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

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

Association of American Petroleum Geologists
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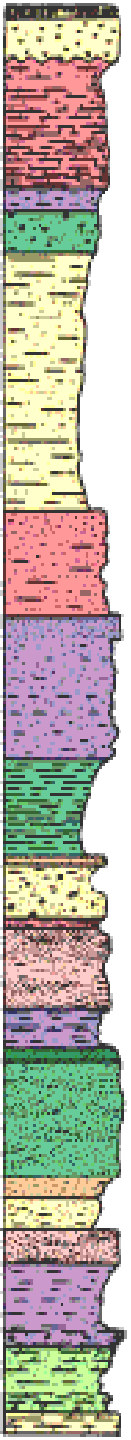
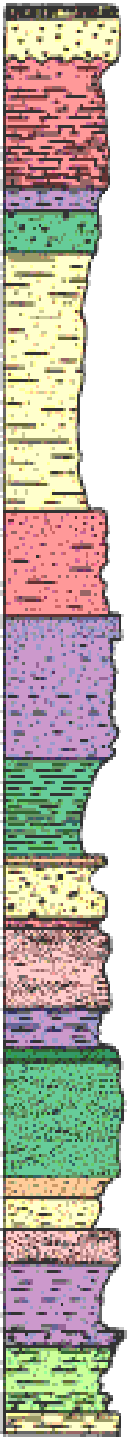


Abstract

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. 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. 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. We will evaluate these misconceptions in some detail.



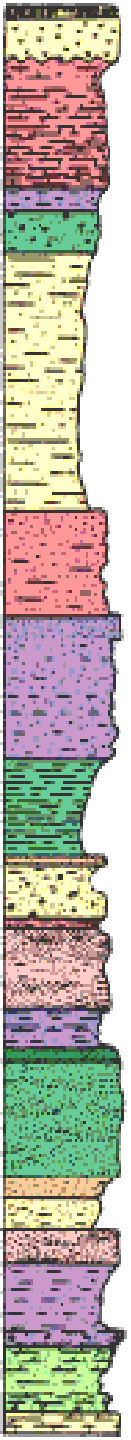
Presentation Coverage

- Pros & cons of nuclear power.
- How to handle public concerns.
- The current state of exploration, development and production practices and anticipated yellowcake prices.
- Based on EMD Uranium (Nuclear Minerals) Committee Annual Report - 2011 found on the EMD website:

  http://emd.aapg.org/members_only/annual2011/Uranium_EMDAR2011.pdf .

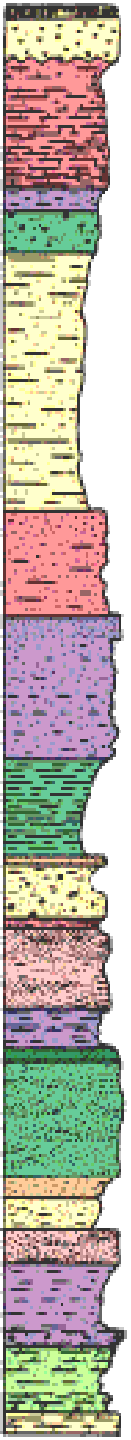
- Also based on a presentation made to the HGS in late 2010

  http://www.mdcampbell.com/HGSUraniumRecoveryRealitiesV1.9.pdf



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 Department of Energy 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.



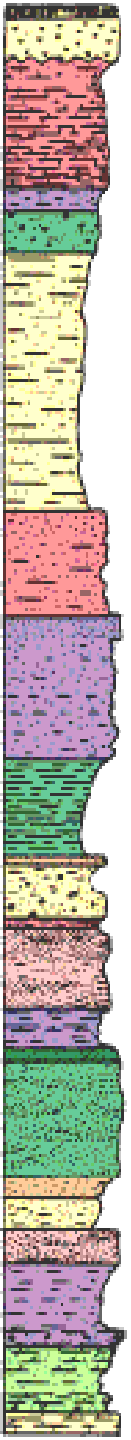
Nuclear Power for Electrical Generation Pros and Cons

- **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 that must be managed, although high-level waste is a resource that can be reprocessed and storage alternatives are available.
    - Total high-level waste produced since the 1950's would fill a football field 14 feet deep.
    - 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.

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 Power for Electrical Generation Pros and Cons

- **Cons**

  - 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 was during the 9th century.

  - A Case of Management Expediency?

  - Lessons to Learn….Again! Build to withstand the likely threat.

  - Impact on U.S. building program? Probably a brief slowdown as safety of U.S. nuclear power plants is re-examined.

