial
- Unconformity
- Volcanic
- Vein
- Sandstone
- Total

(EMD UCOM Report, 2011)

IAEA: UDEPO Data, 2009

Past and Current Uranium Resources Available in the World

Estimates of Known Recoverable Uranium Resources:
2011, 2009, 2007, and 1999



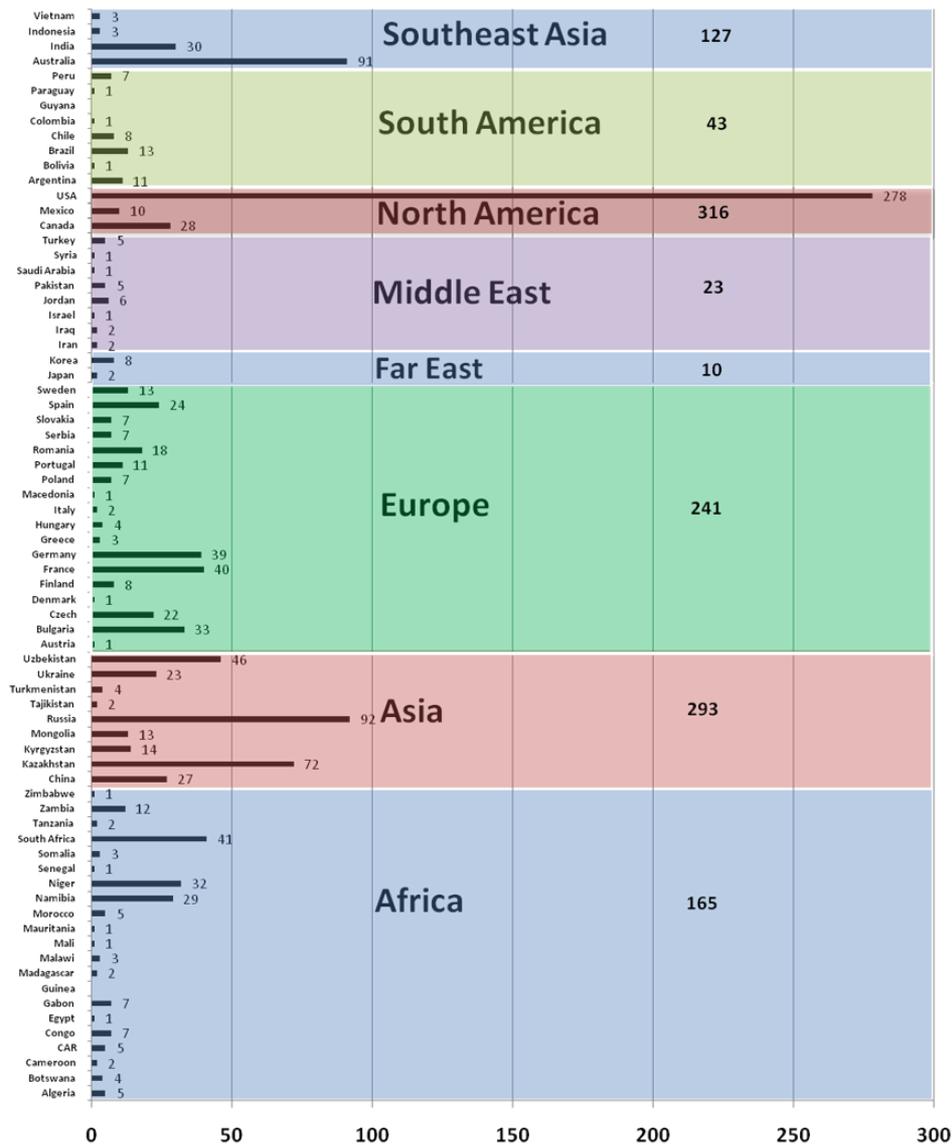
(IAEA-UDEPO Data, 2009)

Note: Reasonably Assured Resources plus Inferred Resources, to US\$130/kg U, 1/1/09, from OECD NEA & IAEA, *Uranium 2009 Resources, Production and Demand ("Red Book")* and earlier estimates by IAEA (2009, 2007) and WNI (1999).

