Uranium Resources in the Middle East

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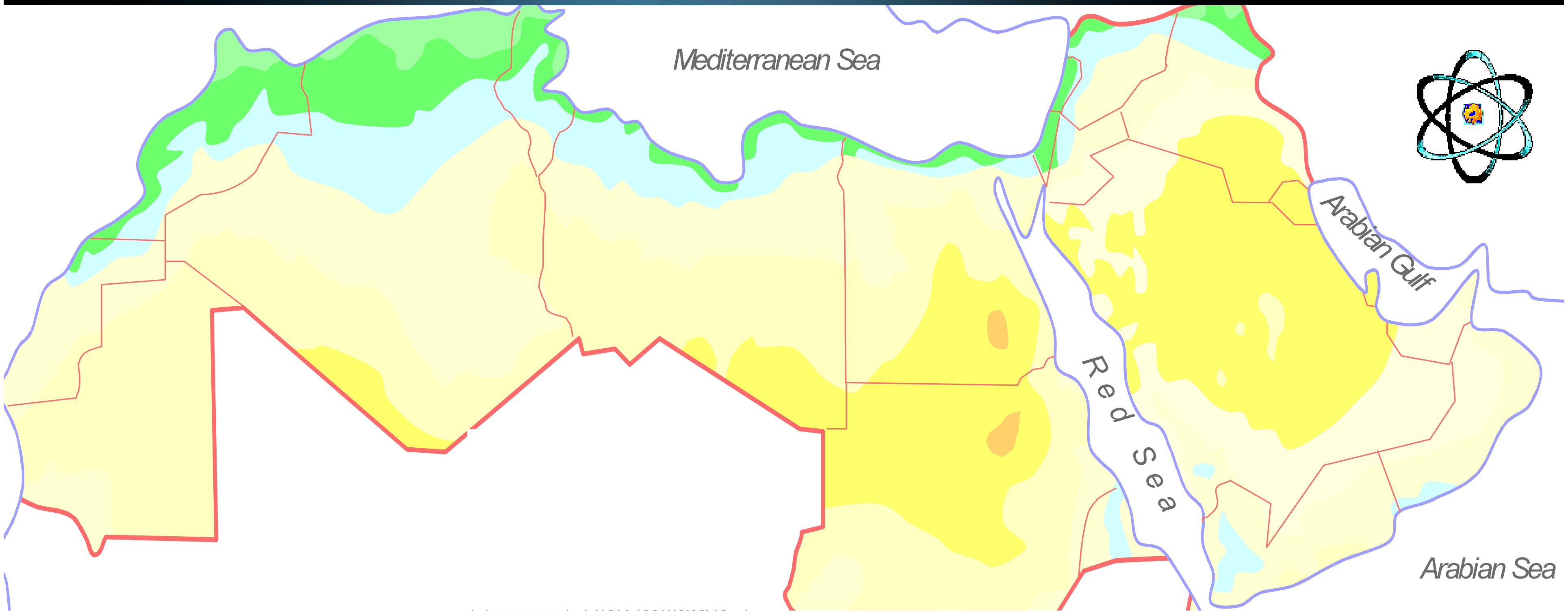
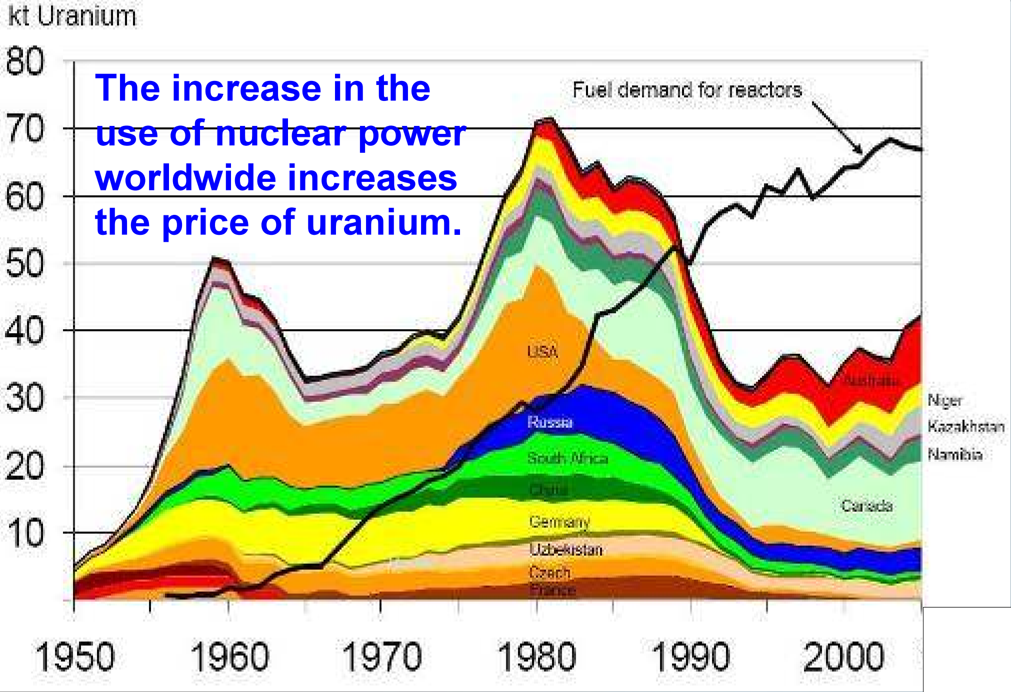
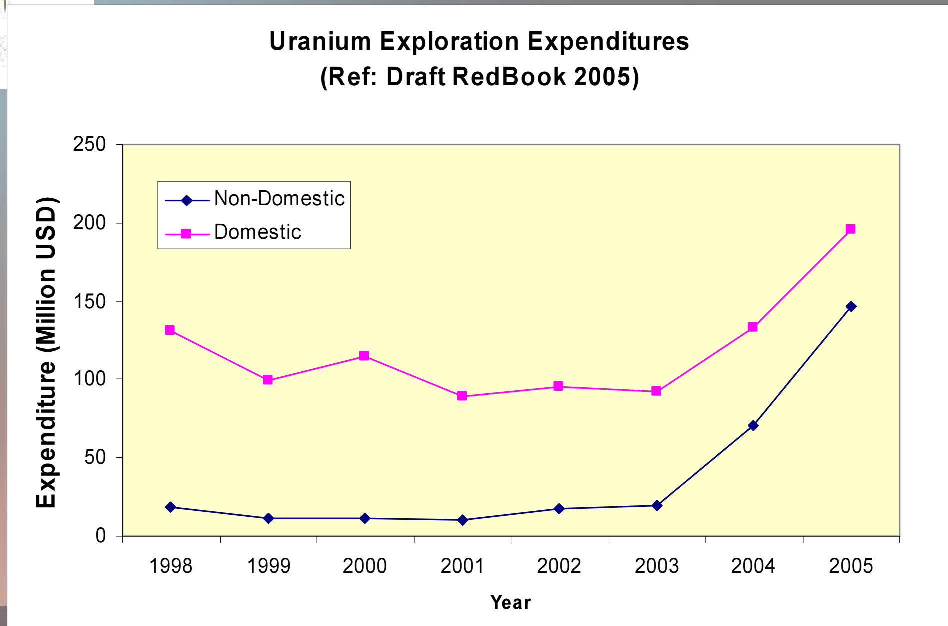


Uranium, uranium and uranium !



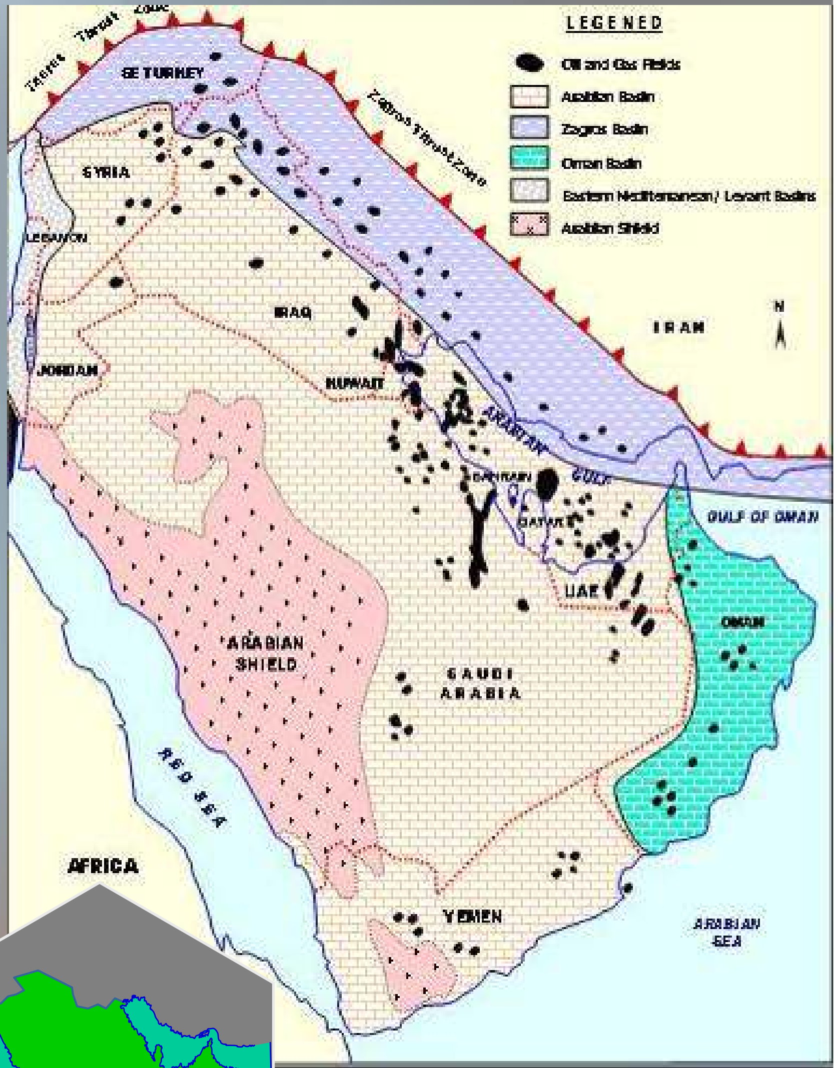
These trends are traceable worldwide and it will continue to grow.



Uranium Resources of the Middle East Region

Although best known for its hydrocarbon resources, oil, the Middle East together with several North African countries is potential home to uranium bearing deposits that have not been fully investigated and explored.

Thus it is important to know where presently reported uranium resources are located, and further investigate and locate additional ones.



