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Are Higher Prices Helping Uranium Supply?
A Progress Report

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Uranium supply and sustainability

The uranium price rise of the past two years has resulted in a remarkable shift in industry thinking on the health of the uranium supply sector. In this brief time span, many have moved from a belief that uranium supply was truly vigorous, a vast, seemingly endless source well beyond the conceivable needs of the sector, to a near-panic that the commodity is now analogous to an endangered species. Reality is in fact neither of these imagined scenarios – the uranium resource inventory never was endless, as known resources for all commodities are always finite at any given moment, nor is it in danger of permanent extinction. The patient simply needs medical help in the form of new investment, something that markets should quite efficiently provide. This Paper examines the evidence for this new investment to answer the question posed in the title – are higher prices helping supply?

Previous papers [*1*, *2*] have presented the evidence from several perspectives, based on both resource economics principles and the history of other metals, that support the following conclusion: uranium supply, like that for other metals, is *economically sustainable*. This means that normally functioning metals markets and technology change provide the mechanisms to ensure that supply, at costs affordable to consumers, is continuously replenished, both through the discovery of new resources and the redefinition (in economic terms) of known ones. Some of the key arguments for this conclusion are summarized briefly as follows:

1. **Absence of metal price increases:** Evidence from centuries of metals use in society argues that metals are economically sustainable, and that cost-reducing impacts from new technology, exploration, and substitution have resulted in most commonly used metals being cheaper in real currency than before.

2. **Uranium is “just” a metal:** Despite being an energy commodity, uranium has the geological attributes of metals, and is expected to display the same economic sustainability into the long term as new exploration cycles, spurred by market indications of supply tightness, generate new resources to replace those depleted.

3. **Low replacement costs:** The replacement cost for uranium can be estimated by looking at the results from the first exploration cycle, and indicate that uranium has been, relative to the price the market accords to uranium, inexpensive to discover. Historic finding costs for uranium are about 2% of the current spot price of US$29.50/lb U_3O_8.

But having made the case that uranium is economically sustainable in functioning markets, is there any evidence from the last two years to support this? Is the market behaving as theory predicted, and if not, how does this impact uranium supply?

Recent market responses

Having talked about a uranium price recovery for what seems like a geological time period, we are no longer risking reader scepticism by suggesting that we are seeing such a recovery, as uranium spot prices at the time of this writing (25 July 2005) have reached US$29.50/lb U_3O_8, compared to prices of US$10.90 two years ago, in July 2003. At least in nominal dollar terms, this two-year price trend supports a conclusion that the second significant uranium price recovery has begun. The first price peak coincided with nuclear power's rapid growth, and resulted in uranium spot prices reaching almost US$44/lb U_3O_8 in 1978. The first exploration and mining cycle that was fuelled by this price peak (Cycle 1 – between 1970 and 1985) resulted in the discovery of a large proportion of the world's presently known uranium resources, and allowed the development of the majority of the world's large uranium mines. If we concede that the past two years of price increases signal the start of Cycle 2, the following sections will examine what has happened in the supply sector during this initial two years of Cycle 2. Note that in using this terminology, we are describing the beginnings of an open market and peacetime nuclear supply history. There was clearly a previous, smaller cycle during and post World War II, whose behaviour was strongly impacted by government supply requirements and contracts for military uses.

The roots of this price increase are not complicated, and reflect the observations that sales volumes of secondary sources of uranium have diminished appreciably. This includes excess utility inventory, uranium sold by trading companies and enrichers, and uranium under the HEU agreement that may have been sold on the spot market. Primary uranium supply, meanwhile, had not grown during the period of low uranium prices, so that there has been no significant buffer of uranium mining capacity to easily offset reductions in supply from secondary sources.

Development responses

According to normal economic behaviour, producers of a commodity in undersupply, as evidenced by rapid increases in price, should respond by increasing production where they can do so at relatively low expenditure of money and time. Since our nominal Cycle 2 starting date of July 2003, there have been several responses from the uranium development and mining sector that have an immediate or potential impact on total primary uranium supply. Some of the more significant ones that would act to increase supply are as follows:

- Cameco announced plans to increase annual capacity at its McArthur River operation from 18.7 million lbs U_3O_8 per year to 22 million lbs U_3O_8 per year, and also made a construction decision on the Cigar Lake joint venture.