(Wise and Campbell, 2011)

Current Uranium Resources Available in the World

World Uranium: Number of Known Deposits
by Country & Region - 2009

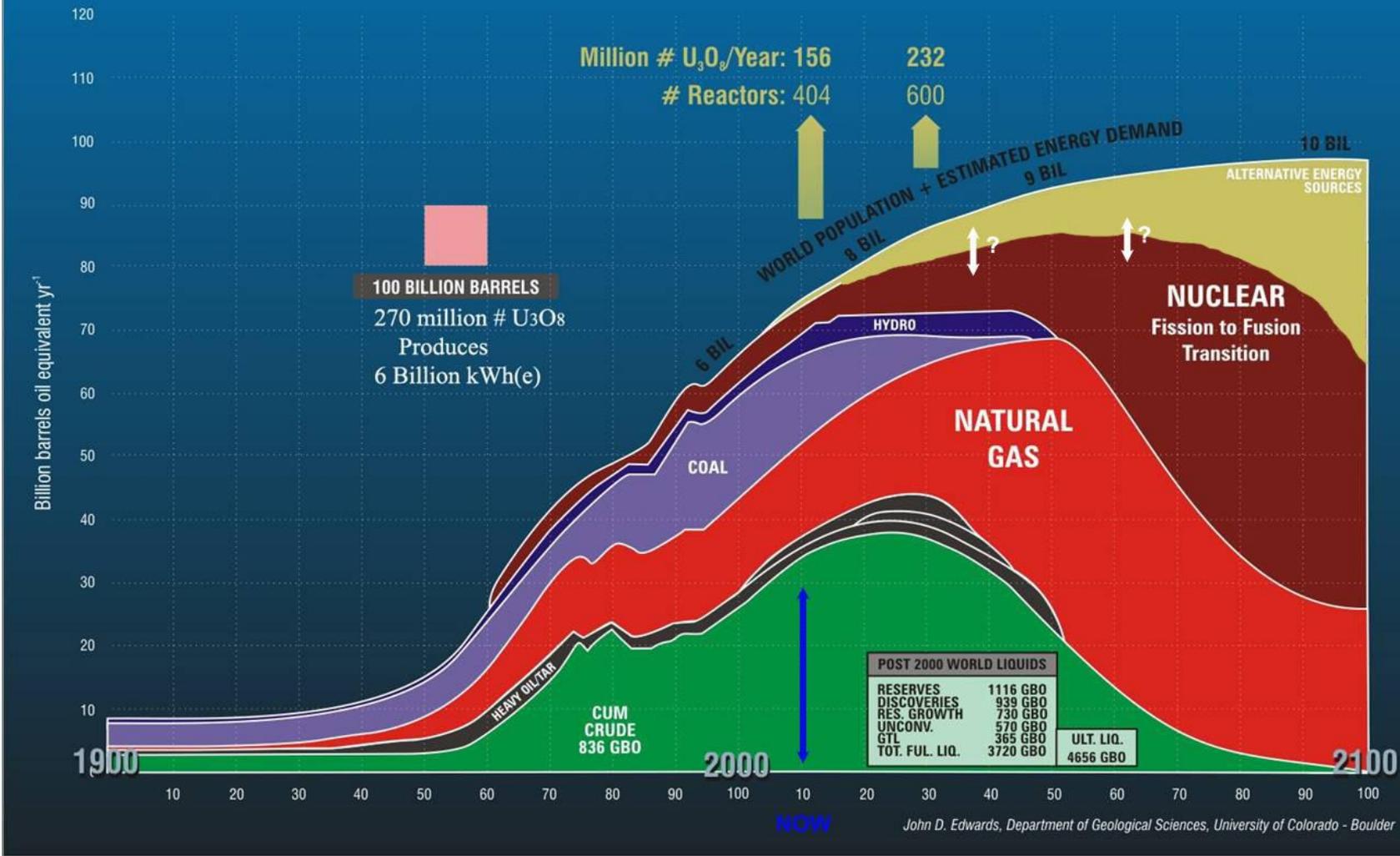


(EMD UCOM Report, 2011)

(IAEA-UDEPO Data, 2009)

Where is the Energy Coming From in the Future?