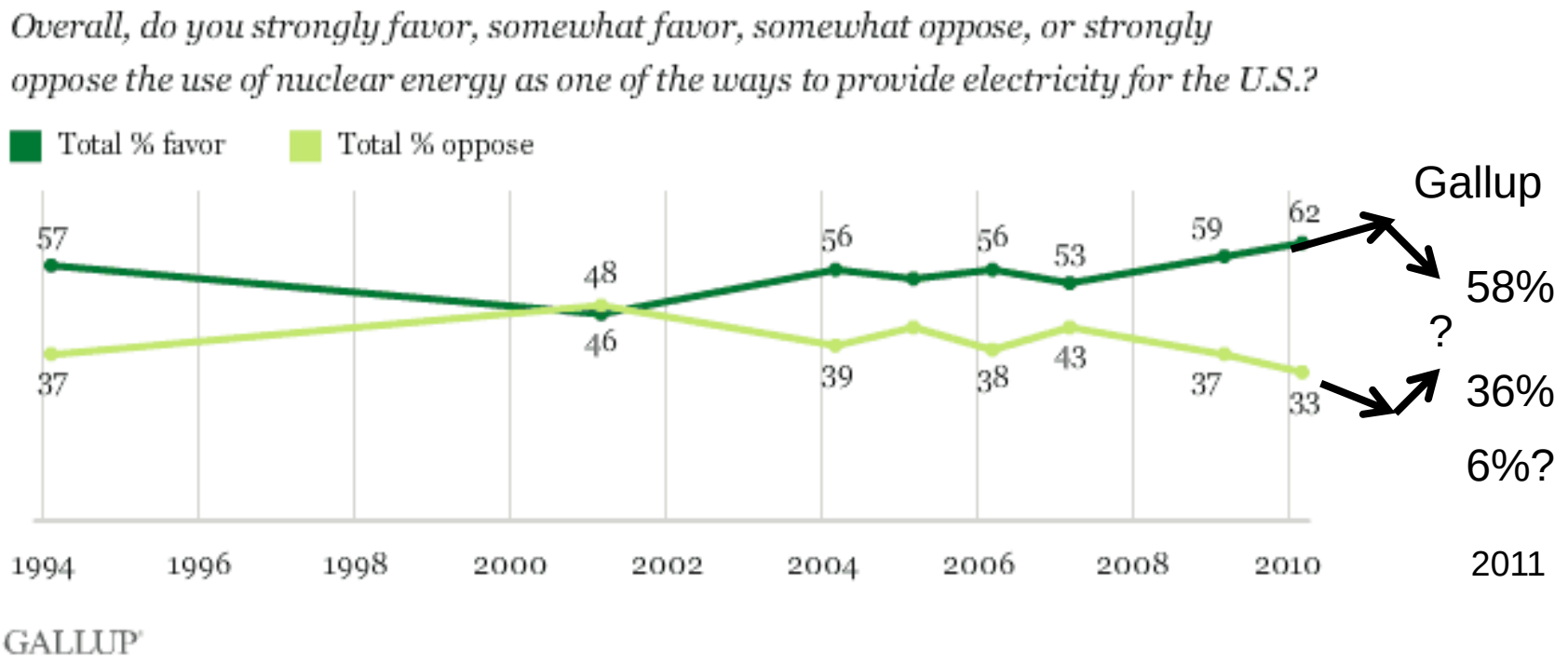
  - New power plants have already taken into account additional safety concerns and are more efficient in electricity production.

  - This too will pass…because the benefits far out weigh the dangers of nuclear power to generate electricity in the U.S.

Nuclear Concerns Treated by News Media

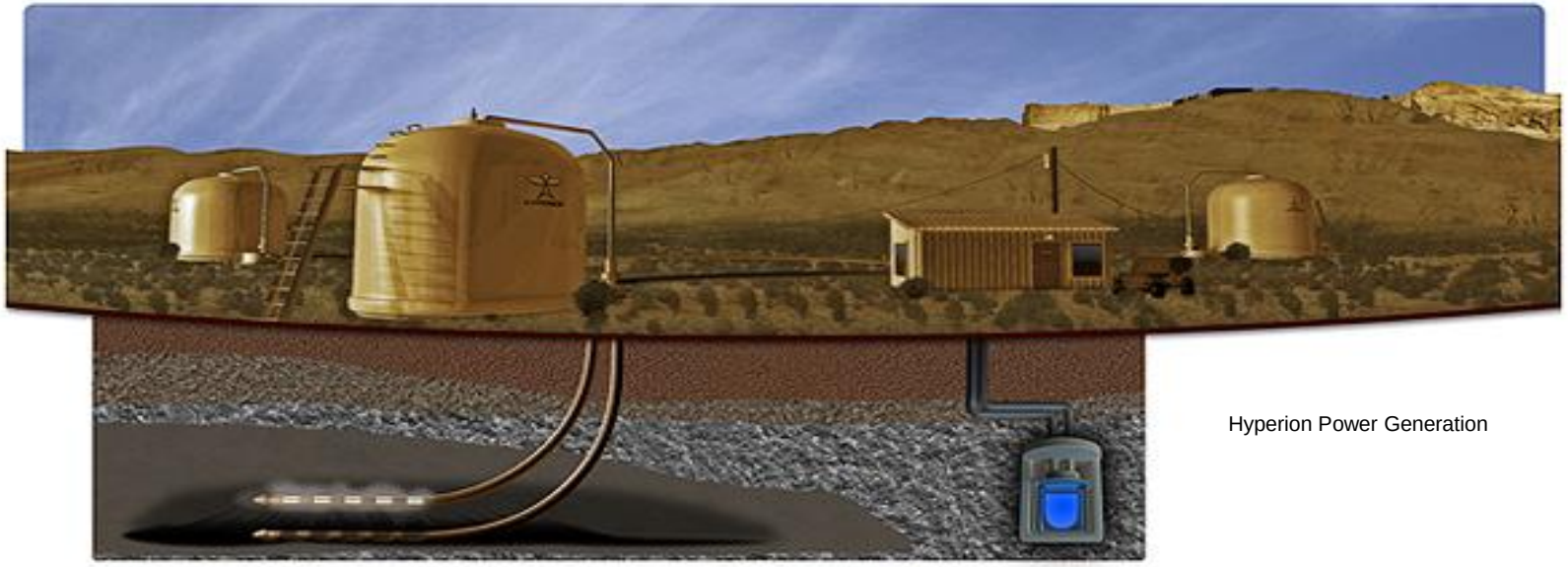
- Billions of dollars in subsidies needed for all alternate-energy resources, including nuclear.
- Biodiesel is subsidized $1.00 per gallon.