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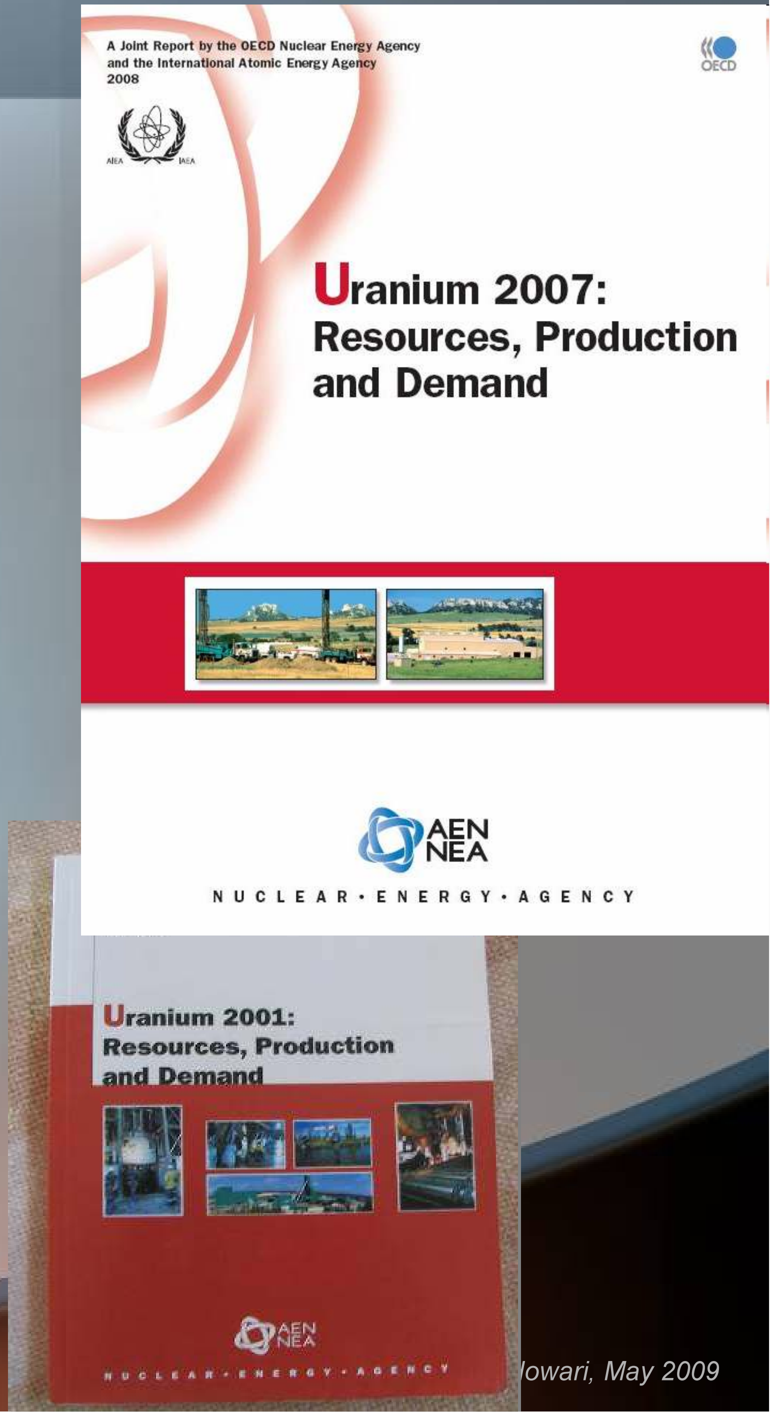
The Red Book

- The Red Book is a document published by the European Union and The International Atomic Energy Agency every two years, and it gives the official uranium resources reported by every member country, according to specified categories.

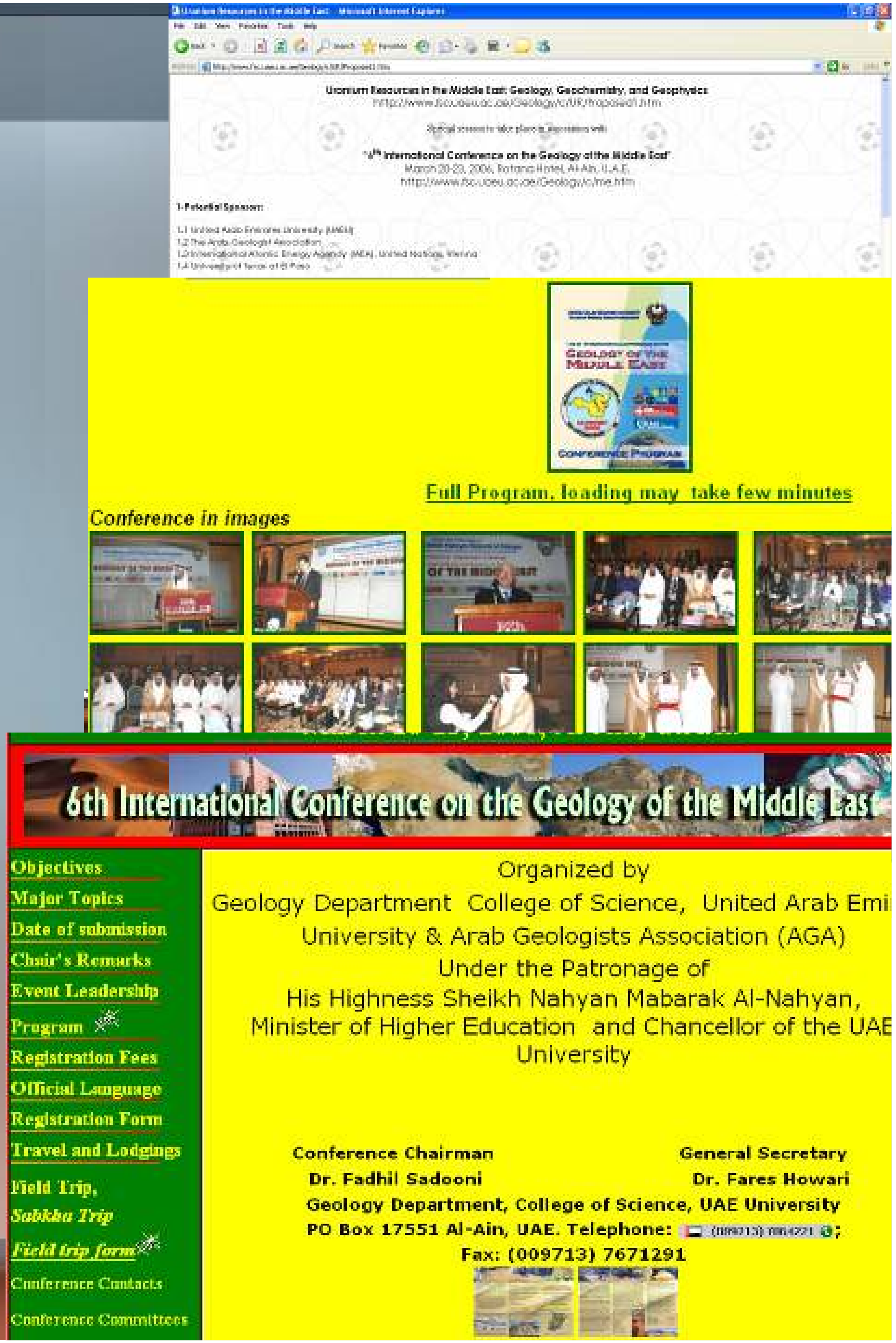
- However, scientific literature of Uranium Geology does not coincide completely with the information presented in the Red Book especially in the Middle East.



First Step!

- A vast amount of information resides in reports, Master's theses and Ph.D. dissertations in universities throughout the Middle East region. Compilation from these latter data bases is only in the beginning stages to form a background to move forward in a structured uranium exploration program.

- An attempt made through 6ICGM to present the significant findings in form of maps and tables. Integration with large scale geotectonic features is still in process.



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Uranium Production Cycle

Nuclear Fuel Engineering

Nuclear Fuel Cycle and Materials Section

Uranium Production Cycle

Technical Meeting on "Uranium Exploration and Mining Methods", 17 – 11 November 2008, Amman, Jordan

Presentations

Introductory Session:

- Meeting Agenda
- Introduction to the Technical Meeting by Jan Slezak, IAEA scientific secretary
- Jordan welcome address - a background situation speech on nuclear issues by HE Khaled Toukan, JAEC
- IAEA subprogramme on uranium production cycle by Jan Slezak, IAEA
- Nuclear development in the Middle East countries by Fares Howari, USA
- WNU-School of Uranium Production by Jan Slezak, IAEA

Current uranium production cycle issues:

- Uranium geology of the Middle East with focus on new prospective and mining potential by Fares Howari, USA
- Joint OECD-NEA/IAEA Uranium Group recent activities and Red Book 2007 by Jan Slezak, IAEA
- Recent developments in uranium production cycle in Jordan by Ned Xoubi, JAEC
- Nuclear safety aspects in uranium production cycle by Shaun Guy, IAEA

Uranium geology and exploration:

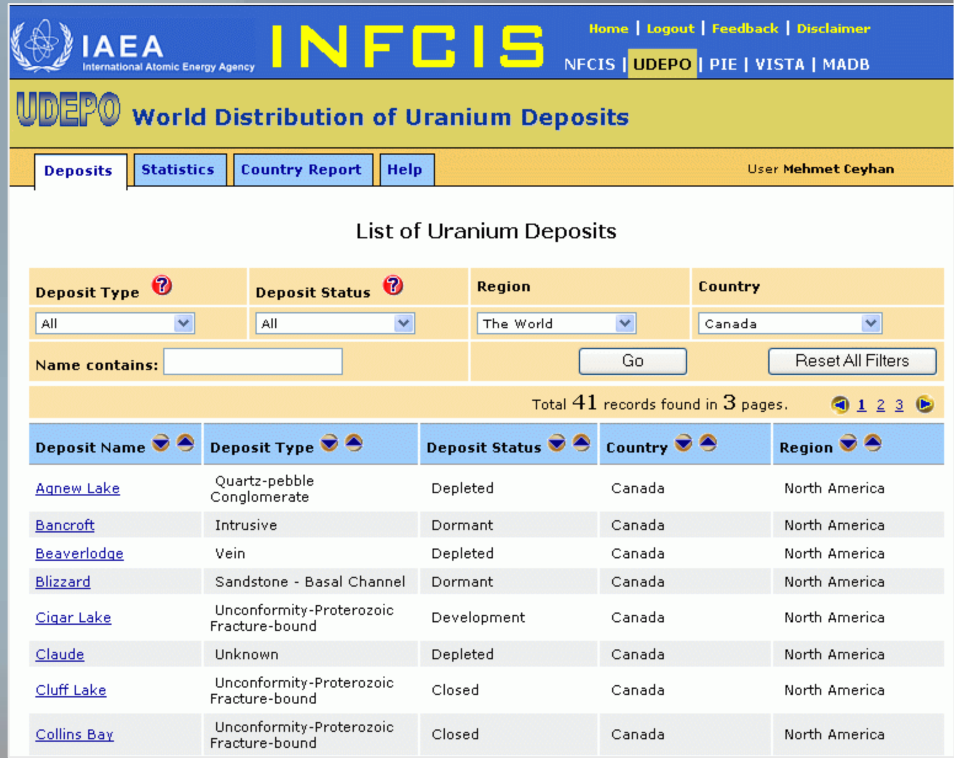
- Recent developments in uranium exploration in Canada by Geoff Parslow, Canada
- Uranium Mineralization of the Bayawula deposit, Erlian Basin, North East China by Nie Fengjun, China
- Remote sensing and reflectance spectroscopy as useful tools for uranium exploration by Fares Howari, USA
- Uranium exploration methods and techniques by Geoff Parslow, Canada
- Methods of uranium exploration in arid terrains by Abdelaty Salman, Egypt
- Nuclear policies in the Middle East by Fares Howari, USA
- Recent developments in uranium exploration in Australia by Aden McKay, Australia
- Reserve estimation for uranium deposits by Abdelaty Salman, Egypt
- IAEA guidance on radiation safety aspects in the uranium production cycle by Shaun Guy, IAEA
- Results of the IAEA TM on "Implementation of the Sustainable Best Practice in Uranium Mining and Processing" by Jan Slezak, Shaun Guy, IAEA
- Nuclear power plant site selection by Abdelaty Salman, Egypt