- Areva moved ahead on development and permitting for the Sue E deposit in Saskatchewan.

- Paladin Resources advanced plans for development of its Langer Heinrich deposit in Namibia.

- Western Mining announced that it is studying a major expansion of the Olympic Dam copper-uranium deposit in South Australia (since acquired by BHP Billiton).

- Southern Cross Resources is considering development of its Honeymoon ISL deposit in South Australia.

- Cameco and its partner Kazatomprom approved the feasibility for the Inkai ISL deposit in Kazakhstan, and commenced mine development.

- In earlier stage development, a number of known but previously sub-economic uranium deposits in Canada, the US, Asia, and Africa have been dusted off and are in many cases receiving the first new work in over 20 years.

Offsetting these, some other announcements may act in the opposite direction, towards reducing uranium supply despite price increases:

- Rio Tinto announced that it may decide to close its Rossing mine in Namibia, due to the poor mine economics, in part resulting from local currency appreciation against the US dollar, in which uranium prices are denominated.

- ERA announced that the Jabiluka resource in Northern Territory, Australia will not be developed without the approval of the Traditional Owners, who are currently against uranium development.

A full accounting of the uranium supply-demand outlook will be covered by other papers at this symposium, however it is clear that there has been a distinct response from uranium producers during the initial two years of Cycle 2. Much of this production response, though, required that the producers be in a high state of readiness to respond to these price signals. This automatically limited the number of players ready to move, since the extended period of low uranium prices between 1984 and 2003 had the effect of vastly reducing the number of viable uranium mining companies to less than ten. Further, by July 2003, there was very little in the way of advanced uranium assets that could be brought quickly to production by new companies, since most of these deposits had been uneconomic and abandoned during lower prices, and few companies could survive the long market low with no cash flow available from their assets.

The next tier of known deposits in North America, Africa, Australia and Asia is being re-explored to bring the knowledge and data on these resources up to current standards. Undoubtedly some of these will see production at current prices, but there will be a necessary time lag to production of two to ten years depending on location. This time lag reflects the time needed to meet securities exchange standards on technical disclosure, to raise financing, and to move through permitting, environmental assessment, and licensing in areas that may not have seen uranium activity in decades, or indeed ever. As part of this process, the industry will likely encounter strong negative views on nuclear power and uranium, that continue to hinder rational development of new mines in many regions. Under today's societal expectations of best practices in sustainable development and community consultation, mining companies no longer have an option of proceeding in defiance of community views.

Most projects will still move through this in a supportive uranium market, but time is lost in the process, exacerbating tight primary supply. This is not a problem isolated to developing countries, as even a sophisticated mining power like Australia continues to support policies, at federal and state levels, that demonize nuclear power, deny the global benefits that accrue from nuclear generation, and generally make uranium mine development extremely difficult.

Exploration responses

In addition to increasing production, the mining sector typically increases expenditures on mineral exploration during times of undersupply and price response, as stronger prices increase the range of new discoveries that could generate a return. During the two-year beginning of Cycle 2, there has been a very rapid and significant increase in the number of exploration companies that have been started for uranium exploration, or changed their strategy to include uranium as a target. Several sets of data help to quantify this response:

1. **Total number of companies exploring for uranium**

   In 2000, while uranium prices were still in decline and nearing eventual lows, there were about 30 companies actively exploring for uranium. Roughly half of these were producers, including state-owned uranium companies, while the other half were junior explorers with a long-term view of the market and faith in the price recovery. In 2005, there are approximately 175 companies actively pursuing uranium, an increase of over 500%.

2. **Number of new junior entrants in uranium**

   Of the increase cited above, the vast majority of the 175 uranium explorers, roughly 140, are new junior companies formed to explore for uranium, or existing juniors who have added uranium to their portfolio. The importance of a healthy junior exploration sector cannot be overstated – through the sheer number of companies, amount of investment, and exploration diversity of this sector, the pace of exploration and discovery is increased in ways that the major producer sector alone cannot accomplish.