Nuclear power was continuing to rise in popularity. Jones (2010) of Gallup reported that Americans' support for nuclear power has increased to 62%, establishing a new high, but then Fukushima Daiichi happened (see graph below).



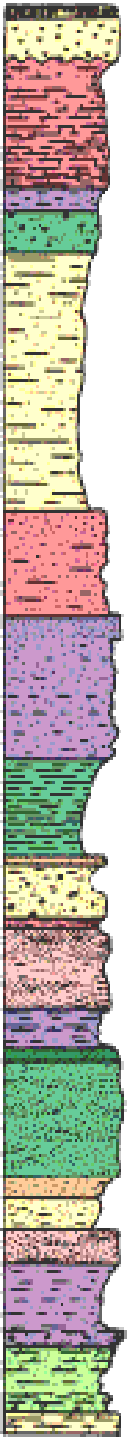
Small-Scale Nuclear Plants

Bill Gates has endorsed using small-scale nuclear power plants (25,000 MW or less), called “nuclear batteries,” for cities after disasters such 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.
Of note is that GE is using nuclear-waste products to fuel their reactors.



Hyperion Power Generation

- **25 MWe – Electricity for > 20,000 Residents (For Disasters or for Remote Operations (Mining, Construction, Oil & Gas Production, etc.)**
- **30-Yr System Life (7-yr fuel replacement cycle)**
- **$30 million Capital Cost**



Uranium Recovery Techniques: Past & Present

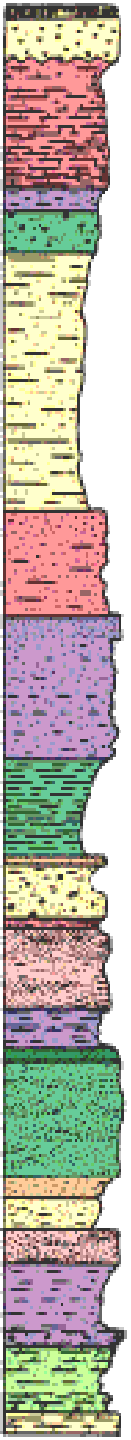
- **Underground**
  - Problems with radiation exposure to miners who smoke tobacco, etc.
  - What to do with tailings from the old mines? Environmental remediation?
  - Prior to the environmental movement there were insufficient regulations to address health, safety, closure, and remediation concerns.

- **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.

Yellowcake Price History & Projections

Historical Spot Price of U_3O_8 (after UXC.com) and Projected Price, see C&A News Release