Uranium production:

World Distribution of Uranium Deposits (UDEPO)

UDEPO web site

- It gives list of deposits
- provides easy navigation and search



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UDEPO World Distribution of Uranium Deposits

Deposits | Statistics | Country Report | Help

User Mehmet Ceyhan

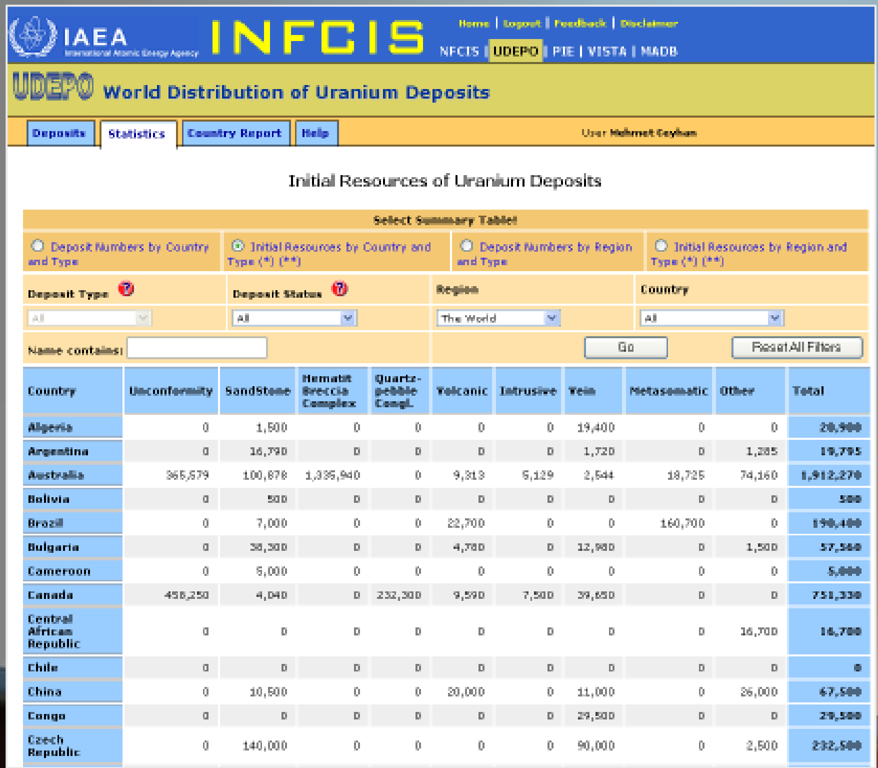
List of Uranium Deposits

Deposit Type: All | Deposit Status: All | Region: The World | Country: Canada

Name contains: | Go | Reset All Filters

Total 41 records found in 3 pages. 1 2 3

Deposit Name	Deposit Type	Deposit Status	Country	Region
Agnew Lake	Quartz-pebble Conglomerate	Depleted	Canada	North America
Bancroft	Intrusive	Dormant	Canada	North America
Beaverlodge	Vein	Depleted	Canada	North America
Blizzard	Sandstone - Basal Channel	Dormant	Canada	North America
Cigar Lake	Unconformity-Proterozoic Fracture-bound	Development	Canada	North America
Claude	Unknown	Depleted	Canada	North America
Cluff Lake	Unconformity-Proterozoic Fracture-bound	Closed	Canada	North America
Collins Bay	Unconformity-Proterozoic Fracture-bound	Closed	Canada	North America



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Initial Resources of Uranium Deposits

Select Summary Table!

Deposit Numbers by Country and Type | Initial Resources by Country and Type (*) (**) | Deposit Numbers by Region and Type | Initial Resources by Region and Type (*) (**)

Deposit Type: All | Deposit Status: All | Region: The World | Country: All

Name contains: | Go | Reset All Filters

Country	Unconformity	SandStone	Hematit Breccia Complex	Quartz-pebble Congl.	Volcanic	Intrusive	Vein	Metasomatic	Other	Total
Algeria	0	1,500	0	0	0	0	19,400	0	0	20,900
Argentina	0	16,790	0	0	0	0	1,720	0	1,285	19,795
Australia	365,579	100,878	1,335,940	0	9,313	5,129	2,544	18,725	74,160	1,912,270
Bolivia	0	500	0	0	0	0	0	0	0	500
Brazil	0	7,000	0	0	22,700	0	0	160,700	0	190,400
Bulgaria	0	38,300	0	0	4,780	0	12,980	0	1,500	57,560
Cameroon	0	5,000	0	0	0	0	0	0	0	5,000
Canada	458,250	4,040	0	232,300	9,590	7,500	39,650	0	0	751,330
Central African Republic	0	0	0	0	0	0	0	0	16,700	16,700
Chile	0	0	0	0	0	0	0	0	0	0
China	0	10,500	0	0	20,000	0	11,000	0	26,000	67,500
Congo	0	0	0	0	0	0	29,500	0	0	29,500
Czech Republic	0	140,000	0	0	0	0	90,000	0	2,500	232,500

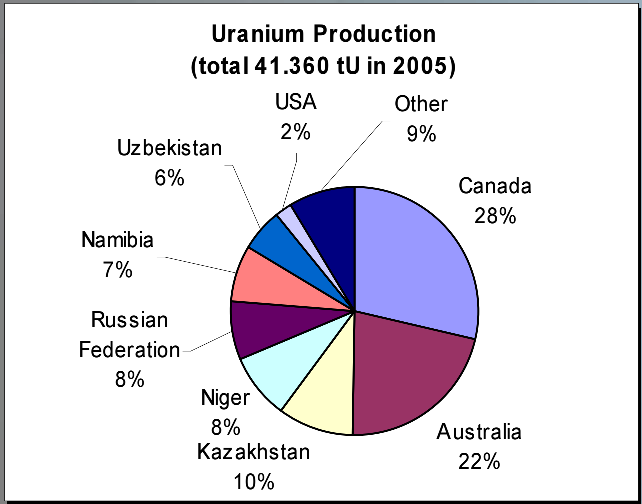
- gives worldwide summaries
- this example gives the initial uranium amounts in the deposits by country and by deposit type

Source, IAEA

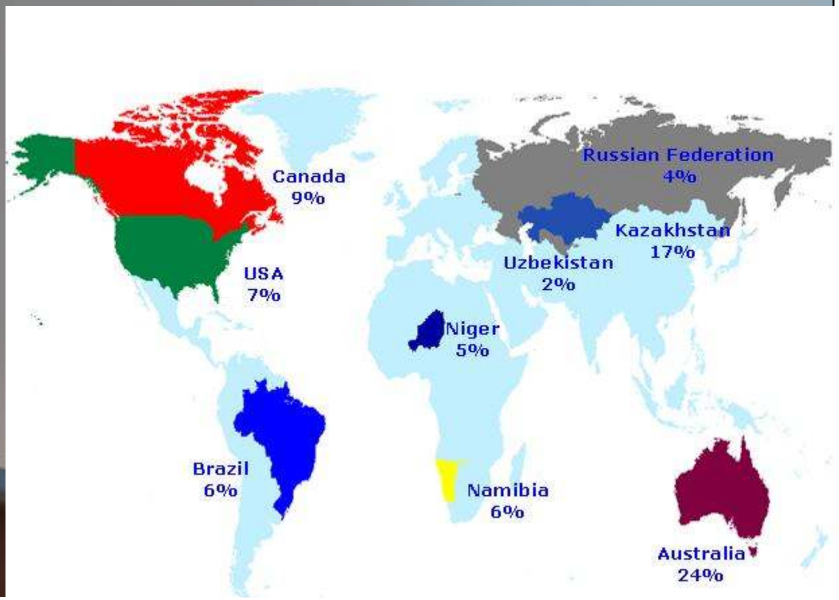
Some global examples from the Red Book

Countries with major Identified uranium resources and countries with major nuclear power

Known Identified Resources: 4.743 million tons U
Undiscovered Conventional Resources (prognosticated+Speculative) : 7.07 million tons U
Undiscovered Speculative (cost range unassigned): 2.98 million tons U
Unconventional Resources in Rock Phosphates alone: 22 million tons U



Country	Uranium Resources Tons 'U' (Percentage of world)		No. of Operating NPPs (% Electricity)
Australia	1 143 000	24%	Nil
Kazakhstan	816 099	17%	Nil
Namibia	282 359	6%	Nil
Niger	225 459	5%	Nil
Uzbekistan	115 526	2.5%	Nil
USA	342 000	7%	104 (20%)
Canada	443 800	9.4%	20 (~12%)
South Africa	340 596	7%	2 (5.9%)
Russian Fed.	172 402	3.6%	30 (16%)
Brazil	278 700	6%	2 (4%)
India	64 840	1.4%	15 (2.8%)
China (excl. Taiwan)	59 723	1.3%	9 (2.2%)
France	100% from overseas sources		59 (78%)
Germany	100% from overseas sources		18 (32%)
Japan	100% from overseas sources		54 (30%)
Korea (R.O.)	100% from overseas sources		19 (38%)
UK	100% from overseas sources		23 (19.4%)



