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ALTA 2020 Uranium-REE Conference

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Application of Membranes Forum

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Uranium-REE Opening Address

THE ROLE OF UNCONVENTIONAL URANIUM RESOURCES

By

Martin Fairclough
Uranium Specialist, Uranium Resources and Production
International Atomic Energy Agency (IAEA) (Austria)

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ABSTRACT

Uranium resources and deposits have been broadly subdivided by the Joint OECD/NEA-IAEA Uranium group[1] as either conventional or unconventional. Unconventional resources are defined as very low-grade resources from which uranium is recoverable as a minor by-product and where there has been no history of commercial production. Furthermore, by-product uranium is defined as such when it is a secondary or additional product, in contrast to co-product where one of several commodities must be extracted to make a mine economic (thus categorising uranium produced from the Olympic Dam mine as a co-product defining the deposit conventional). It is important to note that there are additional definitions regarding co- and by-product uranium that focus on the part of the processing flow sheet at which uranium is extracted, whereby by-product can be extracted from secondary mine waste material and can be defined as by-product extraction from unconventional deposits, such as uranium from phosphates and from residue, waste rock or tailings from gold or copper deposits. Recent interest in the latter is growing as part of a broader interest in the mineral extractives industry of re-mining anthropogenic resources as a means to reduce waste and environmental remediation costs, but still remains conceptual.

For economic reasons the majority of historical uranium production has been from conventional uranium resources. While the confidence in resource estimates of unconventional resources is relatively low, due to lack of data, low grades, and lower economic and technical confidence in their profitable extraction, the proportion of resources is relatively high and has geographic distributions that are different from conventional resources. Consequently, the potential impact on an individual country's domestic supply ambitions, has led to interest in extraction of uranium from unconventional resources. Not only does the extraction of unconventional resources require significant technical investment, but the degree of regulatory and environmental oversight is not any less than is required for conventional resources.

In the IAEA geological classification of uranium deposits most unconventional resources are associated with intrusive plutonic, polymetallic iron oxide‑ copper‑gold breccia complexes (IOCG-U), volcanic-related, Au-rich palaeo-quartz-pebble conglomerate, placers, lignite‑coal, phosphorite and black shale. Identified conventional resources amount to ca. 7-8 Mt U[2]. In recent editions of the Red Book, with similar amounts of unconventional resources. However, the IAEA Uranium Deposit database (UDEPO) lists several hundred unconventional deposits with limited available data (and therefore requiring significant additional work to be included in Red Book) amounting to > 50Mt U. Many of these deposits are outside of the well-established uranium centres in Kazakhstan, Canada, Australia etc and are potential important sources of domestic uranium supply for other countries. While some of these resources are currently destined to reside in mine waste (or have already done so) with no immediate plans to extract them, they remain as part of the unconventional resource inventory for possible future extraction should the economic, technical and environmental factors prove appropriate.

1. OECD/NEA-IAEA Uranium 2018 resources, Production and Demand. Paris, France (2018).

2. International Atomic Energy Agency, Uranium Resources as Co- and By-products of Polymetallic, Base, Rare Earth and Precious Metal Ore Deposits, IAEA-TECDOC-1849, IAEA, Vienna (2018).

Keywords: Unconventional uranium, uranium mining, comprehensive extraction, remining, co-product, by-product.