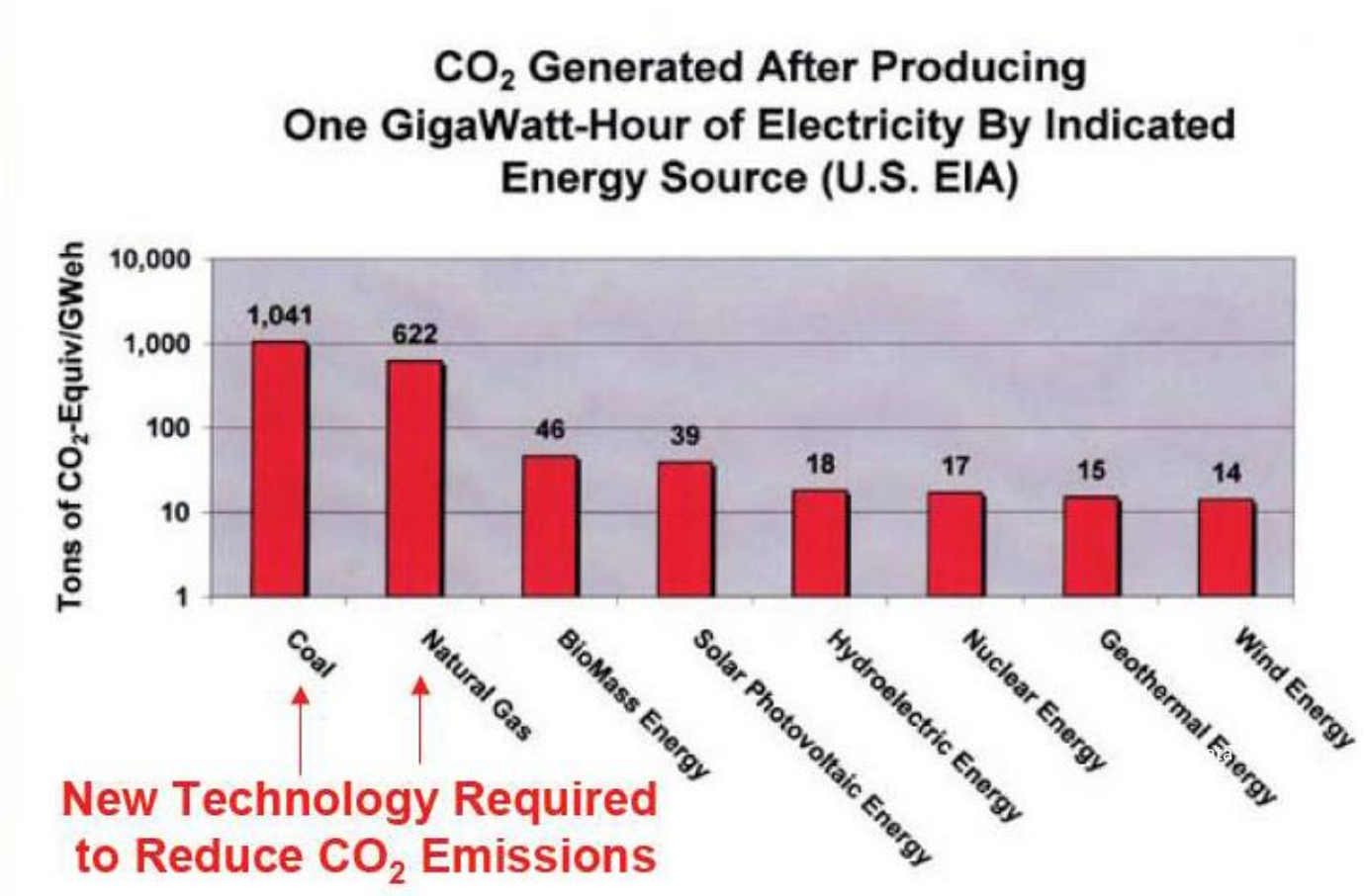


Typical Concerns of Environmental Advocacy Groups & Associated Media

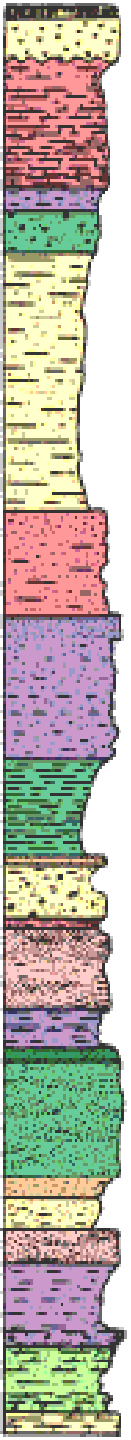
- "Previous ISR mines didn't close using the original cleanup levels, amended levels were used."
- "Mines release radiation into the air."
- "Living around uranium mines show increased cancer rates."
- "Groups want aquifer baseline studies prior to any exploration drilling."
- "In-situ Recovery operations 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."
  - Minor compared to conventional energy sources, i.e., coal, oil & gas, etc.



EIA studies illustrate current understanding of CO_2 production.



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:**

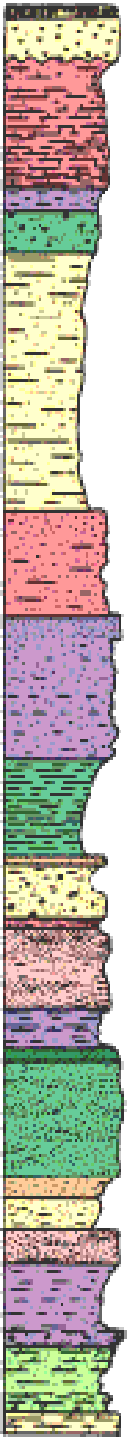
  1) envy of nearby land owners who do not have uranium below their lands,

  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/CAReviewszz/I2MAReviews.htm**

