

Fundamentals of Nuclear Fuel Cycle

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Module description

- 12 lectures
- 12 practical lessons
- 3 Labs

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- 2 tests (10 scores)
 - 2 colloquiums (20 scores)
 - Defense of Lab Reports (20 scores)
 - Research paper (10 scores)
 - Final Exam (40 scores)



100 scores

Research paper

Topic Nuclear Fuel Cycle of

Full description of NFC
10 pages

Deadline 1 March

UK

USA

India

France

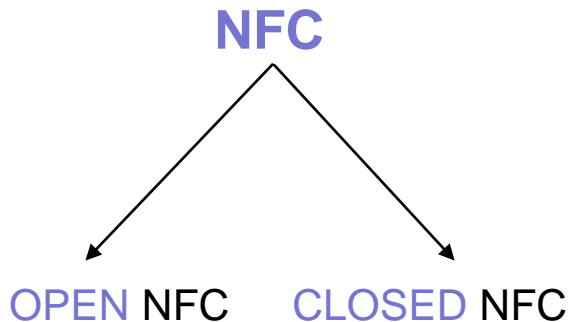
Canada

Japan

China

NFC

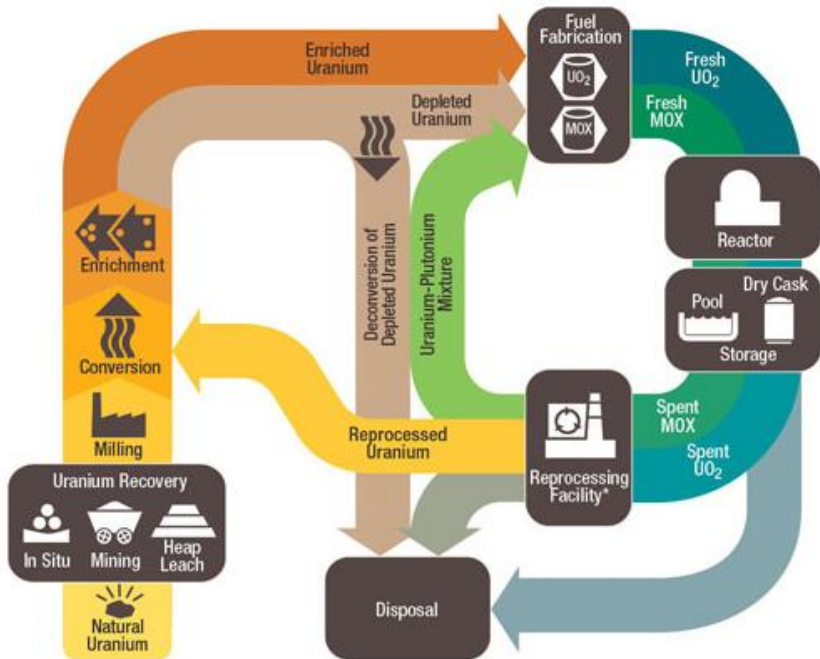
A number of process stages in the supply and waste management of nuclear fuel for reactors



Stages of NFC

- Exploration
- Mining
- Milling
- Conversion
- Enrichment
- Fuel fabrication
- NPP
- Storage
- Reprocessing
- Waste disposal

Nuclear Fuel Cycle





Uranium concentration

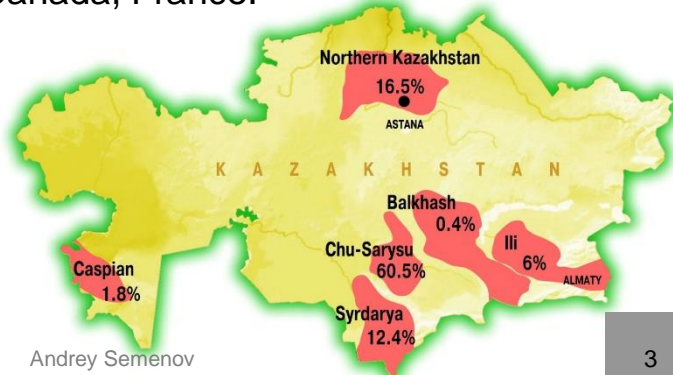
	% U	Parts per million
Very high-grade	20	200000
High-grade	2	20000
Low-grade	0.1	1000
Very low-grade		100
Granite		3-5
Sedimentary rock		2-3
Earth's continental crust		2.8
		0.003

World uranium mines

- Central Asia's mines

Kazakhstan:

1. Company - Kazatomprom (World's leader – 36% of all mining)
2. Production has been increased from 2000 to 19500 tU/yr for 10 years
3. Export to Russia, China, Canada, France.
4. Technology - ISL



World uranium mines

- Central Asia's mines

Russia:

1. Company - AtomRedMetZoloto (ARZM)
2. Production 3500 tU/yr
3. Technology ISL and underground mining

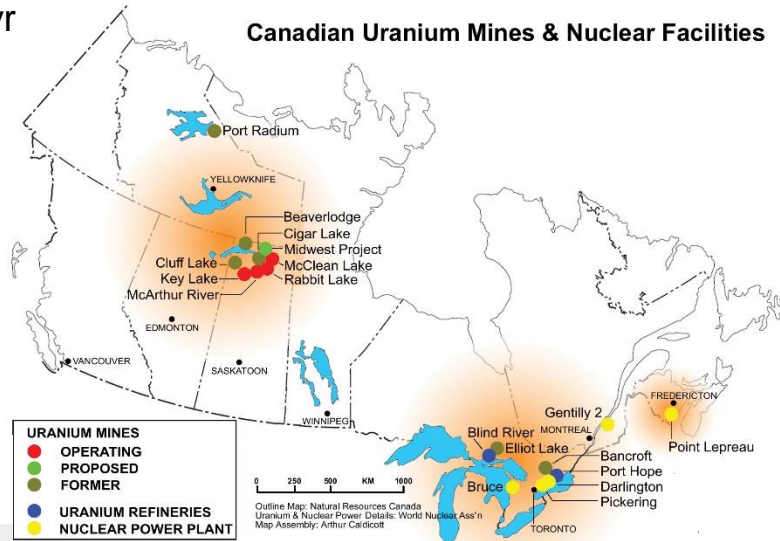


World uranium mines

- North America's mines

Canada:

1. Company – Cameco and Areva
2. Production 9145 tU/yr
3. Technology
ISL and underground mining



World uranium mines

- North America's mines

USA:

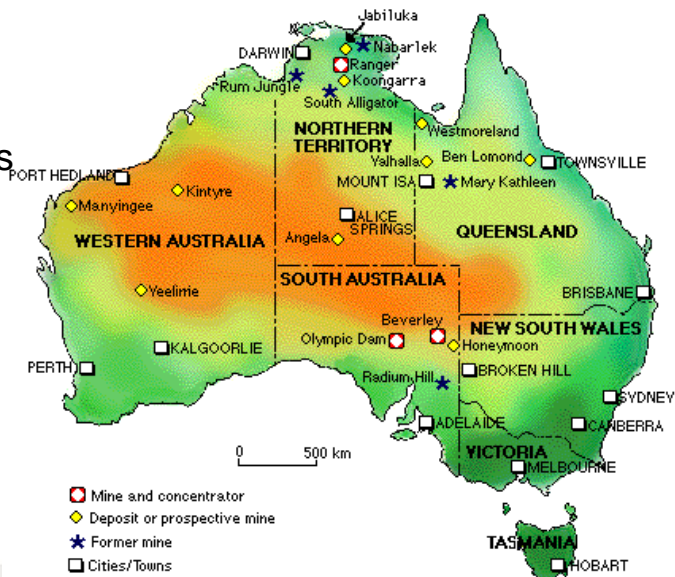
1. Company – Cameco, Uranium One, Denison Mines, etc
2. Production 1500 tU/yr
3. 15 mines operates
4. Technology – ISL and underground mining



World uranium mines

- Australia's mines

1. 11% of the world's uranium resources
2. Only 5 mines operate
3. Production 8500 tU/yr
4. Company – Western Mining Corporation, Energy Resources Of Australia Ltd, etc



World uranium mines

- Africa's mines

Country	Site / Project	Operator	Tonnes	Grade U	Grade U ₃ O ₈	Contained Metal	Contained Metal
			(kt)	(kg/tonne)	(kg/tonne)	(tonnes U)	(M lbs U ₃ O ₈)
Malawi	Kayelekera ¹	Paladin Energy	1,780	1.21	1.43	2,157	5.61
Namibia	Rossing ²	Rio Tinto	19,600	0.42	0.50	8,310	21.61
Namibia	Langer Heinrich ¹	Paladin Energy	16,700	0.59	0.69	9,837	25.57
Niger	Cominak ³	AREVA	1,350	4.58	5.40	6,183	16.07
Niger	Somair ³	AREVA	7,216	2.22	2.62	16,049	41.72
South Africa	Dominion (under-ground) ⁴	Uranium One					
South Africa	Mine Waste Solutions (Buffelsfontein) ⁵	First Uranium	99,400	0.07	0.08	7,049	18.33
South Africa	Vaal River (Great Noligwa) ⁶	AngloGold Ashanti	9,900	0.29	0.34	2,868	7.46
South Africa	Vaal River (Kopanang) ⁶	AngloGold Ashanti	5,100	0.29	0.34	1,483	3.86
South Africa	Vaal River (Moab Khotson) ⁶	AngloGold Ashanti	1,200	0.26	0.31	303	0.79

Uranium minerals

Mineral	Formula	Color	Composition and density [g/cm ³]	Origin	Solubility
Uranite	$x\text{UO}_2 \cdot y\text{UO}_3 \cdot z\text{PbO}$ Oxides: Fe, Co, Ni, V, Cu, Ca	From pitch black to light gray	$(\text{UO}_2 + \text{UO}_3)$ – 66-85%, $\rho = 4.5-7.7$	Hydro- thermal	HNO_3 HCl H_2SO_4



Uraninite - Shinkolobwe, Kat.
Coll. Fr. Coune - © 2010 R. Warr

Uranium minerals

Mineral	Formula	Color	Composition and density [g/cm ³]	Origin	Solubility
Uraninite	$UO_2 \cdot yUO_3 \cdot zPbO$ Oxides: Th, Zr, etc	From black to steel black with tints of brown	$(UO_2 + UO_3)$ – 46-88%, $\rho = 8-10$	Hydrothermal, granite, pegmatite	HNO_3 (dilute), HCl (concentrated)



Uranium minerals

Mineral	Formula	Color	Composition and density [g/cm ³]	Origin	Solubility
Brannerite	(U,Ca,Y,Ce) (Ti,Fe) ₂ O ₆	black	UO ₂ – 29% UO ₃ – 42% TiO ₂ – 31-43%, ThO ₂ – 8% CaO – 1.1-3.45% Fe ₂ O ₃ - 4% ρ=8-10	magmatic, gold-bearing sands of Idaho	HNO ₃ (hot), H ₂ SO ₄ (concentrated)