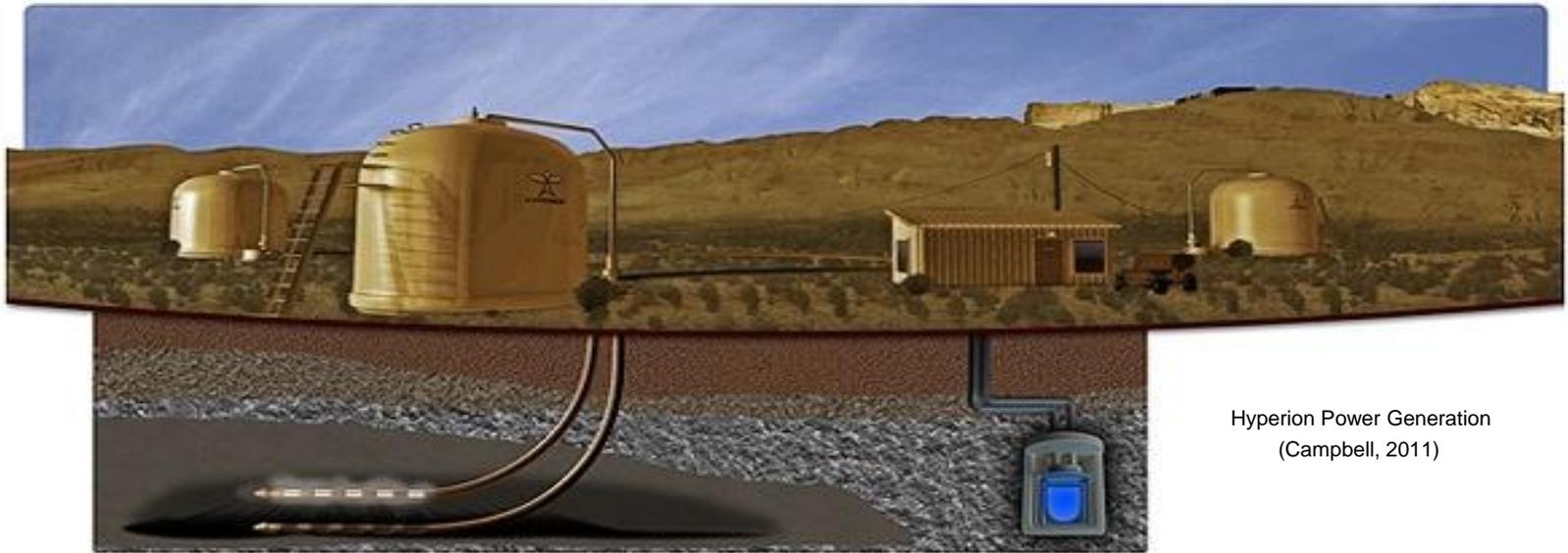
Estimates of 21st Century World Energy Supplies: Billion Barrels Oil Equivalent: **Alternate Universe**



After Campbell and Campbell (2005)

