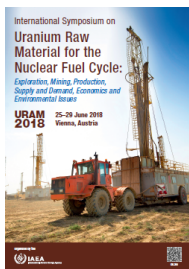


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## UDEPO: THE IAEA URANIUM DEPOSITS DATABASE

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### HISTORICAL BACKGROUND

In 1995, the International Atomic Energy Agency published a map, World Distribution of Uranium Deposits followed in 1996 with a World Guidebook [1] to accompany the map. The guidebook contained information for 582 uranium deposits ( $\geq 500$  tU,  $\geq 0.03\%$  U), describing 13 parameters that included location, status, resource range, average grade range, age, host rock and tectonic setting. However, at that time, for many deposits this knowledge was very limited.

In the late 1990s a considerable amount of information on uranium deposits, particularly from the former Eastern Block countries became available. Then, a sharp increase in the price of uranium in 2005, led to greatly increased exploration and the discovery of many new deposits.

The guidebook and the database on which it is based are known as UDEPO (Uranium DEPOSits). The database has been published on the IAEA web site since 2004 and was continuously updated to include new deposits and provide more information on uranium geology and technical characteristics of the deposits.

In 2009, a technical document World Distribution of Uranium Deposits (UDEPO) with Uranium Deposit Classification [2] was published by the Agency with data for 874 uranium deposits ( $\geq 500$  tU,  $\geq 0.03\%$  U, 37 parameters described).

A new report to be published in 2018, World Distribution of Uranium Deposits (UDEPO) –2016 Edition [3], contains information on 1807 uranium deposits ( $\geq 300$  tU, no grade restriction), and uses the new classification of uranium deposits adopted in 2013 by the Agency [4-6]. It contains summary tables, diagrams and figures illustrating the diversity of the uranium deposits.

The database is continually updated and improved and despite not publishing exact values of resources and grades, is hopefully an interesting and useful tool for geologists and researchers. In addition, a world map of uranium deposits will be published by the Agency in the near future to accompany the database.

### THE UDEPO DATABASE

As of December 2017, 2939 deposits and resources are listed in the database. All deposits with resources greater than 1 tU are included, regardless of their grade or status. The economic value of a resource is not taken into consideration for its inclusion.

In the latest 2016 version of the Red Book, a uranium deposit is defined as “a mass of naturally occurring mineral assemblage from which uranium has been or could be exploited at present or in the future”[7]. For the IAEA UDEPO database, which is primarily a geological database, the definition has been broadened to include any identified geological concentration of uranium resource regardless of the tonnage and grade. Thus, UDEPO lists conventional deposits/resources and also large to very large low grade unconventional resources [3, 8].

The database contains four main types of data with a total of 49 parameters: I) general data, II) geological data, (III) resource data and IV) mine data. Entered parameters in the database are as follows:

I - General data: 1) Deposit ID, 2) Country Name, 3) Deposit Name, 4) Synonym Names, 5) Political Province, 6) Latitude, 7) Longitude, 8) Deposit Status and 9) References.

II - Geological data: 10) Uranium Province Name, 11) Geological Province Name, 12) Deposit Type, 13) Deposit Subtype, 14) Deposit Class, 15) Historical Background, 16) Regional and Local Geological Setting, 17) Deposit Description, 18) Depth to the Top of Mineralization, 19) Mineralization Description, 20) Elemental Association, 21) Stratigraphic Host Rock Age, 22) Radiometric Host Rock Age, 23) Mineralization Stratigraphic Age, 24) Mineralization Radiometric Age and 25) Metallogenic Aspects.

III - Resource Data: 26) Resource (tU), 27) Resource Range (tU), 28) Ore Tonnage, 29) Grade (U%), 30) Grade Range (U%), 31) Date of Estimate, 32) Type of Estimate, 33) Source of Data and 34) Description of Resources.

IV - Mine Data: 35) Cumulative Production (tU), 36) Production Grade (U %), 37) Mined Ore Tonnage, 38) Remaining Ore Tonnage, 39) Mining Methods, 40) Production Centre, 41) Milling Process, 42) Commodities Recovered, 43) Production Period, 44) Remaining Resources, 45) Grade of Remaining Resources, 45) Grade of Remaining Resources, 46) Production Cost, 47) Technical Remarks, 48) Operator and 49) Owners and Shares.

Currently, deposits coordinates (6, 7), discrete grades and resources (26, 29) and production costs (46) are not published by the Agency even where some of these data are available on the web. Only ranges of grade and resource are listed on the UDEPO public site (<http://www-nfcis.iaea.org/>).

UDEPO is organized in a relational database format comprising one main table and several associated tables. The structure of the database allows filtering and systematic querying of the database. UDEPO is designed to facilitate the retrieval of data sets on various deposit related topics ranging from specific information on individual deposits to statistical information on deposits worldwide. Data can be searched according to deposit type, status and country, using the filter tools provided [3].

## RESOURCES IN UDEPO

In UDEPO, resources include all current resource categories and where available, past production. For some historical districts (Canada, Czech Republic, France, Germany, USA, etc.), in many cases, only the production data are available. Where resources for a deposit have been estimated (NI 43-101, JORC, etc.) at several cut-off grades (which is generally the case in company reports and press releases), resources at the lowest cut-off grade are adopted. All data are given in metric tonnes of uranium (tU).