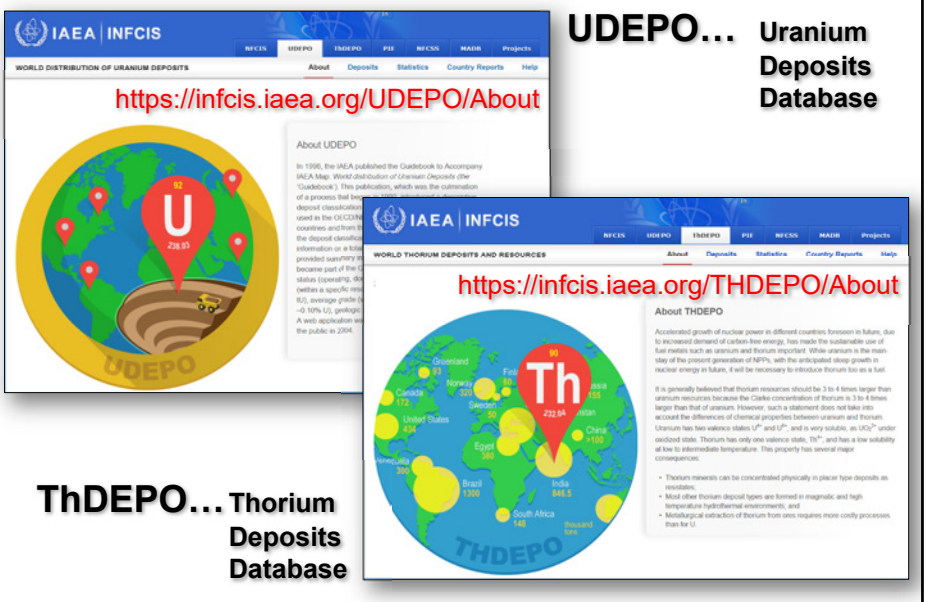
Outline

- Uranium Production Cycle activities at the IAEA
- Uranium Resources, Production and Demand
- Unconventional resources
- Unconventional Deposit types
- Unconventional Resource Production

Uranium Production Cycle Activities

- Authoritative, Objective, and Reliable Information to Support Member States with Characterization and Evaluation of Uranium/Thorium Resources…
  - Resource & Statistical Data
  - Geology
  - Deposit Types
  - Deposit Distribution
  - Undiscovered Resource Assessment and Mineral Potential