Small-Scale Nuclear Plants

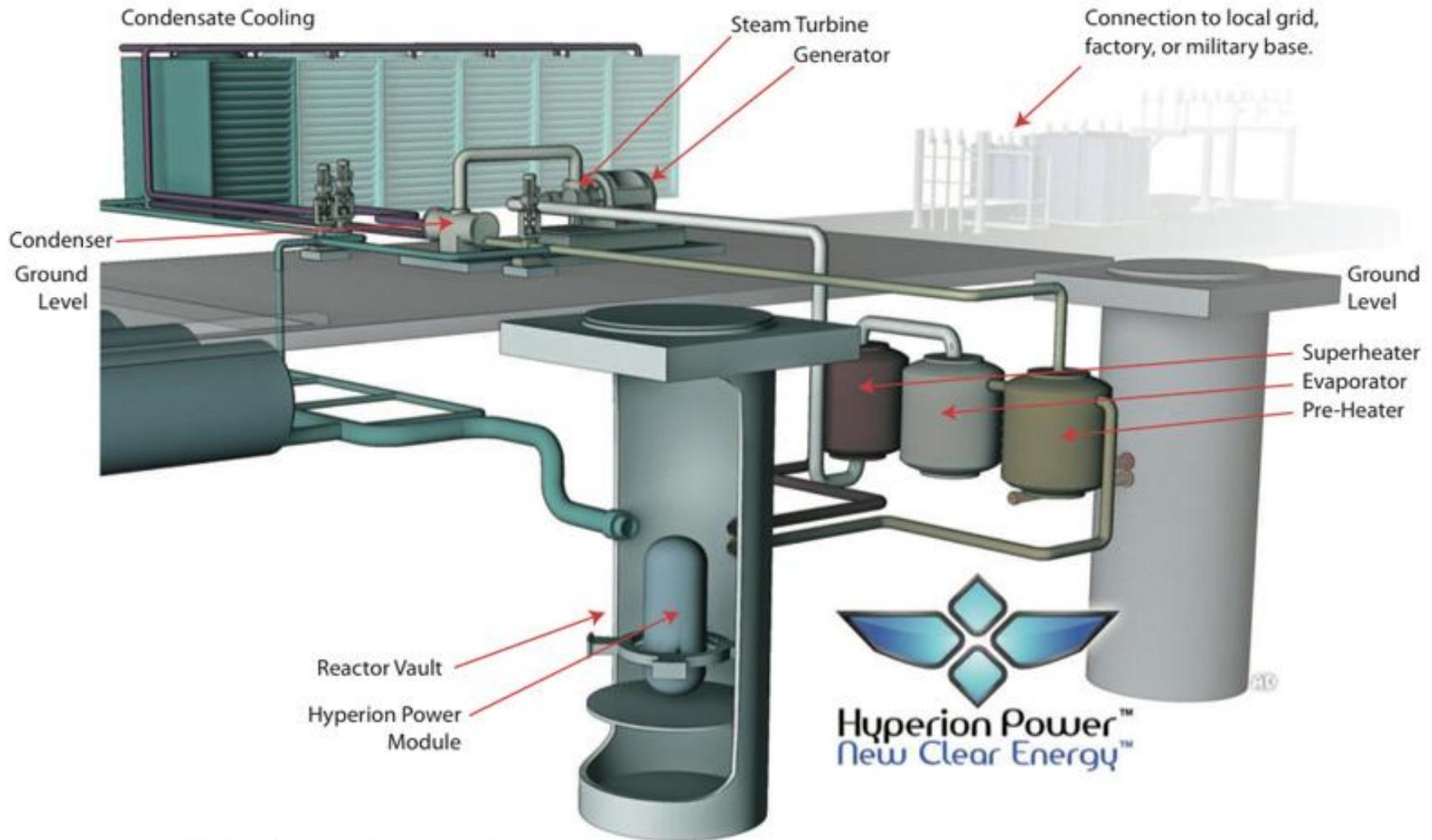
Bill Gates has endorsed using small-scale nuclear power plants (25,000 MW or less), called “nuclear batteries,” for cities after disasters such as hurricanes, earthquakes, tsunamis. Also for use in small communities in remote locations. [Terra Power](#), [Hyperion Power](#), and [Hitachi-GE](#) are building newly designed smaller units at present, much of the research has come from Los Alamos National Laboratory over the past 30 years on space applications. Of note is that GE is using nuclear-waste products to fuel their reactors in part.