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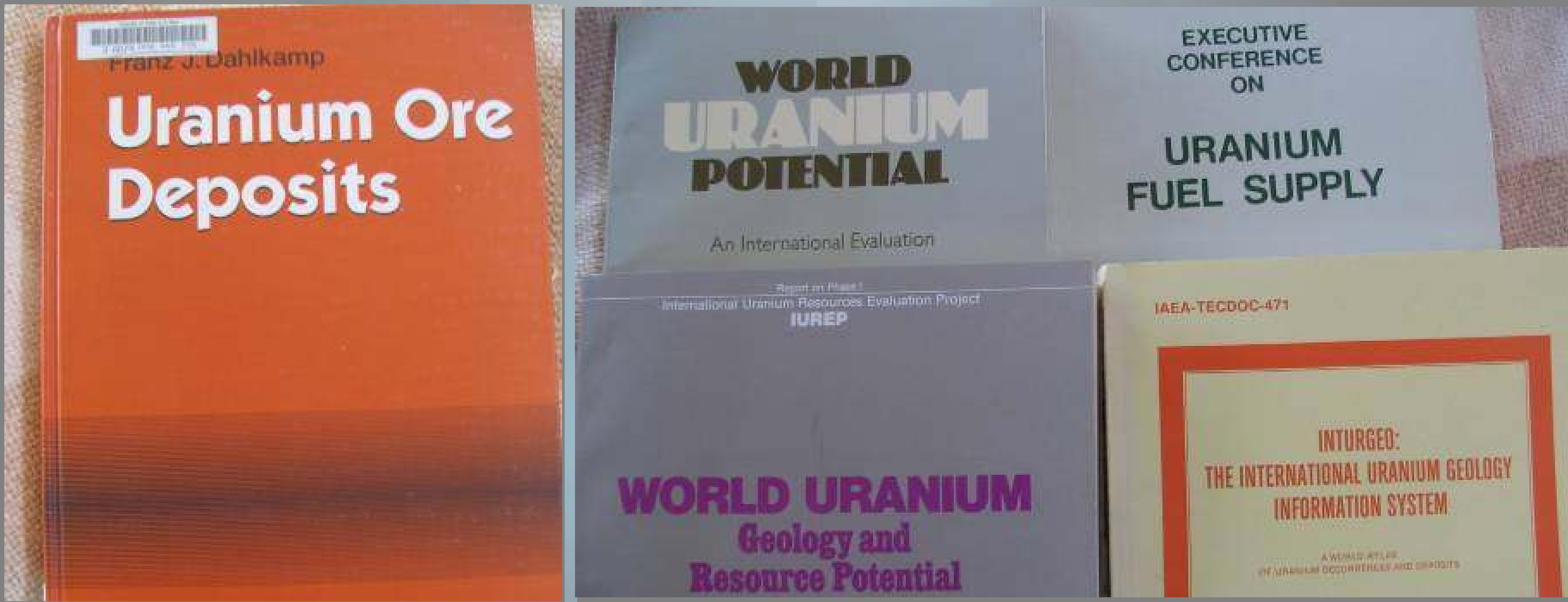
The International Atomic Energy Agency assigns the uranium deposits according to their geological settings to 15 main categories of deposit types arranged according to their approximate economic significance [IAEA, 2004]:

1. Unconformity-related deposits
2. Sandstone deposits
3. Quartz-pebble conglomerate deposits
4. Vein deposits
5. Breccia complex deposits (Olympic Dam type)
6. Intrusive deposits (granite type)
7. Phosphorite deposits
8. Collapse breccia pipe deposits (north Arizona)
9. Volcanic deposits
10. Surficial deposits (calcrete)
11. Metasomatite deposits
12. Metamorphic deposits
13. Lignite
14. Black shale deposits
15. Other types of deposits

Potential occurrences of Uranium in the Middle East



These books have covered global uranium supply, but little to no information on the Middle East!

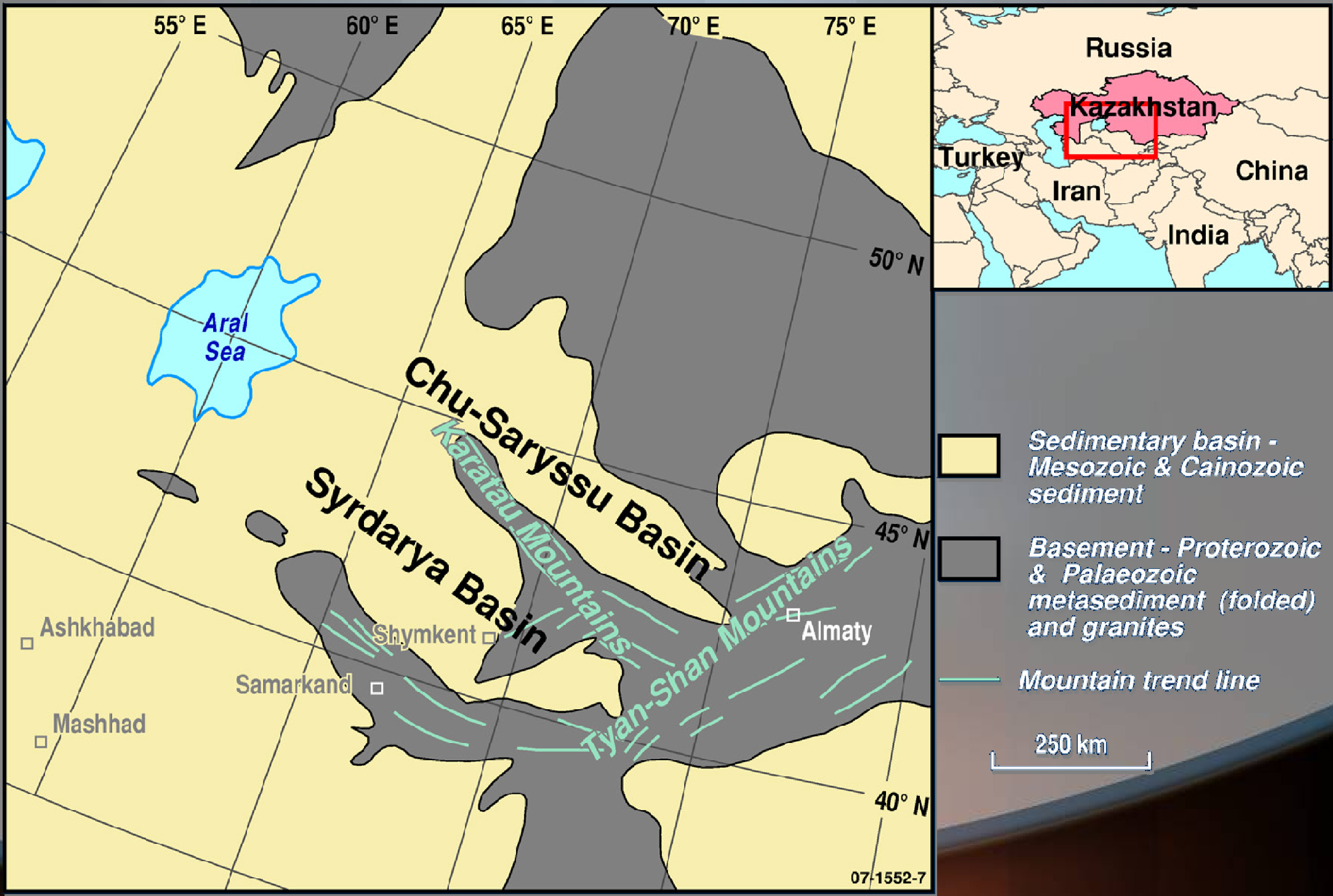
Several exploration models are available but not applied or tested in the Middle East.

1-Models of origin and guides for exploration include Pena Blanca, Mexico, and Ben Lomond, Australia, mineral districts.

2- Models of origin and guides for exploration include Yeelirrie, Western Australia and Langer Heinrich in Namibia (e.g. S3 and S4 are adjacent and related).

3-Model for the sabkhah (playa) calcrete mineralization is the Lake Way U deposit in Western Australia.

Regional geology, southern Kazakhstan



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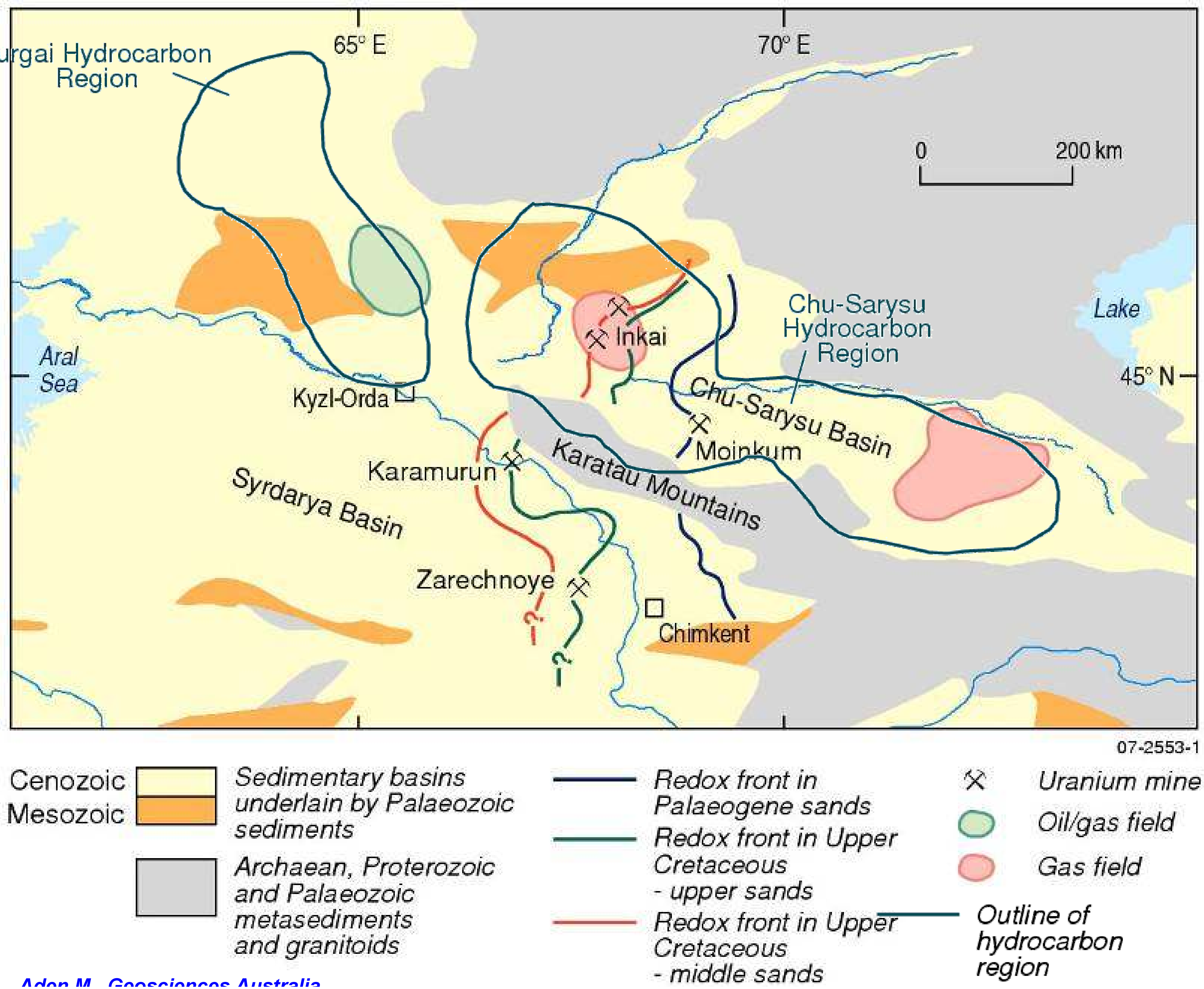
Aden M., Geosciences Australia

Mineralised sequence and underlying hydrocarbon basins



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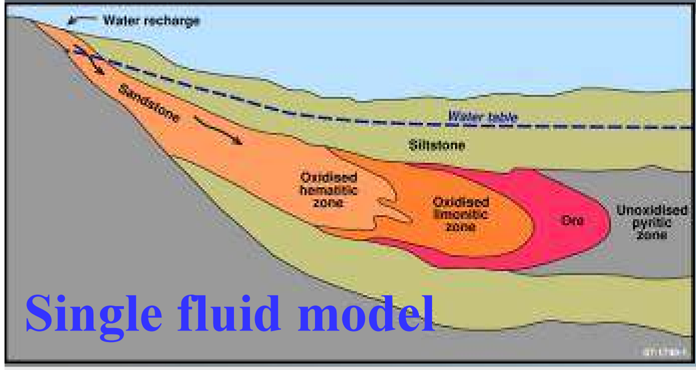
Sandstone uranium systems