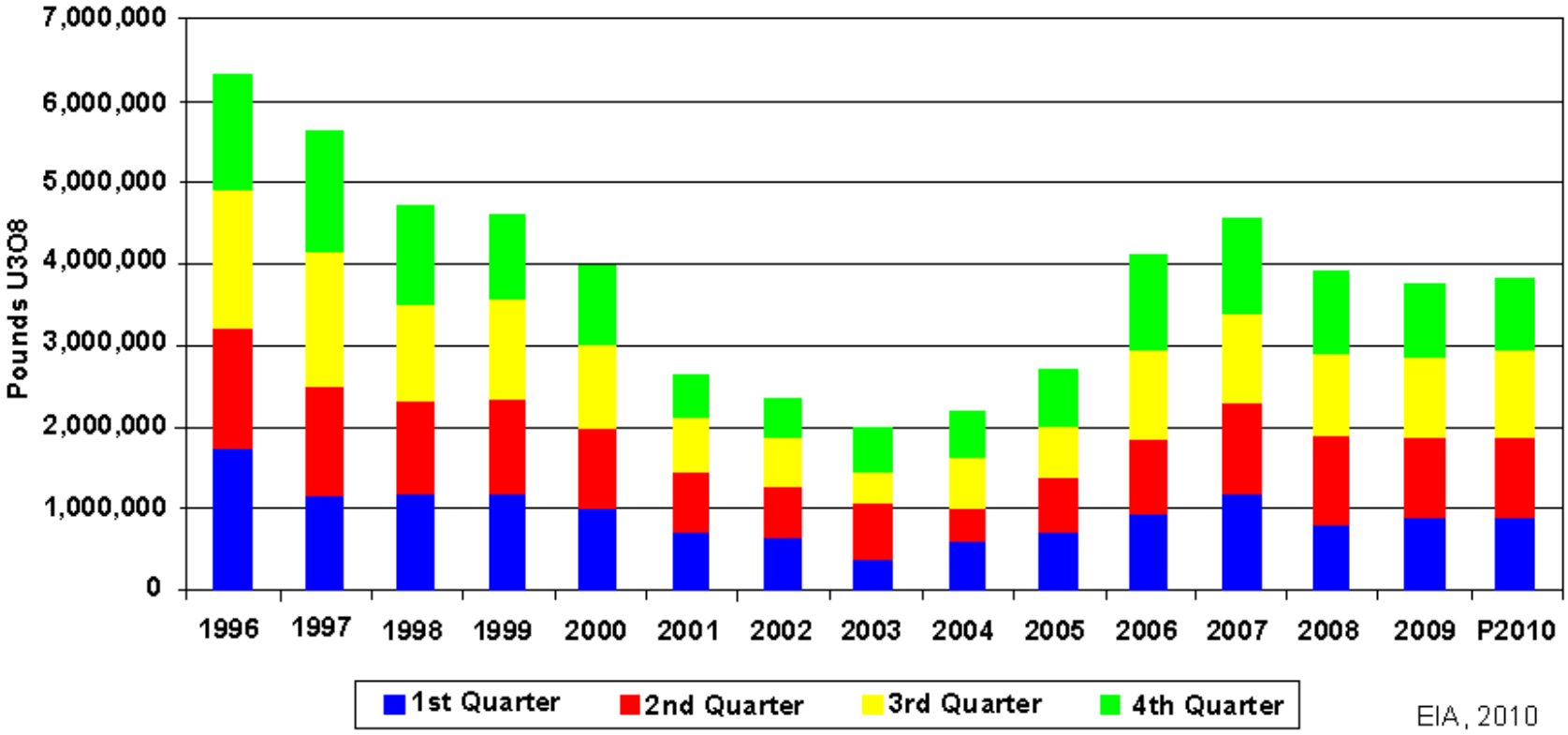


Current Conditions/Expectations of the U.S. Nuclear Industry:

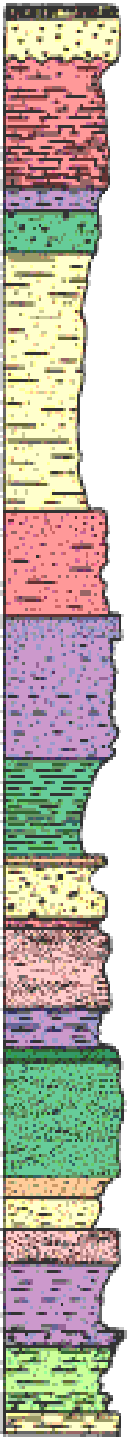
- 4 million lbs / year U_3O_8 (Yellowcake) recovered in U.S. (2010).
- 25 million lbs / year U_3O_8 from Decommissioned Nuclear Weapons Program ends in 2013.
- 29 million lbs / year U_3O_8 current capacity in U.S. (per EIA and Nuclear Regulatory Commission (NRC) data)
- 104 nuclear power plants in U.S. (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, 59 plants under construction, 439 planned and proposed. China is planning more than 150 new nuclear reactors by itself. NEI projects 1,000 to 1,200 reactors globally by 2030.