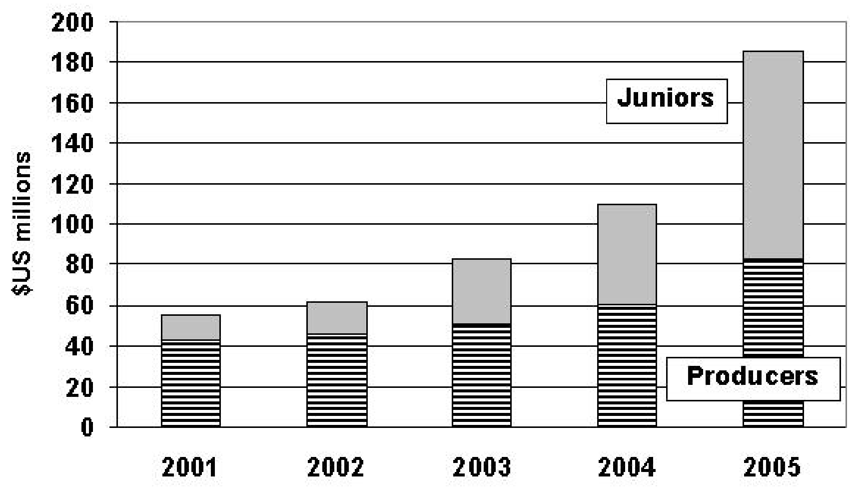
3. Number of major mining companies adding a uranium strategy

To date, only one major producer, BHP Billiton, has added uranium to its commodity portfolio, in this case via the acquisition of WMC and its Olympic Dam operation. The total size of the uranium supply sector is still much smaller than that of other major metals, which may militate against participation by the major diversified metals companies. These diversified companies are also much larger now than during Cycle 1 due to consolidation over the intervening years. To date, we have not seen any substantial entry by petroleum companies, such as took place in the 1970's.

4. Exploration expenditures

From lows of approximately US$55 million in 2000, world uranium exploration is estimated to have reached US$110 million in 2004, and should reach approximately US$185 million in 2005 *(Figure 1)*. These increases represent a 300% growth in investment in five years. More importantly, over half of the estimated 2005 exploration expenditures, and the largest source of increased spending, will be through the efforts of the junior sector, highlighting the rapid response that this sector is capable of.

Figure 1 - Uranium Exploration Expenditures



5. Media coverage of uranium exploration

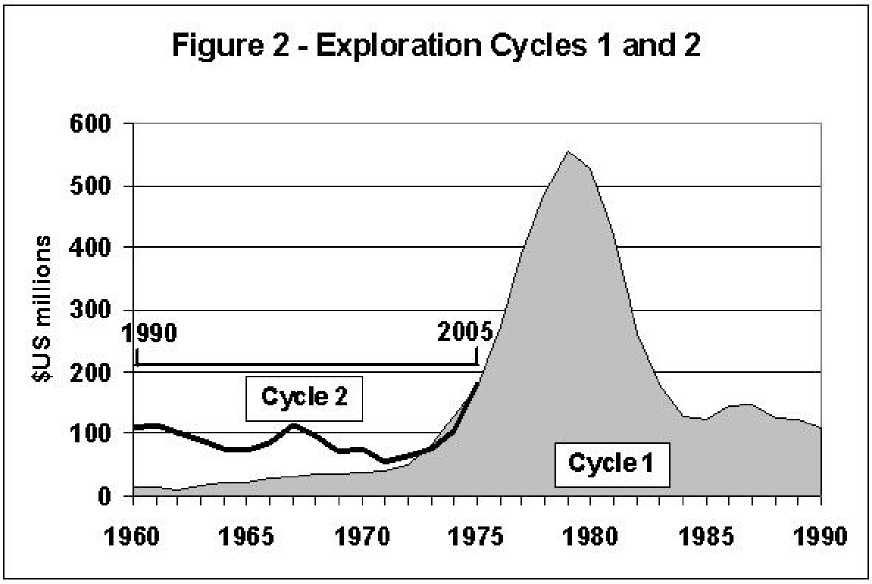
Mining and general public media have increasingly covered the resurgence in uranium exploration, in many cases accompanied by relatively favourable reporting on the parallel resurgence of nuclear power and its role in global energy policy.