Single fluid model

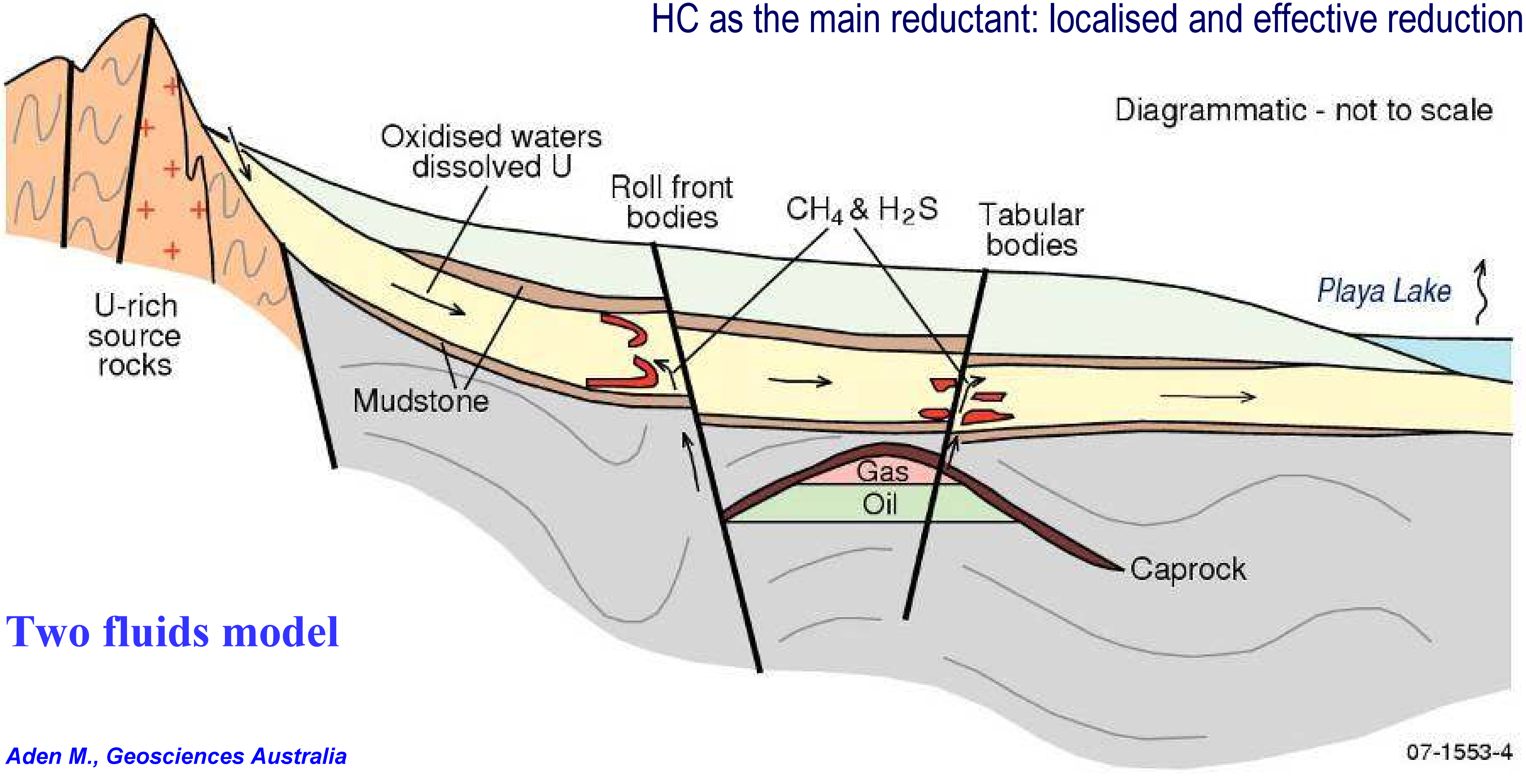
Kazakhstan model (below):

Large basin rimmed by U-rich felsic rocks

Highly permeable sandstones

Very low concentration of organic and inorganic reductant

HC as the main reductant: localised and effective reduction



Two fluids model

Aden M., Geosciences Australia

Uranium in the Middle East

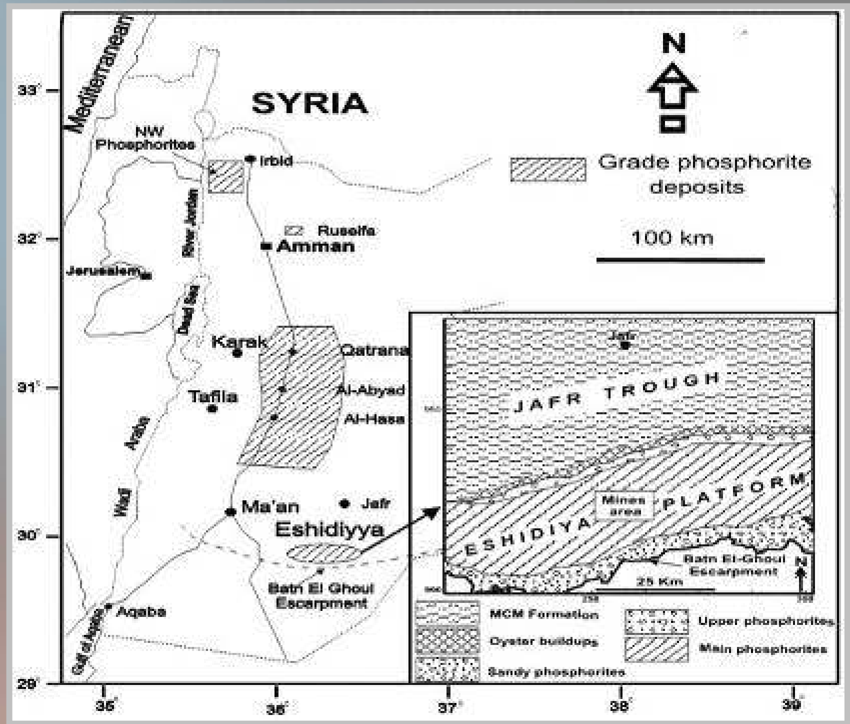
- Geologically speaking the Middle East could have several distinct types of uranium deposits; these could include unconformity related, sandstone hosted, paleoplacer, phosphate calcrete and pegmatite.

However, by far the most important type of economic uranium deposit in the Middle East is yet to be determined.

Uranium in the Middle East

- The Middle East could be considered to house some 20 billion tons of phosphate resources, which, at 20% P2O5 as an average, would contain 4 billion tons P2O5. Most of the Middle East phosphates contain uranium to some extent. The uranium occurs mainly as a replacement element in the structure of fluorapatite and francolite phosphate minerals.

Resources of phosphate of Late Cretaceous and Paleocene age in the Middle East, defined as Iraq, Iran, Jordan, Saudi Arabia, and Syria have been estimated at about 15.7 billion tons containing about 3.4 billion tons of P2O5.



Uranium in the Middle East, Phosphate

- The concentration of uranium varies from country to country and deposit to deposit. For scoping purposes, taking an average U content of 60-120 ppm, the Middle East phosphate resources would contain 1.2 million tons of uranium.

- Uranium extraction requires the conversion of phosphate to phosphoric acid followed by solvent extraction. Thus, recovery of uranium from phosphates is essentially dependent on installed phosphoric acid production capacity and what fraction of that capacity is subject to extraction of uranium.

Uranium in the Middle East, Pan African granite

- The Pan African granites (about 600-500 Ma) are one of the most favorable environments to host vein type uranium deposits. This case is very clear in Algeria, Morocco, Egypt, Sudan, Saudi Arabia, Turkey, and other countries as well.

- The uranium mineralizations are hosted in these granites within some favorable structures as faults and fractures.

The presence of intra-cratonic basins within many basement rocks exposures are another favorable environment. Often these basins are filled with late Proterozoic molasses type sediments as Hammamat series in Egypt and can form important uranium traps according to their geochemical and geological characteristics.

Selected examples

Jordan

•1980- aerial radiometric survey of the entire country

•1982, I989, I997: phosphate evaluation, were close to extraction plant construction

•1700 trenches
•15000 car-borne and foot gamma measuring points

•11000 emanometry and track-etch radon gas points

•Hundreds of boreholes

•Thousands of samples were collected and analyzed

Central Jordan

New Jordanian Discoveries

NRA Estimated Uranium Ore (U3O8) Deposit								
Central Jordan Uranium Areas	Block	Area km^2	Total Area km^2	Average Conc. ppm	Total Average Conc. ppm	Average Ore Thick. meter	Estimated Uranium Ore (U_3O_8) Inventory (tones)	Total Estimated Uranium Ore (U_3O_8) (tones)
Siwaqa	**1**	**7.1**	**28.1**	**688**	**592**	**1.25**	**8.548**	**34320**
	2	**14.9**		**778**		**1.27**	**20.4**	
	3	**0.82**		**488**		**1.42**	**0.8**	
	4	**5.26**		**415**		**1.49**	**4.57**	
Attarat and W. Maghar	**1**	**7.56**	**22.73**	**405**	**345**	**1.34**	**5.74**	**14965**
	2	**3.5**		**342**		**1.23**	**2.06**	
	3	**4.8**		**263**		**1.31**	**2.315**	
	4	**6.87**		**371**		**1.36**	**4.85**	
Khan Azzabib	**KZ**	**9.18**	**9.18**	**946**	**948**	**1.28**	**15.595**	**15595**
Total		*60*	*60*			*1.32*	*64880*	*64880*