Statistical Data – UDEPO, ThDEPO



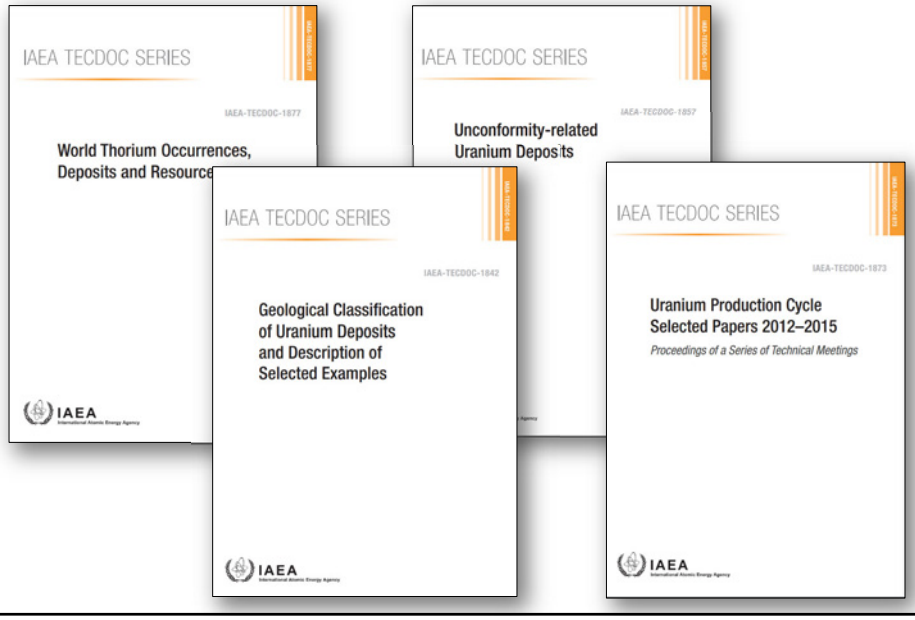
UDEPO… Uranium Deposits Database

ThDEPO… Thorium Deposits Database

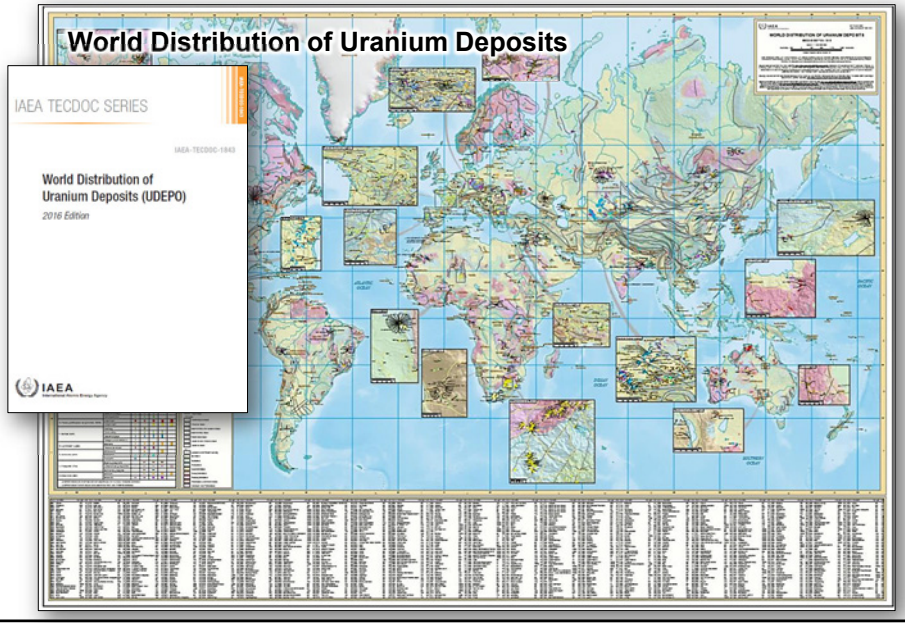
https://www.iaea.org/resources/databases/integrated-nuclear-fuel-cycle-information-system-infcis

Geology

Deposit Types

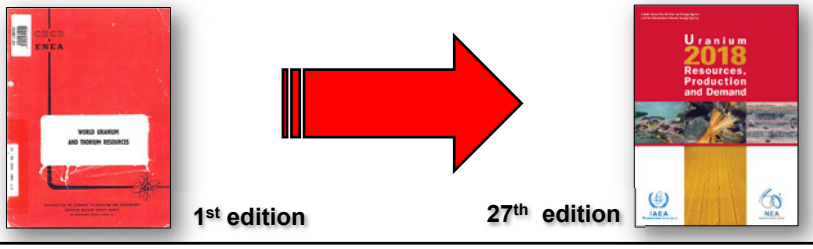


Deposit Distribution



Resource Data – Uranium "Red Book"

- Provides Temporal Statistics and Analyses for Uranium Resources, Exploration, Production, Demand, Secondary Sources, Surplus Military Material, and Supply-Demand Relationships
- Derived From Responses to Questionnaires Designed by the Joint NEA-IAEA Uranium Group and Distributed by the OECD-NEA and IAEA



Resource Data – Uranium "Red Book"

Supply is made up of two major components:

- Resources
- Production

Resource Data – “Red Book”

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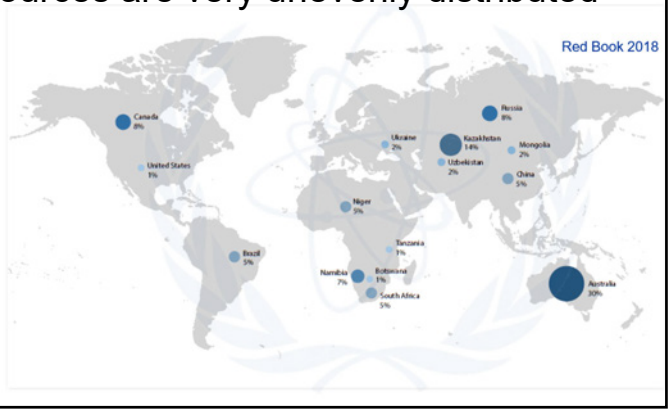
- **Resources**
- Production