6. **Country strategy of new uranium explorers**

   Many of the early new entrants to uranium exploration focused on the pre-eminent production area, the Athabasca basin of northern Saskatchewan, Canada, where land positions were still available, and to a lesser extent in Australia. As this land has become tied up through staking, and more companies turned to uranium, there has been the beginning of a diversification in the country and regional strategy of the new exploration companies. Junior explorers are typically more willing to accept increased project or country risk, and in some cases lead exploration efforts into new regions. We are now seeing increasing junior exploration in regions such as Mongolia, Africa, South America and northern Europe. This regional diversification is extremely important in yielding maximum success from global exploration, akin to the benefits of equity diversification in investment portfolios.

Comparison with first exploration-production cycle

It is still too early in Cycle 2 to analyze the exploration outputs or discovery record, as a longer time period is necessary to allow results to accrue. But since the discovery rate is directly related to the rate of exploration investment, it is instructive to compare expenditures from the first part of the Cycle 2 with those of the first cycle. Global uranium exploration spending has begun a significant rise *(Figure 1)*, but the perspective of a 40 year comparison with Cycle 1 *(Figure 2)* underscores the conclusion that Cycle 2 has a significant way to go if it is to equal the total exploration investment achieved in Cycle 1 (US$4.6 billion between 1960 and 1989, in nominal dollars).



Must the second cycle equal the first? The answer depends in part on the future for new nuclear generation. To sustain or slightly increase present levels of uranium supply may perhaps require less than Cycle 1 investments if this spending is efficiently utilized in prospective areas of the world. But if the current gradual trend towards an increase in new nuclear build accelerates, future shortfalls in supply will become larger very quickly. In this scenario, the market would have full access to the new demand estimates from approved new nuclear generation, and this improvement in future outlook would be an important component in ensuring that the financial markets continue to support uranium exploration through easy access to financing in the junior sector, and, to a lesser extent, higher budgets from uranium producers. Thus, there is an important dynamic in place that will link market support for higher exploration investment levels with the higher supply needs of a future nuclear renaissance.

Another point of comparison between Cycle 1 and Cycle 2 is the dramatic change in the competitive landscape. In particular, the large state-owned uranium companies from Cycle 1, who had invested early in both exploration capability and a worldwide set of projects, are for the most part gone. In their place is an environment dominated by listed public companies – a small group of major uranium companies who have grown by consolidation during the market low, several integrated large mining companies, and a growing tier of junior explorers. In its competitive makeup, the uranium sector in Cycle 2 now more closely resembles other metals sectors such as gold, which relies heavily on market-fuelled junior companies to carry out the higher-risk exploration stages. So while the new composition of the uranium sector should be up to the demands for new supply, these new public companies will also demonstrate a higher dependence on supportive markets and prices compared to many of the Cycle 1 players.

Several state-controlled uranium enterprises do exist of course, but these are almost exclusively focused on uranium supply within the political boundaries of the host nation, in those countries which have exclusively state-owned uranium and fuel cycles (e.g. Russia, Argentina, Brazil, China, India). These “captive” state-owned explorers typically do not have mandates that allow the pursuit of international targets. Even within these countries, the dominant focus on internal supply and energy security has the general effect of subsidizing lower quality deposits which may not be competitive on a global basis, thus increasing the uranium supply cost for the closed market nations. Perhaps most importantly, these countries will completely miss the wave of outside investor money that is accompanying Cycle 2. In the first cycle, this wave of market-fuelled investment made a huge impact in enabling the major Cycle 1 uranium discoveries in Canada and Australia, and more recently Kazakhstan – countries whose open investment policies have directly resulted in the now-leading producers of uranium. It is difficult to avoid the conclusion that, especially during a new uranium exploration-production cycle, countries which are not open for outside uranium investment will incur an opportunity cost, measured through the absence of accelerated discoveries and therefore of increased future production. This opportunity cost may be of little concern for the closed-market countries with relatively small uranium supply needs, but should be of much greater importance for those who are growing their nuclear generation base.

