Franz DAHLKAMP
1. 2009

3. Europe (2014 ?)

4. Africa-Australia ??

2. 2010

1993
Classifications of uranium deposits follow two general approaches, focusing on:

- descriptive features such as the geotectonic position, the host rock type, the orebody morphology, ......: «geologic classification»

- or on genetic aspects: «genetic classification»
1991 IAEA uranium deposits classification

- 1) Unconformity-related 23
- 2) Sandstones 250
- 3) Quartz-pebble conglomerates 22
- 4) Veins 128
- 5) Breccia complexes 1
- 6) Intrusive 13
- 7) Phosphorites 10
- 8) Collapse breccia pipes 10
- 9) Volcanic 43
- 10) Surficial 16
- 11) Metasomatites 12
- 12) Metamorphic 10
- 13) Lignite-coal 22
- 14) Black shales 9
- 15) Other types (carbonates) 13 (582)

Deposits were conventionally listed in order of economic ranking
1) Unconformity-related (McArthur, Ranger)
2) Sandstones (Mynkuduk, Arlit)
3) Hematite breccia complexes (Olympic Dam)
4) Quartz-pebble conglomerates (Witwatersrand)
5) Veins (Limousin, Czech Republic)
6) Intrusive (Rossing, Ilimaussaq)
7) Volcanic and caldera-related (Streltsovska)
8) Metasomatites (Michurinskoye, Lago Real)
9) Surficial (Yeelirrie, Langer Heinrich)
10) Collapse breccia pipes (Arizona Strip)
11) Phosphorites (Uncle Sam, Gantour)
12) Other types (metamorphic, limestones, coal)
13) Rock types with elevated U content (pegmatites, granites, black shales)
The 2013 IAEA classification is a combination between the IAEA classification used in the Red Book since 1991 and the Dahlkamp (1993, 2009) classifications: 15 main types of deposits, 36 sub-types and 14 classes have been retained.
IAEA-NEA Red Book (2012): « Uranium deposit: a mass of naturally occurring mineral from which uranium could be exploited at present or in the future »

IAEA-UDEPO Database:
- geological database first
- no economic connotation: geological resources
- 300 t U minimum, no restrictions for the grade
- 1532 deposits/districts in 74 countries listed end of 2013
IAEA 2013 classification

1. Intrusive
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
IAEA 2013 classification

- 1. Intrusive
- 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
Sediment/sedimentary basins associations

- 11. Surficial
- 9. Sandstone
- 10. Paleo-quartz pebble conglomerate
- 8. Collapse breccia pipe
- 7. Proterozoic unconformity
- 12. Coal-lignite
- 13. Carbonate
- 14. Phosphate
- 15. Black shales

Metamorphic

- 1.1. Intrusive anatectic
- 5. Metasomatite
- 6. Metamorphite

Igneous plutonic and volcanic

- 2. Granite-related
- 4. Volcanic-related
- 1.2. Intrusive plutonic
- 3. Polymetallic hematite breccia complex
Number of deposits by type

- 9. Sandstone: 627
- 2. Granite-related: 129
- 4. Volcanic-related: 124
- 6. Metamorphite: 106
- 7. Proterozoic unconformity: 85
- 1. Intrusive: 83
- 5. Metasomatite: 76
- 10. Paleo quartz-pebble conglomerate: 69
- 14. Phosphate: 49
- 15. Black shales: 45
- 12. Coal-lignite: 33
- 8. Collapse breccia pipe: 16
- 3. Polymetallic hematite breccia complex: 15
- 13. Carbonate: 10 (1532)
Type 1 - Intrusive deposits

Two sub-types:
- **1.1. Intrusive anatectic** *(pegmatites-alaskites)* *(Rossing, Namibia)*
- **1.2. Intrusive magmatic**
  - granite-monzonites *(Bingham Canyon, USA)*
  - peralcaline complexes *(Kvanefjeld, Greenland)*
  - carbonatites *(Catalao, Brazil)*
Type 2 - Granite-related deposits

2 sub-types:

• 2.1. Intragranitic (La Crouzille District, France)
• 2.2. Perigranitic (Pribram District, Czech Republic)
Type 3- Polymetallic iron-oxide breccia complex
(Olympic Dam)
Type 4 - Volcanic-related deposits

3 sub-types:

- 3.1. Structure-bound (Streltsov, Russia)
- 3.2. Stratabound (Maureen, Australia)
- 3.3. Volcano-sedimentary (Anderson Mine, USA)
Type 5 - Metasomatite

3 sub-types:
• 5.1. Na-metasomatite *(Kirovograd District, Ukraine)*
• 5.2. K-metasomatite *(Elkon District, Russia)*
• 5.3. Skarn *(Mary Kathleen, Australia)*