Uranium resources are very unevenly distributed globally



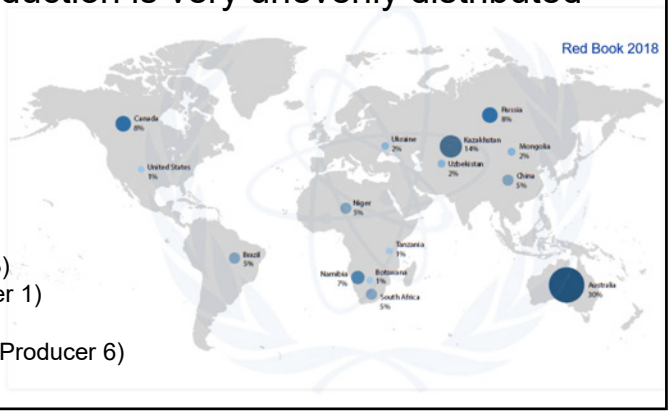
1. Australia
2. Kazakhstan
3. Canada
4. Russian Federation

Resource Data – “Red Book”

Supply is made up of two major components:

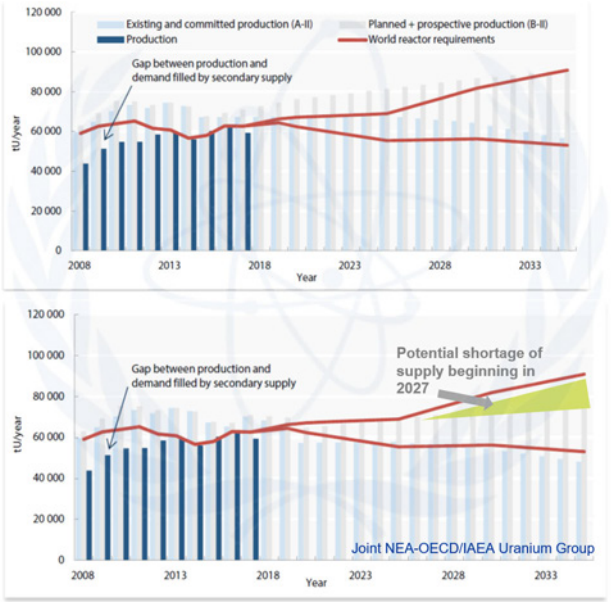
- Resources
- **Production**

Uranium production is very unevenly distributed globally



1. Australia (Producer 3)
2. Kazakhstan (Producer 1)
3. Canada (Producer 2)
4. Russian Federation (Producer 6)

Uranium Production Capability vs Demand



100% of forecasted nameplate production capacity achieved

85% of forecasted nameplate production capacity achieved

Resource Data

Resources alone do not necessarily mean supply

Producers will have to overcome a number of significant and, at times, unpredictable issues in bringing new production facilities on stream, including geopolitical and local factors, technical challenges and legal and regulatory frameworks.

So there is a possibility of a supply risk.

Some countries will look to potential domestic sources of supply to mitigate this risk, but as indicated, few countries have most of the conventional resources

Conventional and Unconventional Resources

Conventional Resources
Established history of production where uranium is a primary product, co-product or an important by-product (e.g. mining of Cu and Au).

Unconventional Resources
Defined as very low grade resources or those from which uranium is only recoverable as a minor by-product.

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By-product uranium is defined as such when it is a secondary or additional product, in contrast to co-product where one of several commodities must be extracted to make a mine economic.

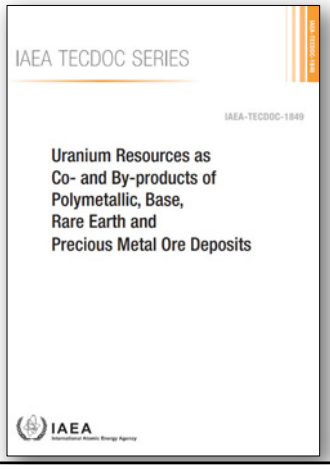
Alternatively, co-product is extracted during primary process, while by-product can be extracted from secondary mine waste material and can be defined as by-product extraction from unconventional deposits.

Conventional and Unconventional Deposit Types

Under the IAEA Classification of Uranium Deposit Types, there are 15 types and 50 subtypes, some of which are either defined as unconventional resources or contain examples that are unconventional.