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



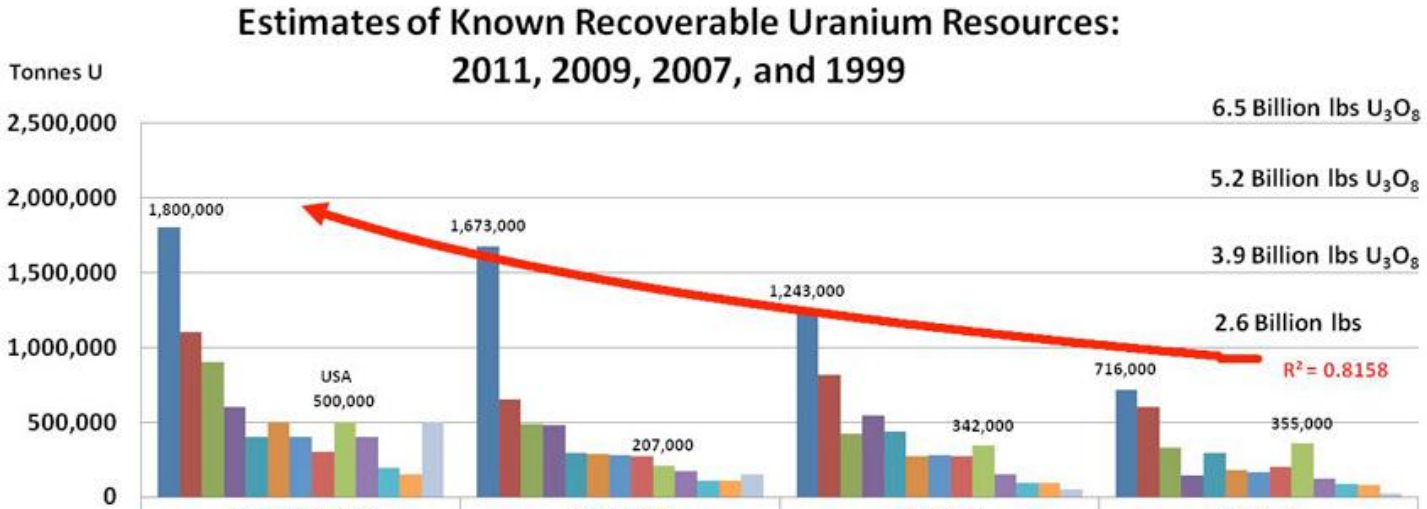
- 4 Mines Operating Today in U.S. = About 4 million lbs/year U_3O_8
- U.S. will need about 20 Mines in production to meet 2021 Requirements….???



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, and/or from
- 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.
- 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.