Ned Xoubi, JERI 2008

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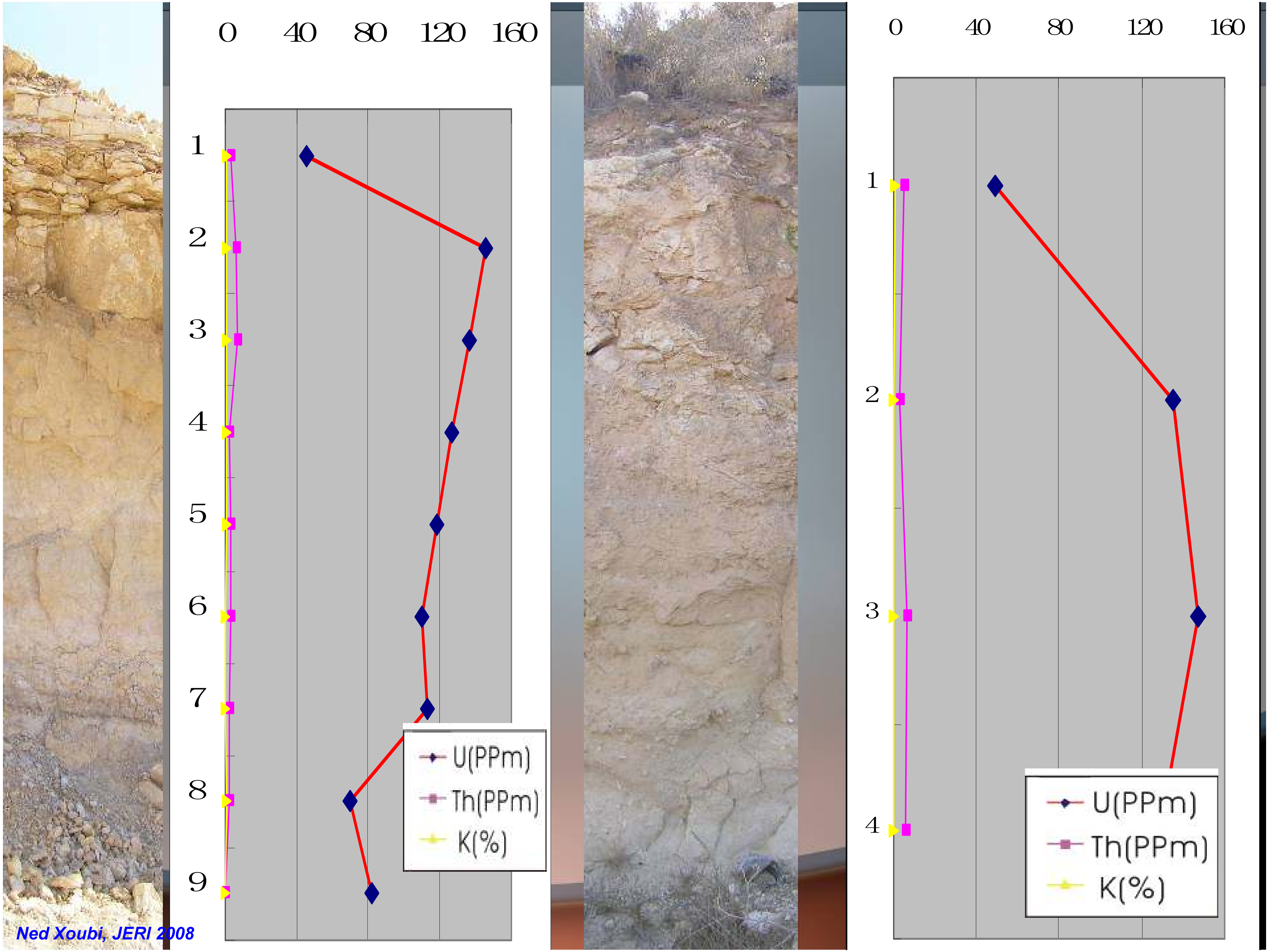

0
40
80
120
160
1
2
3
4
5
6
7
8
9
U(PPm)
Th(PPm)
K(%)
Ned Xoubi, JERI 2008
0
40
80
120
160
1
2
3
4
U(PPm)
Th(PPm)
K(%)

ALGERIA

- **Tassili, Tahaggart, Eglab, Ougarta, Tamart, Timouzeline, Timgaouine, Abankor, El-Bema, Ait-Oklan, Abankor, Tinef, Tesnou, Pharusian**
- **A1: exist in southern Hoggar (north of A2) it belongs to Upper Proterozoic unconformity & basal conglomerates**
- **A2: exist in continental sandstone and found in Tassili south of the Hoggar. *General geological character: Tin-Seririne basin, Tassilian sedimentary cover above the Proterozoic unconformity (A1). Specific locality/deposit names: Tahaggart deposit, southern Tassili; also Eglab, Ougarta Tamart-N-Iblis, Timouzeline,***
- **A3: it can be found in vein and granitic shear zone. Deposit located in southwestern Hoggar, western Hoggar. General geological character: veins in faults in granite batholiths; specific locality/deposit names: Timgaouine, Abankor, El-Bema, Ait-Oklan; occurrences at Abankor, Tinef, and Tesnou.**
- **A4: found in western Hoggar; the specific locality/deposit names is Pharusian chain**

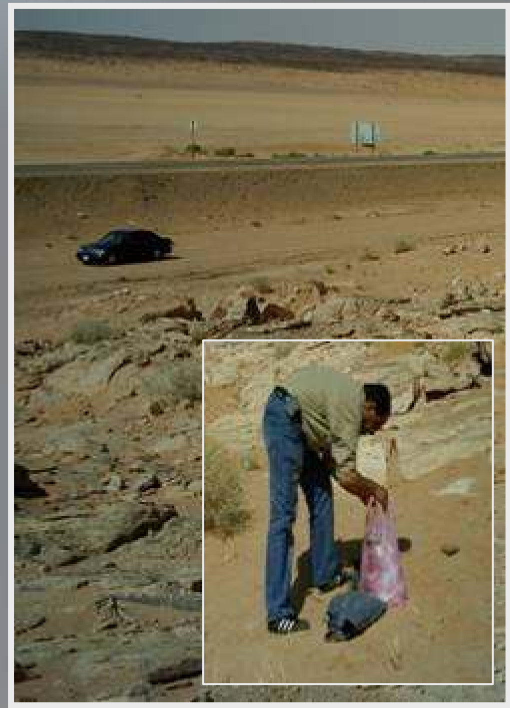
SAUDIA

SAUDIA: Ar Rawdah, Al Hanakiyah; Hulayfah, Jabal Asfar Shwelil, Tabuk, ad Dumathah, Turayf

S1, exist in volcanic type in north central, and consist of Precambrian felsic volcanics, calderas, Umm Misht formation of the Shammar group.

S2 deposit type: sandstone in Tabuk basin, black shales have high U, and adjacent sandstones are prospective targets. Specific locality/deposit names: locations: Tabuk basin (28 30'N; 36 20'E).

S3 deposit type: calcrete; Hulayfah belong carbonate evaporite facies have between 10 and 350 ppm U;

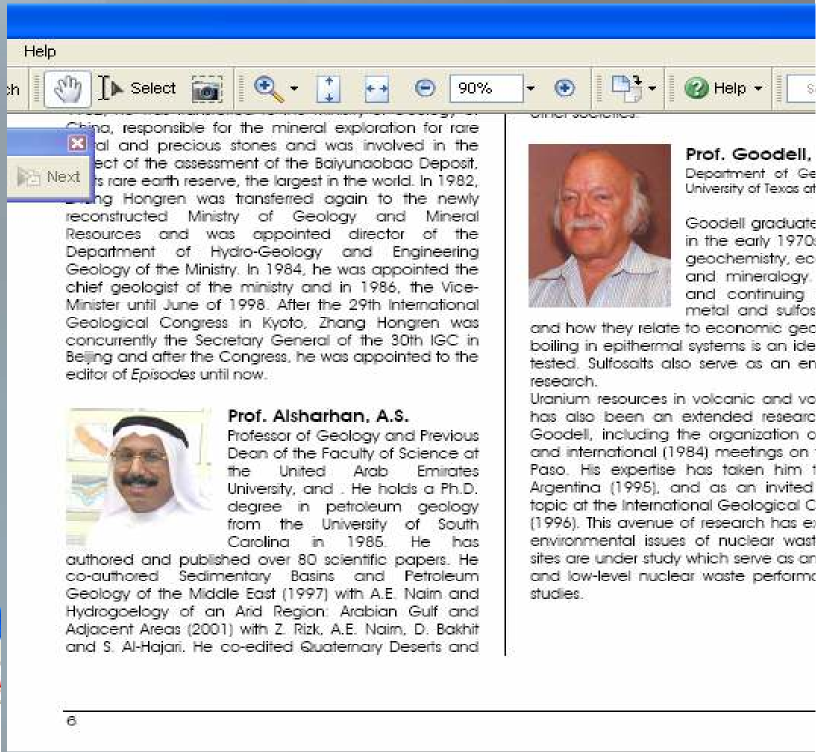


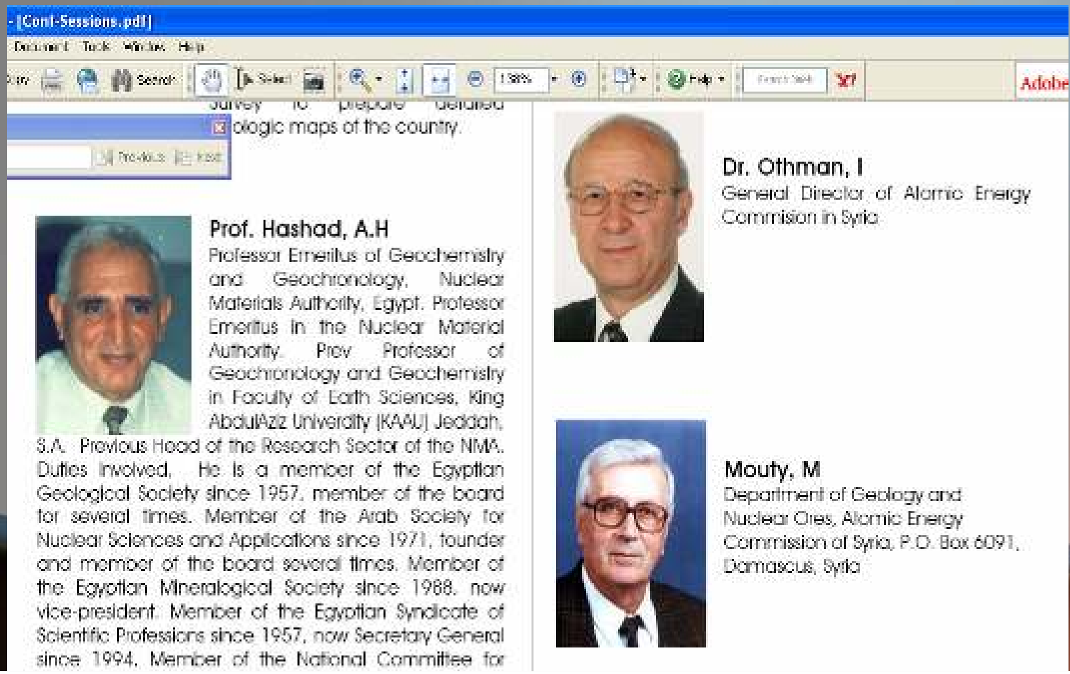
S4, deposit type: sabka, general geographic region: Sabkhah ad Dumathah, general geological character: lake beds, specific locality/deposit names: locations: Sabkhah ad Dumathah (23 35'N; 40 25'E)

S5, deposit type: phosphate, general geographic region: general geological character: Phosphate beds in the Turayf basin contain U.