Discovery, expenditures and timing

The simplest way to forecast the future volume of exploration outputs (i.e. discoveries) is to assume that uranium discovery costs worldwide will be more or less the same as they have been historically. The history of military-driven uranium exploration and mining through the 1940s and 1950s makes it more difficult to isolate the specific discovery results of Cycle 1 which are considered to be driven by nuclear power demand, however simplifying assumptions can be made that provide reasonable estimates. Although the IAEA reports have provided the best continuous source of data on uranium exploration expenditures, the definition of exploration by contributing countries has not been tight enough to use these data as presented to determine discovery or finding costs. During many years, a considerable amount of much more advanced delineation drilling, or wellfield development for ISL, has been included in the IAEA costs (a fact often noted in these reports). The proportion of these advanced exploration or development costs can approach 50% for some years, or be as little as 20%. To better isolate the investments that have led to discovery, 65% of the annual IAEA exploration costs have been utilized as an estimate of “true exploration”, supplemented by information in internal Cameco databases for more recent years.

Using these costs as a basis, the average world discovery cost for Cycle 1 can be estimated as the cost of finding the following:

1. all uranium consumed in nuclear fuel to 2002 (1.05 million tU).

2. minus 40% of this uranium consumed in fuel to account for an estimate of fuel provided by primary or secondary sources discovered prior to Cycle 1 in the military-driven period.

3. plus IAEA’s Known Conventional Resources at 2003 (3.54 million tU) [*3*].

4. minus an estimate to account for the uranium still present in the Known Conventional Resources, but again discovered prior to Cycle 1 during the military uranium period (~1 million tU).

This sum, 3.15 million tU, represents an estimate of the uranium that is considered to have been the discovery and production output from Cycle 1. This output is divided into the total spent on exploration during Cycle 1 as defined above, about US$4.6 billion (nominal dollars), to yield an approximate discovery cost of US$1.50/kgU. Given the nature of the estimates required to derive this discovery cost, it should be considered a reasonable order of magnitude, but it nevertheless underlines how inexpensive, relative to present or long term average uranium prices, the continual re-supply of uranium has been. Indeed, since only the IAEA Known Conventional Resource category at <US$80/kg has been used as a proxy for the discovery output, any eventual upgrading of the more speculative resource categories will reduce this discovery cost estimate.

It should be noted that these costs are slightly lower than published in a previous WNA Symposium Paper [*2*] due to increases in the IAEA resource estimate utilized, and a slightly lower estimate of applicable exploration expenditures with further research into these data. Discovery costs for the economic Athabasca basin uranium deposits were about one-third less than these global average costs, at about US$1.00/kgU, demonstrating the variability of discovery costs by region and geological model.

While knowing approximate discovery costs over the long term does allow an estimate of the eventual volume of uranium discovered, we also need to estimate the time required to get to production. In terms of timing, a production cycle always lags the exploration cycle by a time period that depends on the time required to develop, license and construct new operations. For the Athabasca basin exploration cycle in Saskatchewan, Canada, the beginning of significant production from this basin was almost 10 years after the start of exploration, and the peak of production (which should be reached in about 3 years) will be a sobering 45 years after the beginning of exploration activity in this region [*1*].

Will new regions have similar time lags, or can we expect that new mining projects can be moved more quickly into a needy market?

The answer may involve dimensions that have opposing effects. Certainly, the presence of a generally undersupplied market will ensure that companies invest the necessary amounts to move promising projects through at a faster rate than happened when prices were very low. At some level, however, large and complex development projects can only move so fast, as there will still be significant technical or permitting risk associated with most projects, and corporate decision processes need structured approval milestones. But in general, strong markets should help in shortening the cycle compared to the past 20 years.