Hyperion Power Generation
(Campbell, 2011)

- 25 MWe – Electricity for > 20,000 Residents (For Disasters or for Remote Operations (Mining, Construction, Oil & Gas Production, etc.))
- 30-Yr System Life (8-10 year fuel-replacement cycle)
- \$30 million Capital Cost

Small-Scale Nuclear Plants



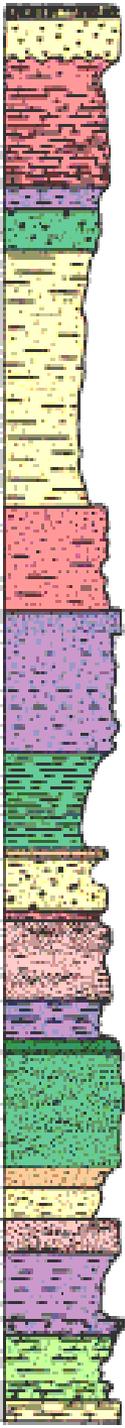
Hyperion Power Module-based 25MWe Electric Power Plant

Small-Scale Nuclear Plants

Operational Characteristics:

Hyperion Power Generation
(Campbell, 2011)

Reactor Power	70MW Thermal
Electrical Output	25MW Electric
Lifetime (Power Module)	8 – 10 years
Size (meters)	1.5w x 2.5h
Weight (tons)	Less than 50
Structural Material	Stainless Steel
Coolant	Lead-Bismuth Liquid
Fuel	Stainless Clad, Uranium Nitride
Enrichment (% U-235)	<20%
Refuel on Site	No
Sealed Core	Yes
License	Design Certification
Passive Shutdown	Yes
Active Shutdown	Yes
Transportable	Yes – Intact Core
Factory Fueled	Yes
Safety & Control Elements	Two Redundant Shutdown Systems & Reactivity Control Rods



Small-Scale Nuclear Plants

Operational Characteristics:

Hyperion Power Generation
(Campbell, 2011)

1 Transportable:

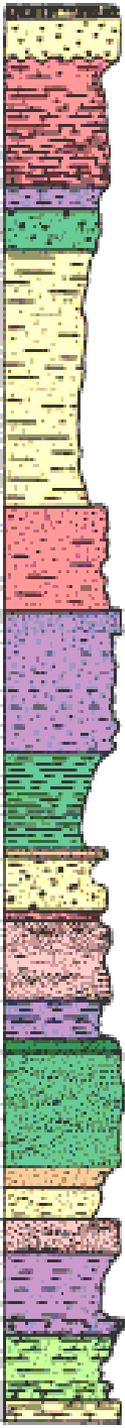
- Unit will measure approximately 1.5 meters wide x 2.5 meters tall
- Fits into a standard fuel transport container
- Transported via ship, rail, or truck
- Modular design for easy and safe transport

2 Sealed Core:

- Safe and Secure: Developed for Space Program at Los Alamos in NM
- Factory sealed; no in-field refueling, closed-fuel cycle
- Returned to the factory for fuel and waste disposition

3 Safety:

- System built to minimize breaches through a combination of inherent and engineered features
- Inherent negative feedback keeps the reactor stable and operating at a constant temperature
- Sited underground, out of sight
- Proliferation-resistant; reactor module never opened once installed in the field.