Potential occurrences of Uranium in the Middle East e.g Egypt and Saudi Arabia

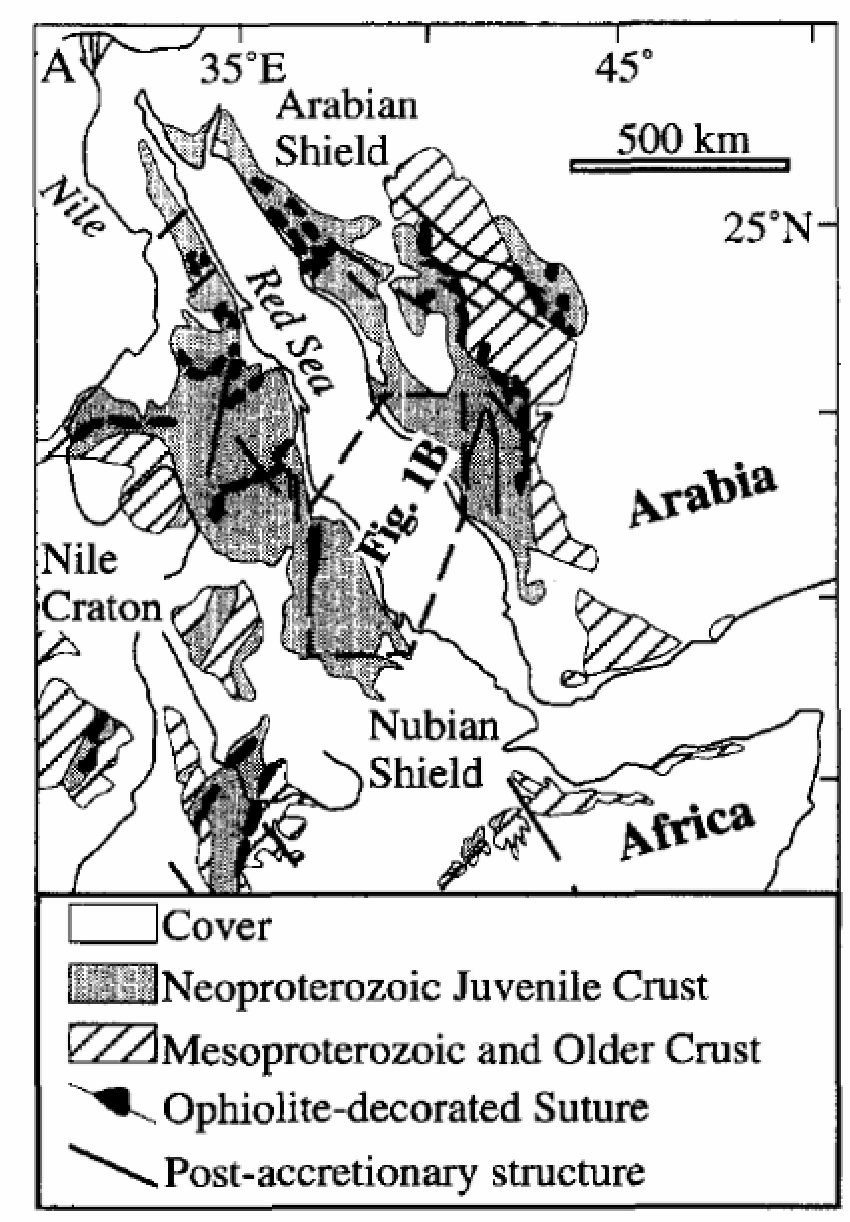
"Igneous & Metamorphic-related Vein-types deposits consist of U mineralization in lenses or sheets or disseminations filling joints, fissures, fractures and stockworks in post-accretionary structures which include several fault systems e.g. Najd fault system. The deposits are commonly spatially related to peraluminous granites especially at their contact with host rocks of siltstones and greywackes"



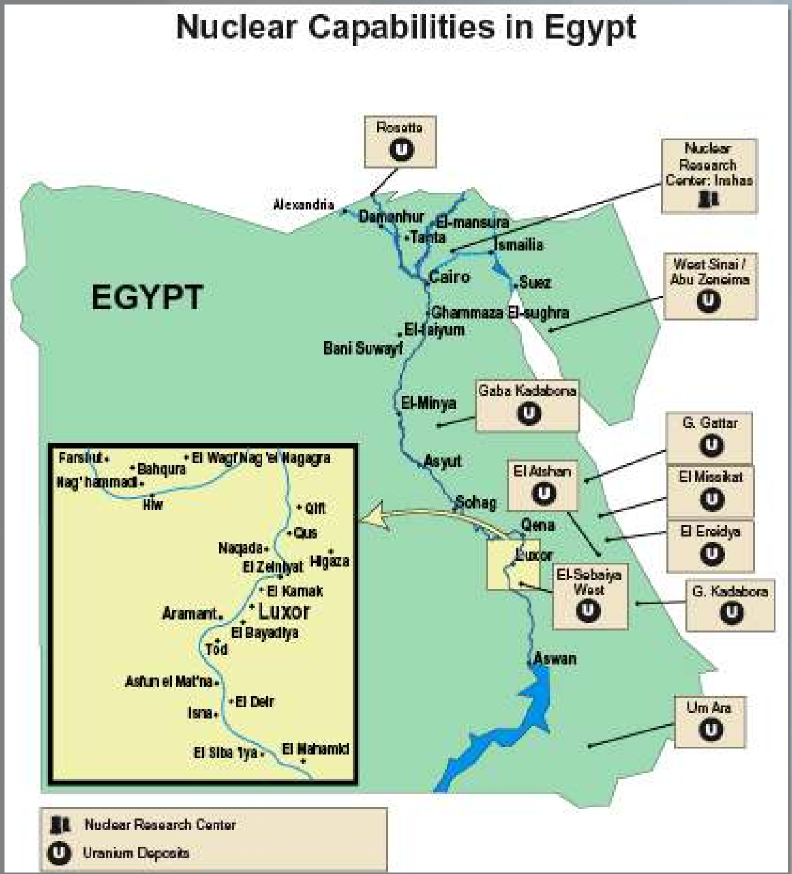


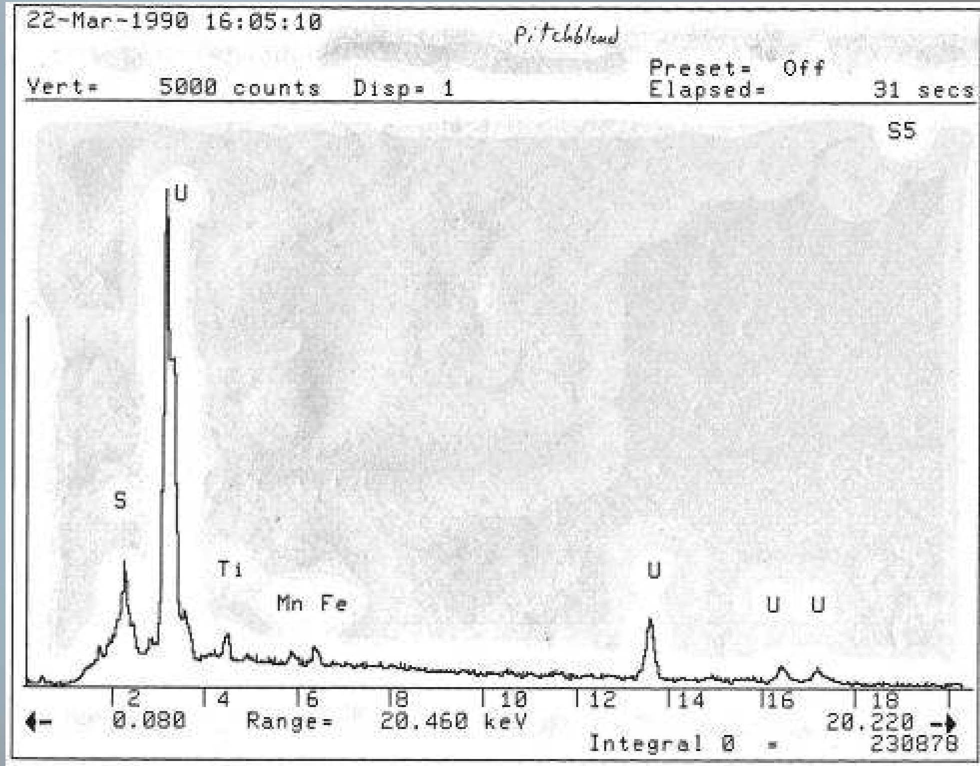
Cont ....

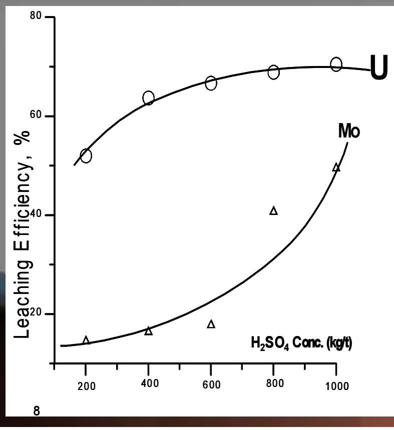
Some opinions suggest that convective circulating fluids (mixture of meteoric and connate waters), heated in response to intensive tectonism, leached U from the host metasediments and transported it as uranyl-carbonate complexes to the marginal zone of the granite plutons.