Current Uranium Resources Available in the World

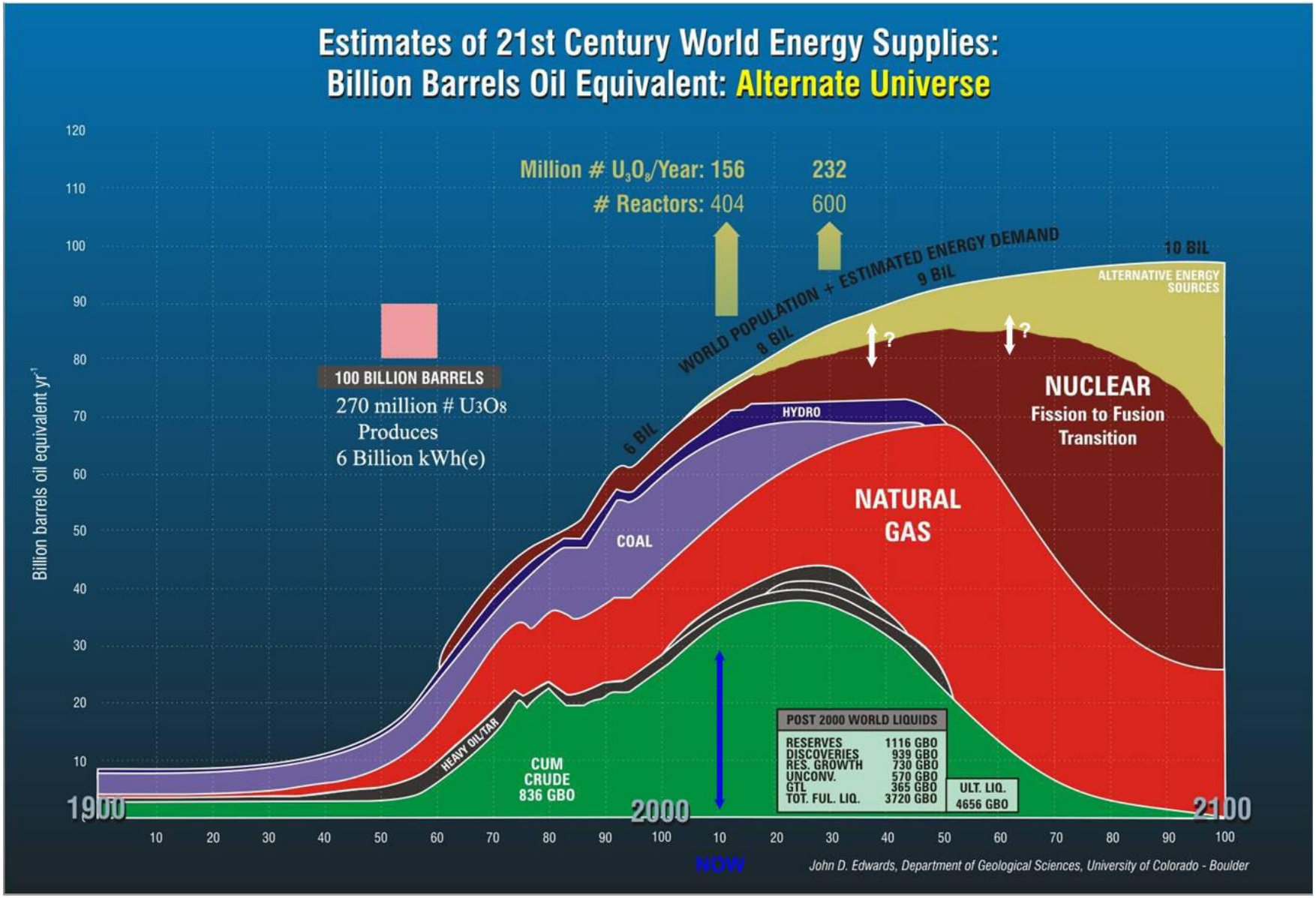


	2011- Estimate 8.6 Million Tonnes U	2009 - IAEA 5.4 Million Tonnes U	2007-IAEA 5.2 Million Tonnes U	1999-UI 3.4 Million Tonnes U
Australia	1,800,000 4.7 Billion lbs	1,673,000	1,243,000	716,000
Kazakhstan	1,100,000	651,000	817,000	599,000
Canada	900,000	485,000	423,000	326,000
Russia	600,000	480,000	546,000	141,000
South Africa	400,000	295,000	435,000	293,000
Namibia	500,000	284,000	275,000	181,000
Brazil	400,000	279,000	278,000	162,000
Niger	300,000	272,000	274,000	200,000
USA	500,000 1.3 Billion lbs	207,000	342,000	355,000
China	400,000	171,000	150,000	125,000
Uzbekistan	190,000	111,000	95,000	83,000
Ukraine	150,000	105,000	90,000	81,000
Other Countries	500,000	150,000	50,000	25,000

(IAEA-UDEPO Data, 2009)

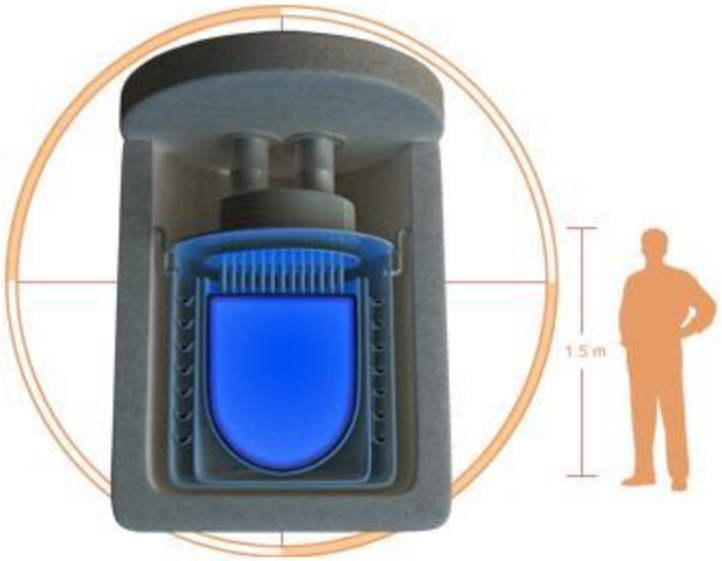
Note: Reasonably Assured Resources plus Inferred Resources, to US$130/kg U, 1/1/09, from OECD NEA & IAEA, *Uranium 2009 Resources, Production and Demand ("Red Book") and earlier estimates by IAEA (2009, 2007) and WNI (1999).*

Where is the Energy Coming From in the Future?



After Campbell and Campbell (**2005**)