As of the end of 2017, the database includes 2939 deposits distributed among the 15 types, 38 subtypes and 14 classes of deposits defined in the IAEA geological classification of uranium deposits [4-6]. The 15 types with their numbers of deposits and their aggregate geological resources are listed below:

Type 1. Intrusive 129 deposits 2 847 000 t U  
Type 2. Granite-related 586 deposits 527 000 t U  
Type 3. Polymetallic iron-oxide breccia complex 21 deposits 2 562 500 t U  
Type 4. Volcanic-related 204 deposits 1 908 500 t U  
Type 5. Metasomatite 152 deposits 1 070 000 t U  
Type 6. Metamorphite 225 deposits 663 000 t U  
Type 7. Proterozoic unconformity 114 deposits 1 547 500 t U  
Type 8. Collapse breccia pipe 18 deposits 19 500 t U  
Type 9. Sandstone 951 deposits 4 827 000 t U  
Type 10. Paleo quartz-pebble conglomerate 144 deposits 2 504 000 t U  
Type 11. Surficial 123 deposits 532 000 t U  
Type 12. Lignite-coal 75 deposits 7 406 500 t U  
Type 13. Carbonate 34 deposits 184 000 t U  
Type 14 Phosphate 73 deposits 14 326 000 t U  
Type 15. Black shale 75 deposits 21 749 000 t U  
Unknown 15 deposits

In 2017, total geological resources of uranium in UDEPO stand at 62 674 137 tU, within the 2755 deposits with known/estimated resources. The largest resources are contained in unconventional resource deposit types such as those associated with polymetallic iron-oxide breccia complex (IOCG-U), phosphate, lignite-coal and black shale. It should be noted that for the polymetallic iron-oxide breccia complex deposits, 80% of the resources are contained within a single deposit, Olympic Dam. The most important conventional resource deposit types are the sandstone-hosted type followed by the Proterozoic unconformity type and the volcanic-related type.

Eighty three countries have uranium deposits/resources listed in UDEPO.

Geological resources within UDEPO can be compared to the “economic” Red Book data:

- World historical uranium production to 2016: 2 802 230 t U,
- Red Book 2016 conventional resources (< USD 260/KgU): 7 641 600 t U,
- UDEPO conventional resources (including Olympic Dam): 14 034 700 tU. The sum of world historical production and Red Book resources is 10 443 830 t U, thus UDEPO identifies an additional 3.5 Mt.

## VALUE OF UDEPO

The various data contained in the database, even if not currently complete enable one to produce compilations for deposit types, subtypes and classes, country resources, uranium provinces resources, statistical diagrams using various parameters, cumulative frequency diagrams, grade-resource-tonnage scatter plots for each types and subtypes, etc. With the addition of new data, it will be possible to derive statistical geological information on parameters such as tectonic setting, age of mineralization, associated elements, and also on various mining parameters, etc.

The number of deposits for each resource range and their total geological resources is presented below:

- 1 000 000 t U 11 deposits 41 013 600 t U
- 100 001-1 000 000 39 deposits 8 081 000 t
- 50 001- 100 000 52 deposits 3 016 000 t
- 25 001- 50 000 89 deposits 3 200 000 t
- 10 001-25 000 218 deposits 3 342 500 t
- 5 001-10 000 250 deposits 1 795 300 t
- 2 501-5 000 300 deposits 1 098 000 t
- 1 001-2 500 428 deposits 721 000 t
- 300-1 000 580 deposits 355 700 t
- 1-300 786 deposits 87 000 t

General information such as the uranium endowment (tU/km<sup>2</sup> x 100) for each continent can be calculated using conventional resources numbers:

- North America: 12
- South America: 2
- Asia: 7
- Europe: 13
- Africa: 13
- Australasia: 12 This may indicate that South America as well as Asia, are probably underexplored in comparison to other continents.

## PRESENT AND FUTURE OF THE DATABASE

In term of data presented, the UDEPO database is unique as it provides freely accessible information on global uranium deposits. However, it must be emphasized that:

- Data entry of 49 parameters for each deposit/resource is time consuming as for most databases. Large portions have not yet been completed,
- Coordinates are collected, but are not published. Collected data will permit the publication of a world map of uranium deposits in 2018,
- Exact numbers for resources and grades are not published owing to the loose definition of resources in an economical sense, and the aggregation of different categories of resources. However, the Agency will allow the publication of these data in the near future if the official references to the numbers are presented in the database,
- None, little or incomplete deposit information has been compiled for some countries like China, Kyrgyzstan, Pakistan, Uzbekistan,
- The recent inclusion of small deposits within the range 1-300 t U has drastically increased the number of deposits which were previously aggregated in historical mining districts or ignored (Czech Republic, France, Germany, USA, etc.). For example, today, USA has 406 deposits/resources listed in UDEPO, but a recent compilation indicates that the number of deposits/resources is in the order of 4000 !
- In the future, new additions will most likely come from unconventional resources/deposits associated with intrusive plutonic, phosphates, black shale and coal-lignite deposit types. It is inferred that most of these host rock formations contain at least some uranium concentrations in the range of 10-200 ppm, but no information is available concerning their specific grades. Estimates of the number of such geological formations suggest there could be in the range of 5-6000 additional unconventional deposits [8].

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## Country or International Organization

France

**Primary author:** Dr BRUNETON, Patrice (Private Consultant)

**Co-authors:** Mr ZALUSKI, Gerard (Cameco, Saskatoon, Saskatchewan, Canada); FAIRCLOUGH, Martin (International Atomic Energy Agency); Dr CUNEY, Michel (CNRS - GeoRessources - CREGU - Universite de Lorraine); Dr JAIRETH, Subhash (Geoscience Australia); Mr LIU, Xiaodong (East China Institute of Technology)

**Presenter:** Dr BRUNETON, Patrice (Private Consultant)

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