Offsetting this effect, however, will be a series of delaying factors that reflect the fact that the mining world is not the same as it was in the 1970s when many large uranium projects were commissioned.

- Today's mining companies have largely embraced the global expectation that they require a "social licence to operate" for any new mine development and, as part of this practice, sustainable development from the earliest stages of new activity. These changes have large implications for new uranium mines, as best practice now requires community and local consultations as well as meeting all other requirements under mining, safety and environmental legislation. The time required, the requirement to have considerable environmental and nuclear safety expertise, and the expectation that companies share a greater amount of financial benefits, all raise the entry barriers for any company that wishes to become a uranium miner.

- Environmental assessment, permitting, and licensing processes, at least in developed countries, are significantly slower for uranium projects than they were in the 1970s, and are less tested and therefore less known in many developing countries.

- Public companies must now meet much more stringent standards for disclosure to shareholders, which in turn requires more work be done to verify the basis for disclosure of uranium resources and development decisions.

- Nuclear energy continues to be undervalued by countries who use it and especially by those that do not, creating a default environment of scepticism when considering new uranium mine developments. Few national governments have backed up their professed desire for clean air by providing nuclear-friendly policies that explicitly encourage uranium production, and many have done precisely the opposite.

Requirements for a successful Cycle 2

To allow Cycle 2 to match or exceed the new discovery record of Cycle 1, it is apparent that at least an equal total investment level should be reached. From 1990 through 2005, Cycle 2 will have resulted in US$1.5 billion in world exploration investment, still only a third of the total exploration expenditures of US$4.6 billion (nominal dollars) from Cycle 1. Cycle 1 featured a very sharp peak in exploration spending, which correlated with the uranium price peak in the late 1970s. Exploration processes are far more efficient under a more sustained style of funding than this example, and the nuclear industry would benefit from a longer period of elevated exploration spending than we saw in Cycle 1, even if the maximum annual level of Cycle 1 spending is not achieved.

To enable an efficient and sustained Cycle 2, markets must be allowed to set uranium prices based on accurate global supply information. Nuclear utilities could also provide support for the uranium mining sector, if necessary, through assistance in lifting resource development policies that discriminate against uranium mining. Countries whose energy policies depend on nuclear power should also consider how they might be able to influence uranium development policy, in their own country and in other regions with production potential. China is one country now demonstrating a strong political interest in the uranium policies of other producing regions, to ensure a wider choice in future supply for China's nuclear generation growth, and likely a lower average supply cost. Overall, the success of the exploration sector in discovering low-cost resources for the future depends to a large extent on the wide availability of prospective exploration land.

Conclusions

- The responses of the uranium exploration and mining sector during the first two years of the second peacetime uranium exploration and mining cycle, Cycle 2, are entirely consistent with expectations based on resource economics and the price-supply dynamics exhibited by other metals. Producers have increased production, and world exploration investment has increased by 300% since 2003 and 500% since 2001.

- The low uranium prices of the 1980s and 1990s were a gift to nuclear generation, but could also be argued to have been a Trojan horse. Hidden in the benefit of US$10.00/lb uranium was a huge loss of discovery of new uranium resources, and of industry capacity and readiness to respond quickly to undersupply.

- Sustaining Cycle 2 is of immense importance to the nuclear industry, in particular if this cycle must not only equal the discovery results of Cycle 1, but exceed them due to the increasing likelihood of a nuclear renaissance, and also due to the impending depletion of available secondary uranium supplies.

- Since price is always the variable that takes care of supply shortages, the primary uranium shortfalls widely forecast to be ahead should be the driver for prices strong enough to enable successful financing of the remainder of Cycle 2 exploration and development investment.

- An important consideration as we see investment levels rising is the chequered nature of support for uranium mining around the world. It is in customers' long-term interest to examine what they can do to encourage prospective supply countries to support new uranium mines and nuclear-friendly policies.

- The beginning to Cycle 2 looks to be a great first 1000 metres… in a 10 000 metre race. Endurance, more than starting speed, will win for the nuclear industry.

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