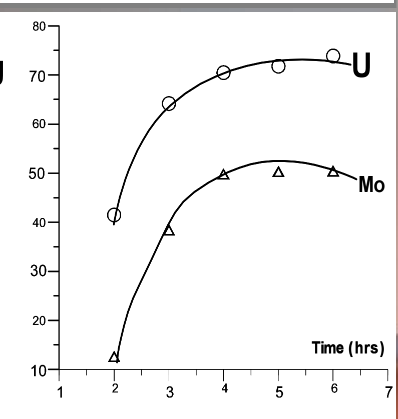


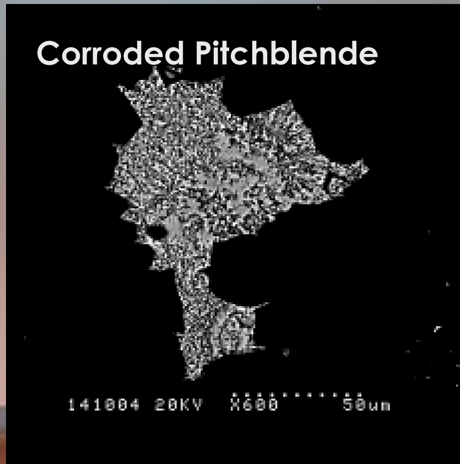
EGYPT

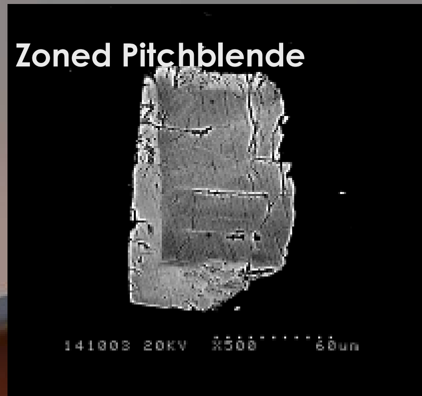












After Tarek I, NMA

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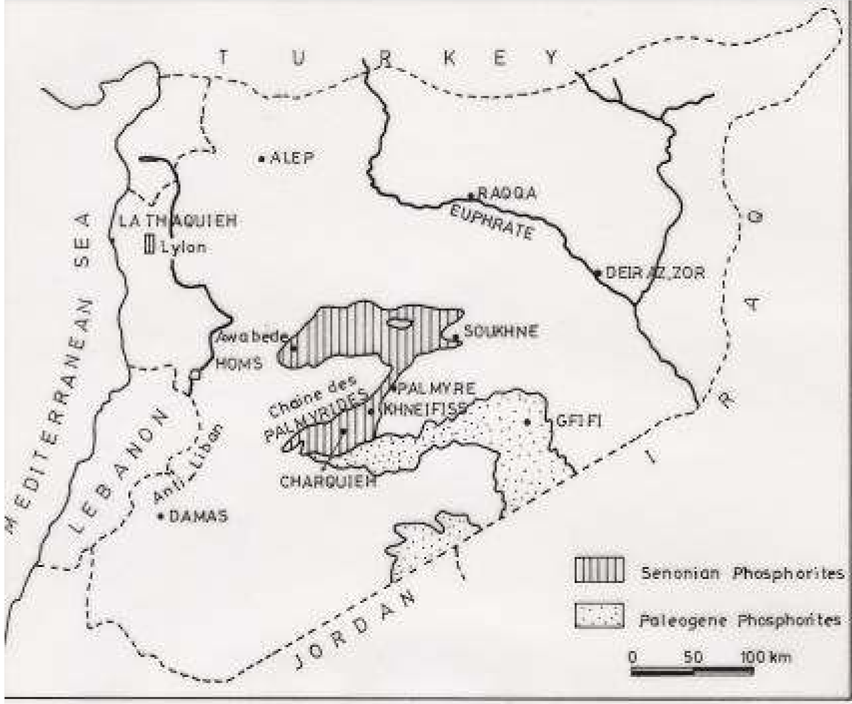
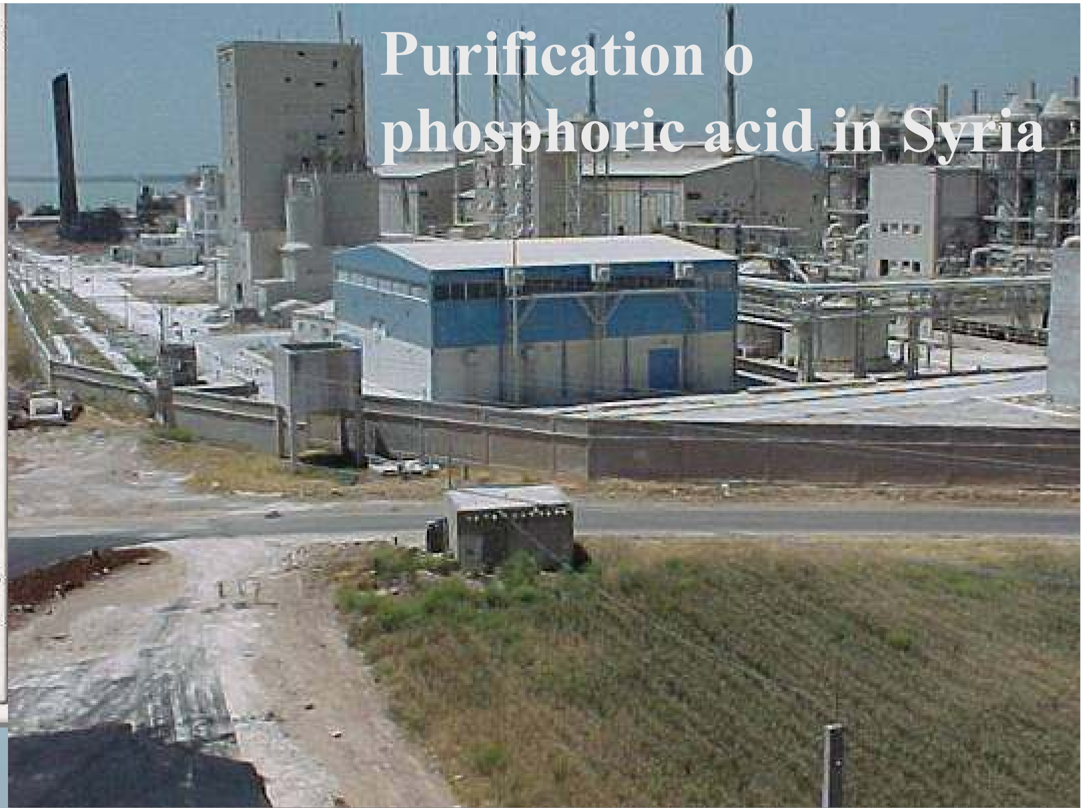
Abu Rusheid Shear Zone

Precipitation of secondary U-minerals along walls of joints and fractures

After Hashad, NMA



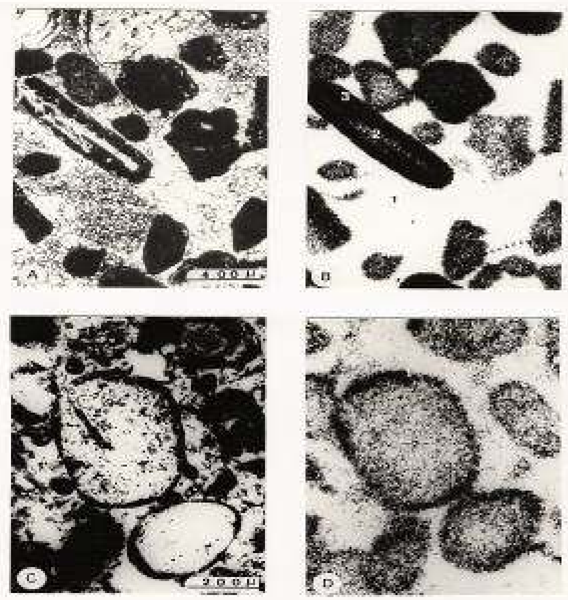
Purification o phosphoric acid in Syria



Distribution of uranium in phosphorite by fission tracks method.

A- Hard phosphorite: different phosphatic elements with coated grain (bone) in natural light.
B- Same sample in A- fission track study:
- Matrix free of uranium.
- Uranium is always related to phosphatic grain.
- The coated grain, uranium in the nucleus is less than in the cortex .
C- Uncoated phosphatic grain-pigmented at the cortex by organic matter- natural light-Morocco phosphorite
D- The same sample in C-fission track study: The pigmented cortex is more richer in uranium (363 ppm), than non pigmented internal part of the grain (2, 82 ppm).

After Othman I, (Syria's Atomic Energy Commission) 2006,




Saghand
Uranium Mine
Uranium mining and
pre-processing
support facility
N
DigitalGlobe Quickbird commercial satellite image

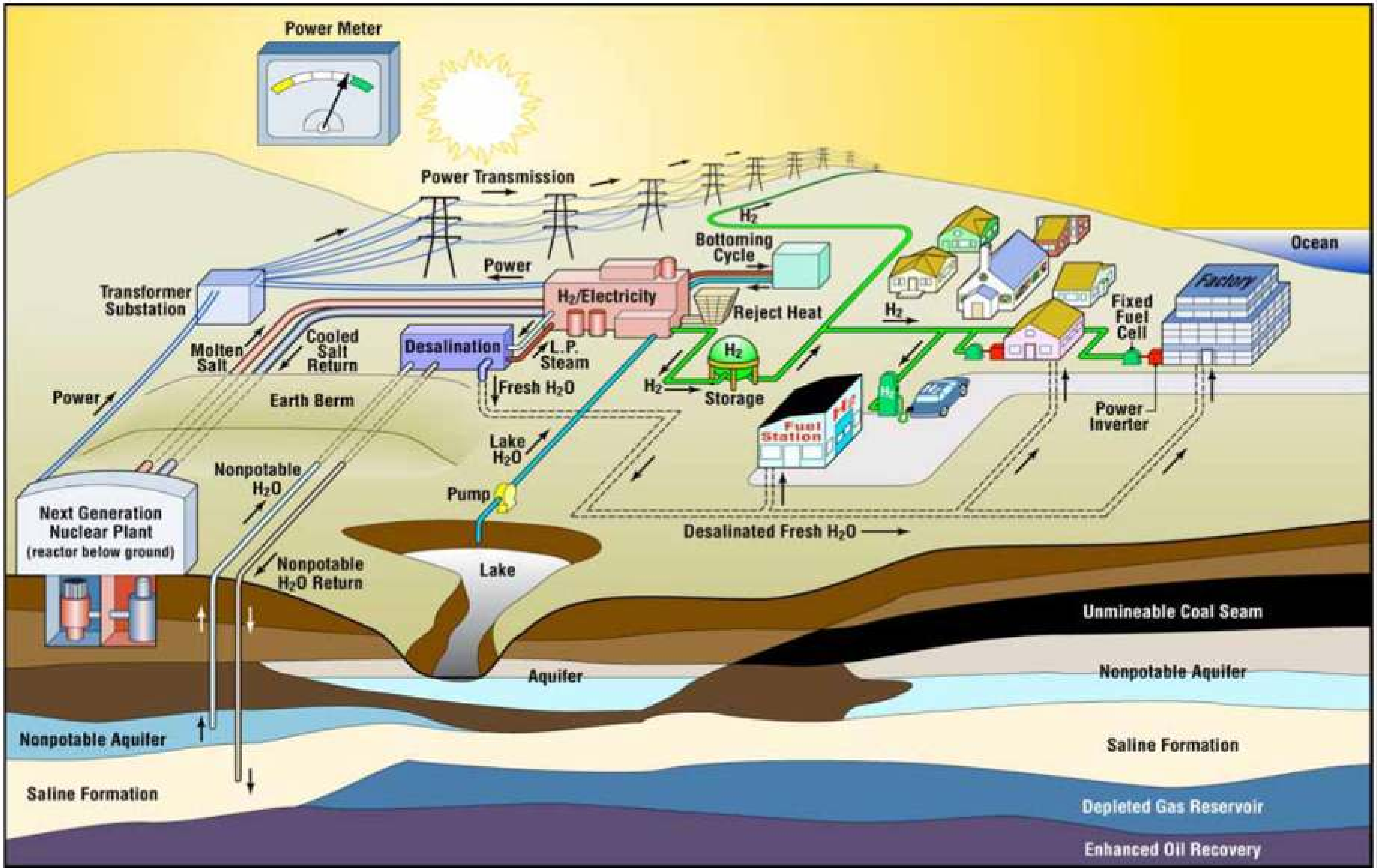

Gachin Uranium Production Plant (Undeclared prior to May 2004)
Reagent storage area
Production Area (leaching/ion exchange/precipitation /drying/packaging)
Entrance/securi gate
Ore receiving area
Tailings pipeline
Crushing / grinding circuit
(Later modified)
Waste Tailings pond
N
DigitalGlobe Quickbird commercial satellite image
22 AUG 02

- *Conclusion:* There are lots of potentials for development of Uranium Resource exploration programs in the Middle East.

- Hundreds of Anomalies and potential have Identified across the Middle East. Examples were given from Jordan, Saudia, Egypt, Libiya, and Syria, and Algeria.

- *Recommendation*: Utilization of petroleum drill data for oil exploration (Gamma ray Logs!)


Thank You



F. M. Howari, May 2009