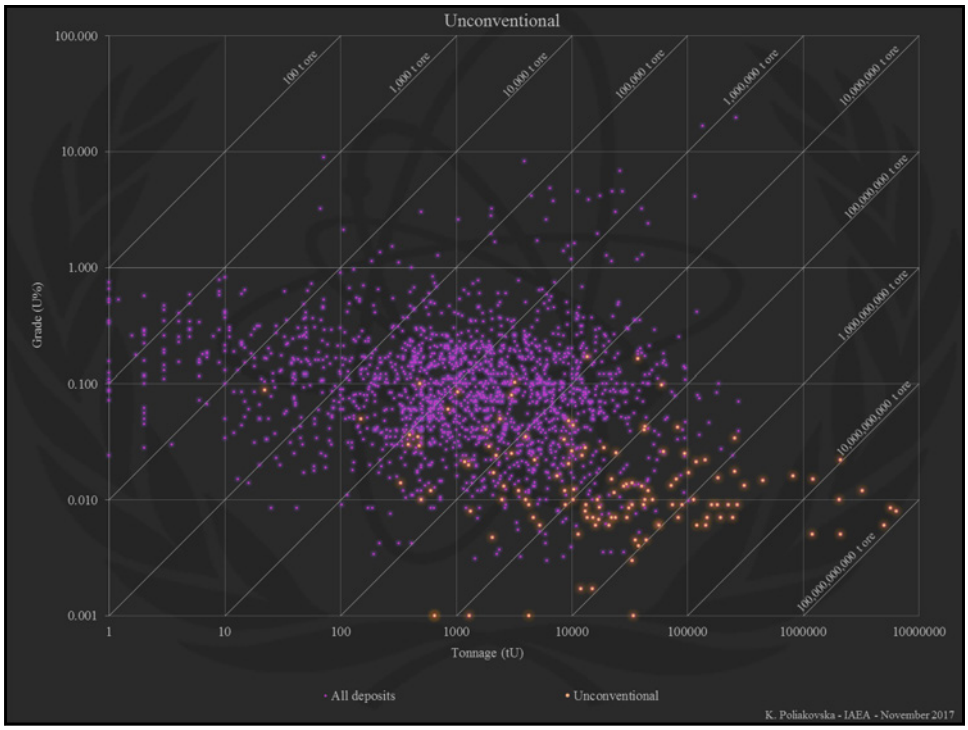
Conventional and Unconventional Deposit Types

1. Intrusive anatectic and intrusive plutonic* (granite monzonite = porpyhry copper, carbonatite, peralkiline complexes = REE)
2. Granite-related
3. Polymetallic hematite breccia complex*
4. Volcanic-related
5. Metasomatite
6. Metamorphite
7. Proterozoic unconformity
8. Collapse breccia pipe
9. Sandstone*
10. Paleo quartz-pebble conglomerate*
11. Surficial
12. Coal-lignite
13. Carbonate
14. Phosphate
15. Black shales*