Dahlkamp, 2009
Type 6 - Metamorphite

3 sub-types:

- 6.1. **Stratabound** *(Forstau, Austria)*
- 6.2. **Structure-bound**
  - Monometallic veins *(Schwartzwalder, USA)*
  - Polymetallic veins *(Shinkolobwe, Democratic Rep of the Congo)*
- 6.3. **Marble-hosted phosphates** *(Itataia, Brazil)*

*Dahlgren, 2009*
Itataia-Santa Quiteria deposit

6.3. marble-hosted phosphate

Complex hydrothermal metasomatic Cambrian-Ordovician uraniferous collophane deposit, hosted by Precambrian metamorphic marls

Dahlkamp, 2009
Type 7 - Proterozoic unconformity

- 3 sub-types:
  - 7.1. basement-hosted (Jabiluka, Australia; Millenium, Canada)
  - 7.2. unconformity-contact (Cigar Lake, Key Lake, Canada)
  - 7.3. stratiform fractured-controlled (Lambapur, India)
7.3. **Stratiform fracture-controlled (India)**

*Dahlkamp, 2009*
Type 8 – Collapse breccia pipes

Wenrich and Tityley, (2008)
Type 9 - Sandstone

5 sub-types:

- **9.1. Basal channel** *(Beverley, Australia)*
- **9.2. Tabular** *(Niger)*
- **9.3. Rollfront** *(Wyoming; Kazakhstan)*
- **9.4. Tectonic-lithologic** *(Lodève; Gabon)*
- **9.5. Mafic dikes/sills in Proterozoic sandstones** *(Wesmoreland, Australia)*

*Dahlkamp, 2009*
9.1. Basal channel

9.2. Tabular

9.3. Roll-front

9.4. Tectono-lithologic

9.5. Mafic dikes in Proterozoic sandstones
Type 10 - Paleo quartz-pebble conglomerate

Two sub-types:

10.1. **Au-dominant** (Witwatersrand Basin, South Africa)

10.2. **U-dominant** (Blind River-Elliot Lake area, Canada)

*Dahlkamp, 2009*
Type 11 - Surficial deposits

Four sub-types:

- 11.1. Peat-bog *(Kamushanovskoye, Kyrgyzstan)*
- 11.2. Fluvial valley *(Yeelirrie, Australia)*
- 11.3. Lacustrine-playa *(Lake Maitland, Australia)*
- 11.4. Pedogenic and fracture-filled *(Beslet, Bulgaria)*

*Dahlkamp, 2009*
Type 13 - Carbonate

13.1. Stratabound
(Tumalappalle, India)

13.2. Cataclastic
(Mailuu-Suu, Kyrgyzstan)

13.3. Karst
(Sanbaqi, China)

Dahlkamp, 2009
Type 12 – Coal-lignite  
*(Koldzat, Kazakhstan; Freital, Germany)*

Type 15 – Black shale  
*(MMS Vicken, Sweden; Ronneburg District, Germany)*

Two sub-types:  
- *Stratiform*  
- *Fracture-controlled*

*Dahlkamp, 2009*
Type 14 - Phosphate

3 sub-types:

• **14.1. Organic phosphorite** *(Mangyshlak District, Kazakhstan; Minjingu, Tanzania)*

*Dahlkamp, 2009*
14.2. Minerochemical phosphorite *(Morocco, Florida)*

14.3. Continental phosphate *(Bakouma District, Central African Rep.)*

*Dahlkamp, 2009*
Conventional resources are defined as resources from which uranium is recoverable as a primary product, a co-product or an important by-product.

Unconventional resources are resources from which uranium is only recoverable as a minor by-product, such as uranium associated with phosphate rocks, non-ferrous ores, carbonatite, black shale and lignite (Red Book 2012).
1. Intrusive anatectic and plutonic
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 shale
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<thead>
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<th>Resource</th>
<th>Quantity</th>
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<tr>
<td>Phosphate</td>
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<td>7.400.000</td>
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<td>Black shales</td>
<td>6.650.000</td>
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<td>Proterozoic unconformity</td>
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<td>Collapse breccia pipe</td>
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</tbody>
</table>
Final remarks ......

• Revised and improved geological classification of uranium deposits with 15 main types covering most geological formations

• Detailed classification with 50 sub-types and classes

• The UDEPO Database with 1532 « deposits », useful tool being improved regularly

• A new sub-database (UncvDEPO) for unconventional ressources
IAEA technical documents in preparation

- “Geological Classification of Uranium Deposits and Description of Selected Examples”

- “World distribution of uranium deposits - The UDEPO Database”
THANK YOU !