Contribution ID: **70** Type: **Poster**

Using high temperature gas-cooled reactors for energy neutral mineral development processes –a proposed IAEA Coordinated Research Project

Wednesday 25 June 2014 17:10 (1 minute)

Today, uranium mined from various regions is the predominant reactor fuel of the present generation of nuclear power plants. The anticipated growth in nuclear energy may require introducing uranium/thorium from unconventional resources (e.g. phosphates, coal ash or sea water) as a future nuclear reactor fuel. The demand for mineral commodities is growing exponentially and high-grade, easily-extractable resources are being depleted rapidly. This shifts the global production to low-grade, or in certain cases unconventional mineral resources, the production of which is constrained by the availability of large amounts of energy.

Numerous mining processes can benefit from the use of so-called "thermal processing". This is in particular beneficial for (1)low grade deposits that cannot be treated using the presently dominant chemical processing techniques; (2) the extraction of a high purity end product; and (3) separation of high value or unwanted impurities (e.g. uranium, thorium, rare earths, etc.) that be used/sold or, when extracted, will result in a cleaner final product. The considerably lower waste products also make it attractive compared to chemical processing. In future we may need to extract nuclear fuel and minerals from the same unconventional resources to make it feasible and cost-effective. These processes could be sustainable only if low-cost, carbon free, reliable energy is available for comprehensive extraction of all valuable commodities, for the entire life of the project. Nuclear power plants and specifically High Temperature Gas-cooled Reactors (HTGRs) can produce this energy and heat in a sustainable way, especially if enough uranium/thorium can be extracted to fuel these reactors as firstly proposed by Haneklaus et al. („Using high temperature gas-cooled reactors for greenhouse gas reduction and energy neutral production of phosphate fertilizers"-Annals of Nuclear Energy).

The proposed Coordinated Research Project (CRP) will thus conduct research and techno-economic feasibility studies on the combination of the following aspects: (1) the use of unconventional uranium (and thorium) resources as future nuclear reactor fuel; (2) the use of thermal processing to extract minerals and by-products in mining and mineral development processes and (3) the study of the sustainability of these two processes by combining them (individually or combined) with the utilization of HTGRs as the electricity/heat source. The CRP further intends to generate basic data on the availability and characteristics of such low grade mineral resources and the impurities. Finally, the possibility of an energy neutral value addition in sustainable mineral development project will be evaluated by the uranium/thorium recovered in the process.

Although the need to utilize unconventional uranium (and thorium) resources may still be far into the future, the legal requirements for beneficiation of minerals (such as the recent implemented law in Indonesia) and new cleaner regulations of end products (e.g. cleaner fertilizers, reduced impurities in end products) create an urgency to investigate the feasibility of the thermal processing of minerals and for the removal of especially uranium and thorium from end-products.

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Session Classification: Poster Session

Track Classification: The Future of uranium —Focus on development of greenfield sites