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

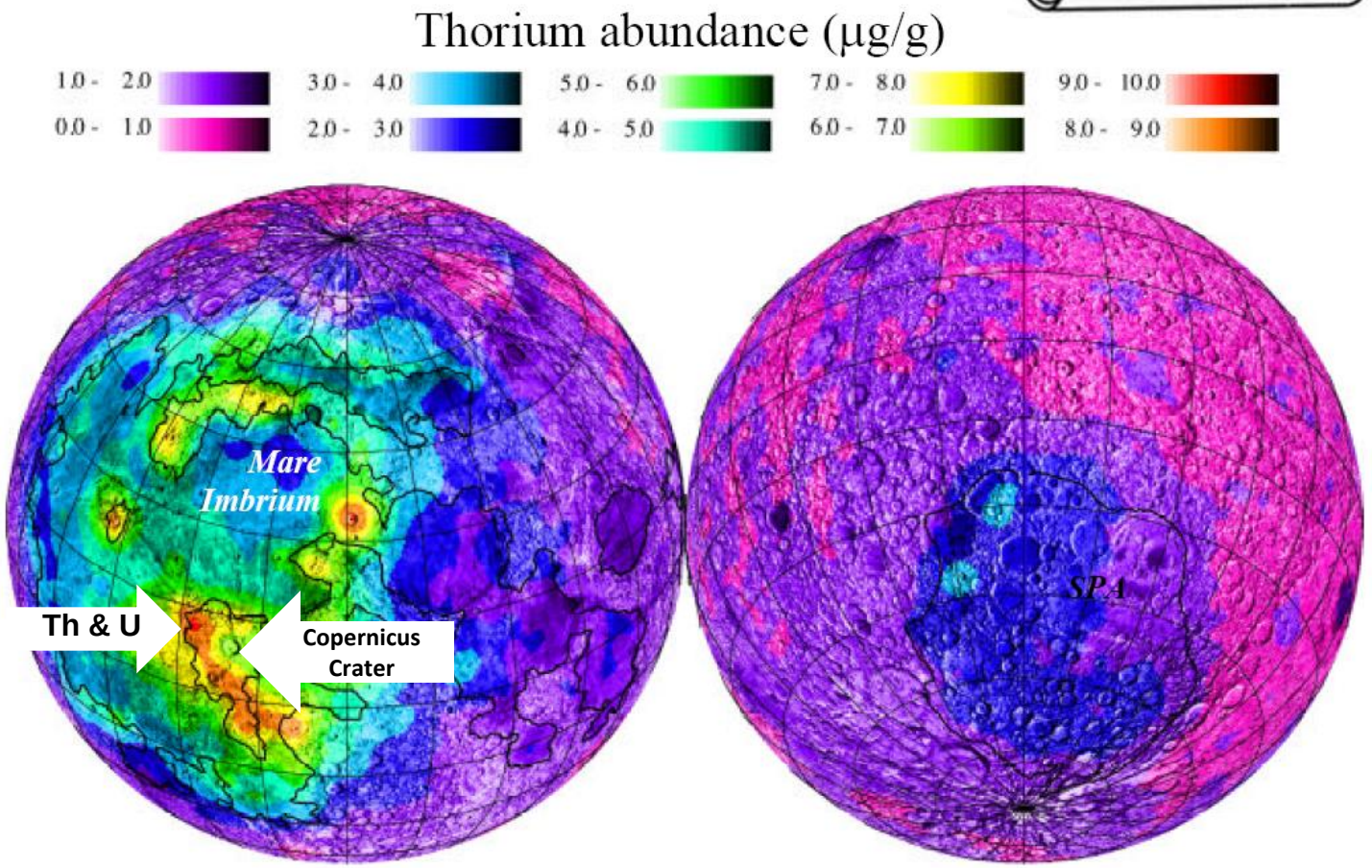


Do We Need to Look Elsewhere Too?

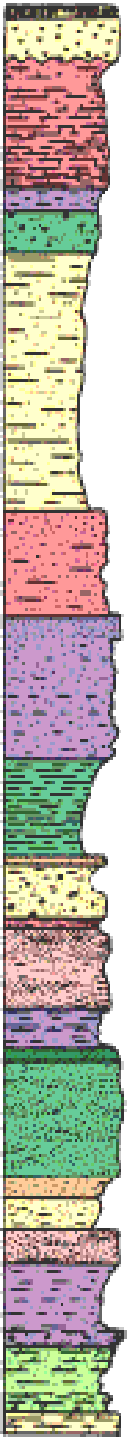
China, India, Japan, Russia
are turning to the Moon!!!

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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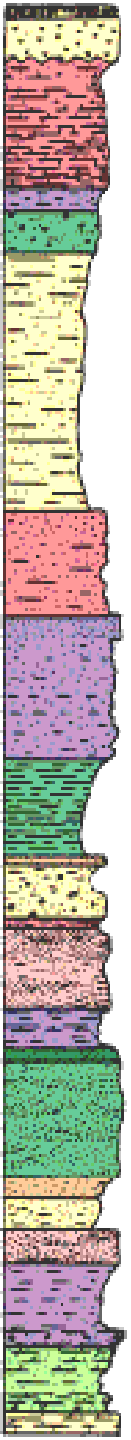

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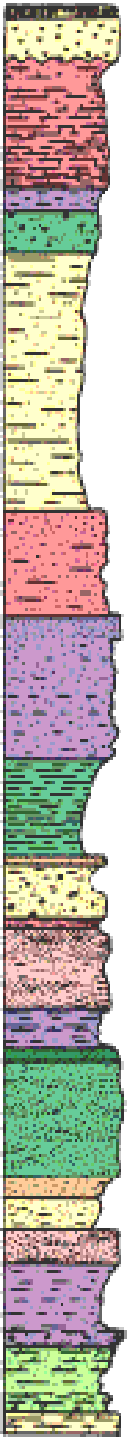

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