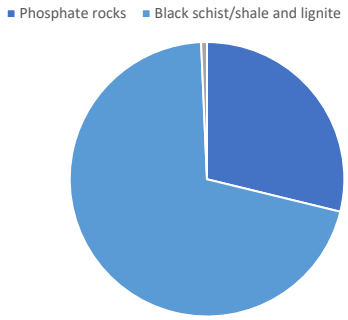


Conventional and Unconventional Deposit Types

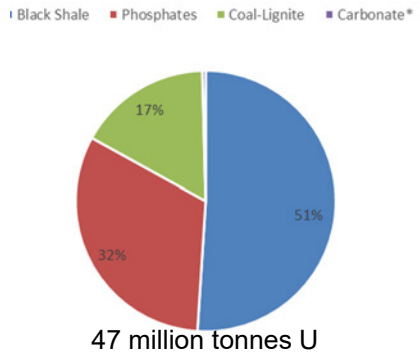
Deposit	Country	Type	Resource	Grade
Phosphoria Formation	USA	Phosphate	7 000 000	0.009
Tarfaya Basin	Morocco	Black shale	6 400 000	0.008
Baltoscandia District	Estonia	Black shale	5 667 000	0.0085
Chattanooga Shale	USA	Black shale	5.000.000	0.006
Northern Great Plains	USA	Lignite-coal	5.000.000	0.005
Oulad Abdoum Basin	Morocco	Phosphate	3.200.000	0.012
Olympic Dam	Australia	Polymetallic breccia complex	2.125.000	0.023
Timahdit	Morocco	Black shale	2.100.000	0.005
Meskala Basin	Morocco	Phosphate	2.000.000	0.010
Randstad	Sweden	Black shale	1.700.000	0.021
Gantour Basin	Morocco	Phosphate	1.200.000	0.015
Northern Latium	Italy	Volcanic-related	1.000.000	0.005



Unconventional Resources



28.5 million tonnes U
(Red Book 2018)



47 million tonnes U
(UDEPO 2018)

Market conditions and technological development will be the main factors that determine the contribution of unconventional U resources to world production totals in the future.

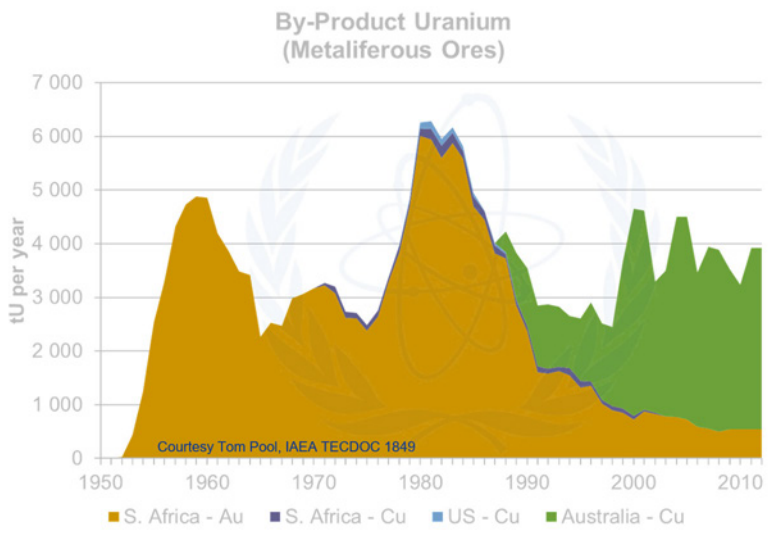
Unconventional Resource Production

Currently 5-10% of global U production is as a by-product or co-product.

As of 2020, Uranium produced in conjunction with other metals has accounted for over ten percent of historical world uranium production (i.e. ~300ktU of 3MtU).

Gold, copper and uranium/vanadium deposits have provided the bulk of this production with ~170ktU, 65ktU and ~65ktU, respectively.

Unconventional Resource Production



Unconventional Resources Production

By product of Copper
- Bingham Canyon, USA, 1978-89, 2-15 ppm, 50 tU/y
- Twin Buttes, Arizona, USA, 100 tU/y
- Yerington, Nevada, USA

Polymetallic Iron Oxide Breccia Complex
- Olympic Dam, Australia (Currently, ongoing co-product of Cu, Au and Ag)

Carbonatite
- Phalabora, South Africa – until 2001 640 tU (30-40 ppm) as by-product of Cu, etc

Coal-lignite
- Freital-Gittersee deposit , Germany, 3 700 tU, 0.12% U
- Dakota Plains, USA
- Min-Kush, Kyrghystan

Paleo quartz pebble conglomerate Au – U
- Continues intermittently in South Africa

Phosphate
- Florida, USA, 17 500 tU (1978 – 1991)
- Belgium (from Moroccan phosphate rock)