Small-Scale Nuclear Plants

Operational Characteristics:

Hyperion Power Generation
(Campbell, 2011)

4 Operational Simplicity:

- Operation limited to reactivity adjustments to maintain constant temperature output of 500°C
- Produces power for 8 to 10 years depending on use

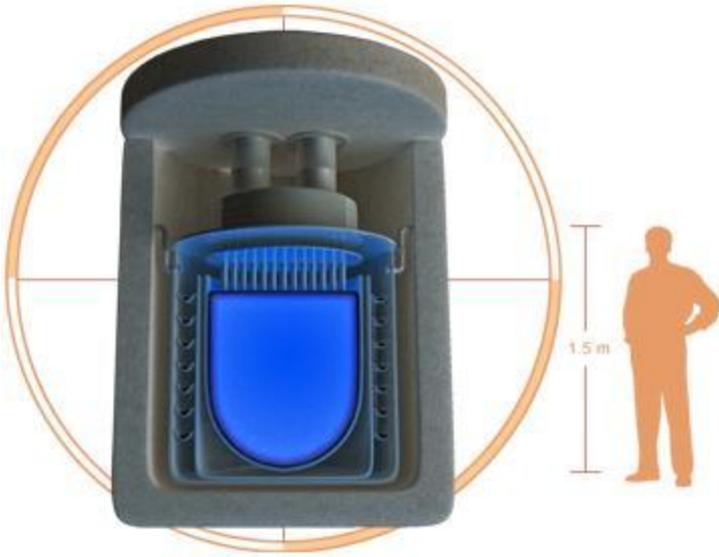
5 Minimal In-Core Mechanical Components:

- Operational reliability is greatly enhanced by the reduction of moving mechanical parts

6 Isolated Power Production:

- Electric generation components requiring maintenance are completely separated from the reactor
- Allows existing generation facilities to be retrofitted
- The Hyperion Power Module in the process of being licensed by national and international regulatory authorities.

Generation of Electricity: Both Small- and Large-Scale Nuclear Energy Plants



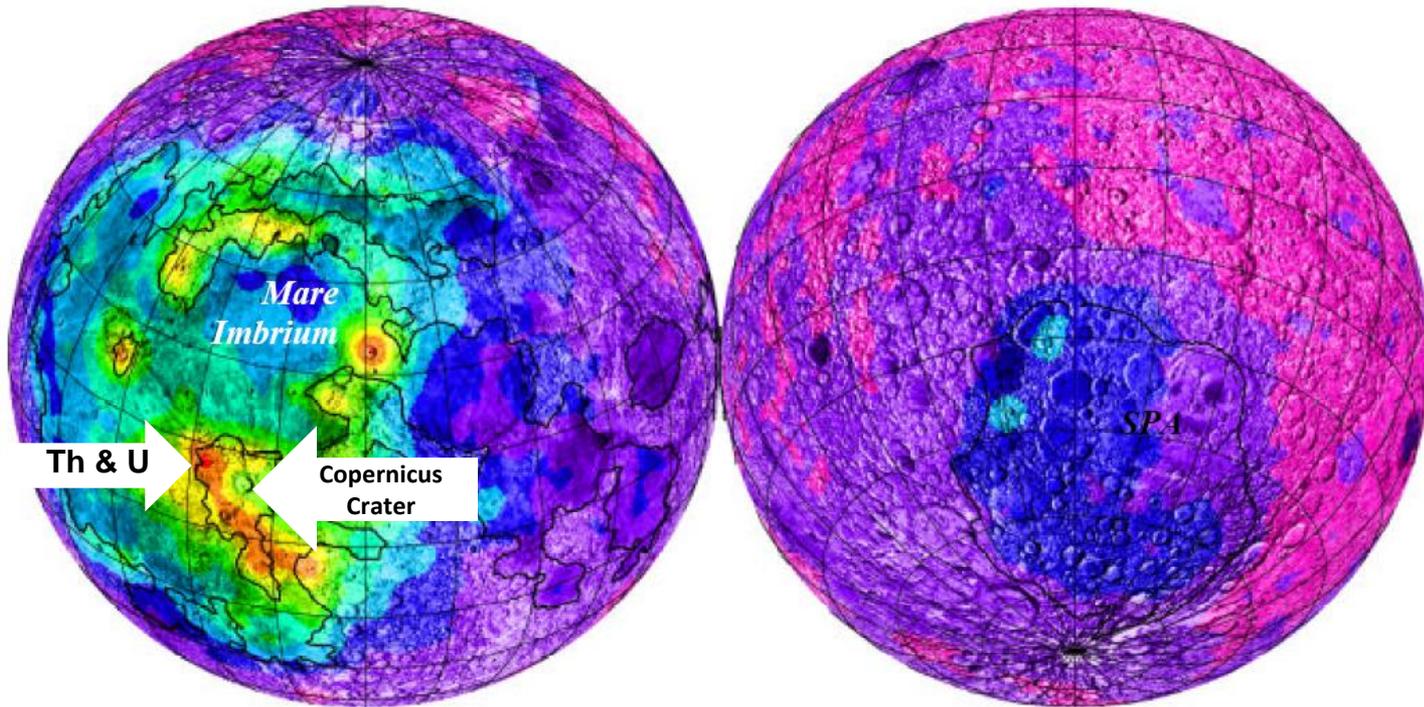
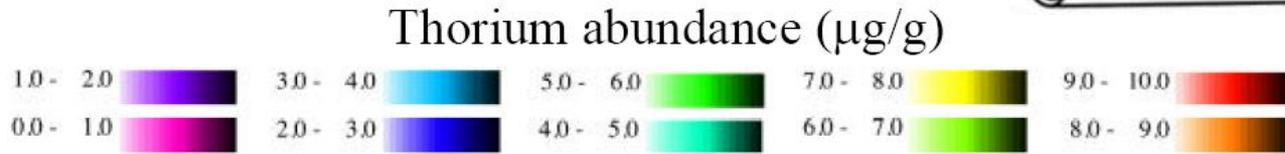
Do We Need to Look Elsewhere Too?