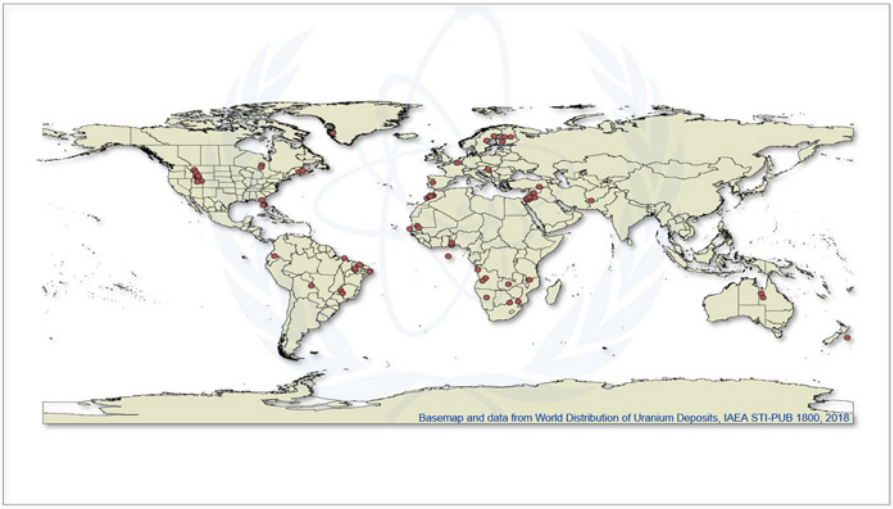
Shale
- Schmirchau-Reust, Drosen, Paitzdorf, Germany

Unconventional Resource Potential

Deposit type-subtype	Resources UDEPO (t U)	Grade (ppm)	UDEPO deposits	World deposits
Intrusive plutonic	1 949 000	10-300	43	1660
IOCG	2 560 000	30-250	18	> 100
Au-Quartz pebble conglomerate	2 036 000	20-500	116	150
Surficial-placers	67 000		13	± 1000
Coal-lignite	7 420 000	1-500	76	1600
Phosphate	14 300 000	50-150	69	1635
Black shale	22 850 000	10-200	76	Several hundreds
	52 170 000		411	6-7000

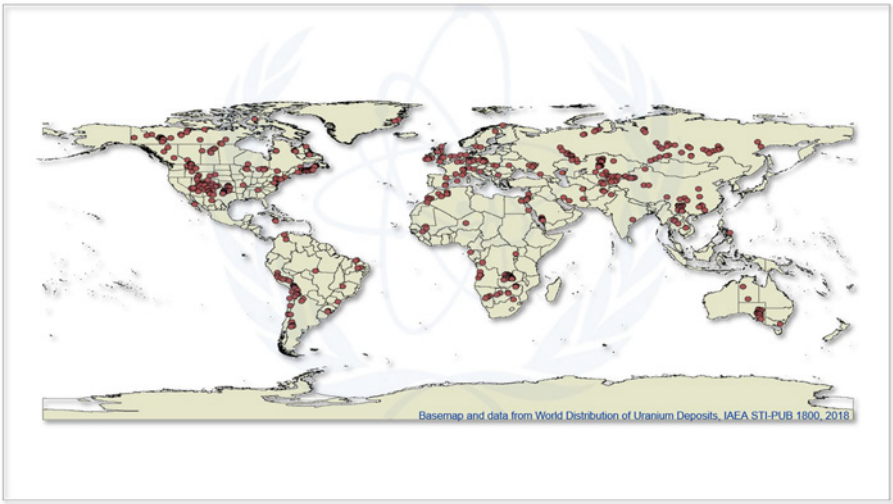
Unconventional Resource Potential

Phosphates with known uranium in UDEPO



Unconventional Resource Potential

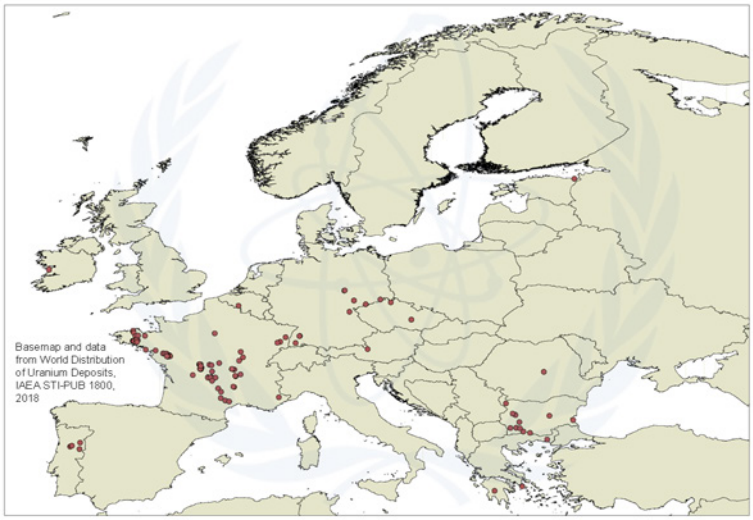
All phosphates worldwide



And finally

Anthropogenic Unconventional Resources

Mine waste sites in Europe analysed for uranium



Anthropogenic Unconventional Resources

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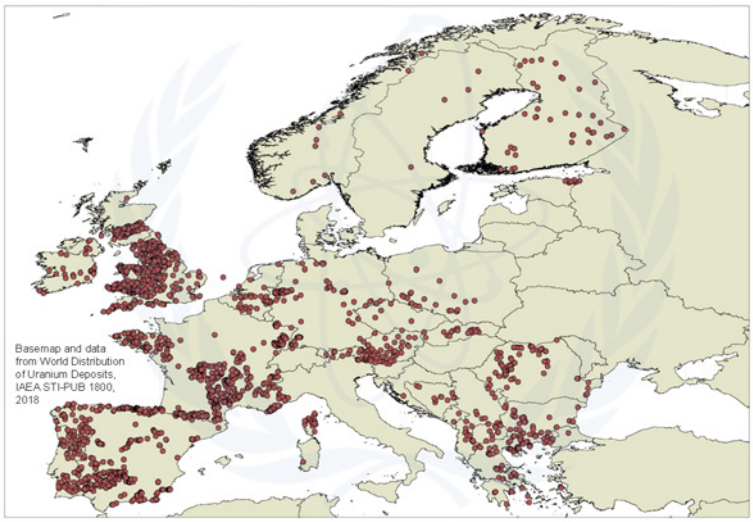
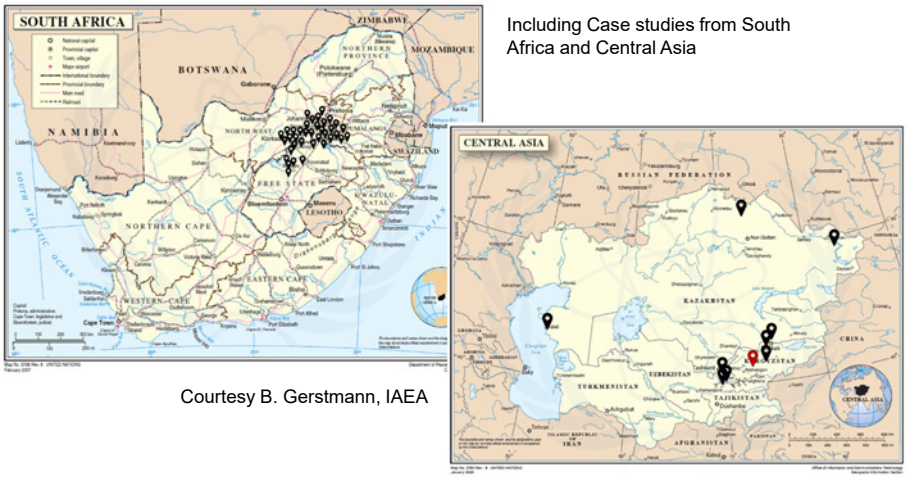


Anthropogenic Unconventional Resources

IAEA TECDOC in preparation: A Preliminary Inventory and Assessment of Uranium Resources in Mine Wastes (2021)



Including Case studies from South Africa and Central Asia

Courtesy B. Gerstmann, IAEA

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