**China, India, Japan, Russia
are turning to the Moon !!!**

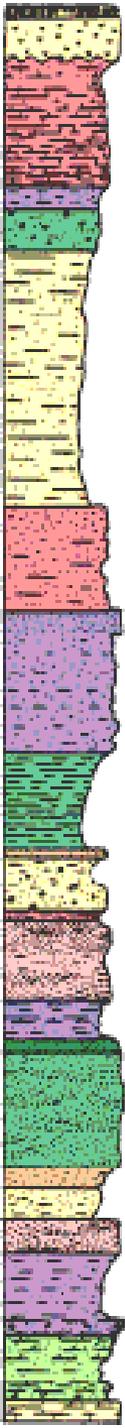
WHY?

**Uranium has been discovered.
Rare Earths, Helium-3, Water, etc.**

We think the 2nd Space Race may well be afoot....

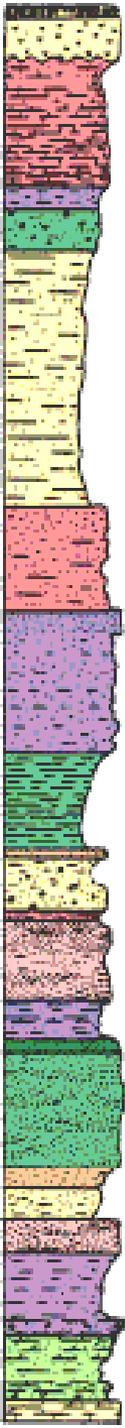


(After Elphic, et al. (2000); Campbell, et al. (2009); Yamashita (2009); and Campbell and Ambrose (2010))



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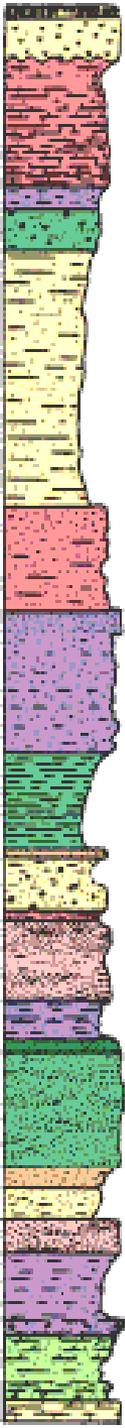
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