



Dow process for uranium recovery from phosphoric acid

Jean-François Ferraro
Global Commercial Development Leader
IAEA Vienna Nov. 4-6th, 2009



Agenda

- Background
- Challenges
- The resin
- The process
- Future
- Q&A



Dow Water and Process Solutions

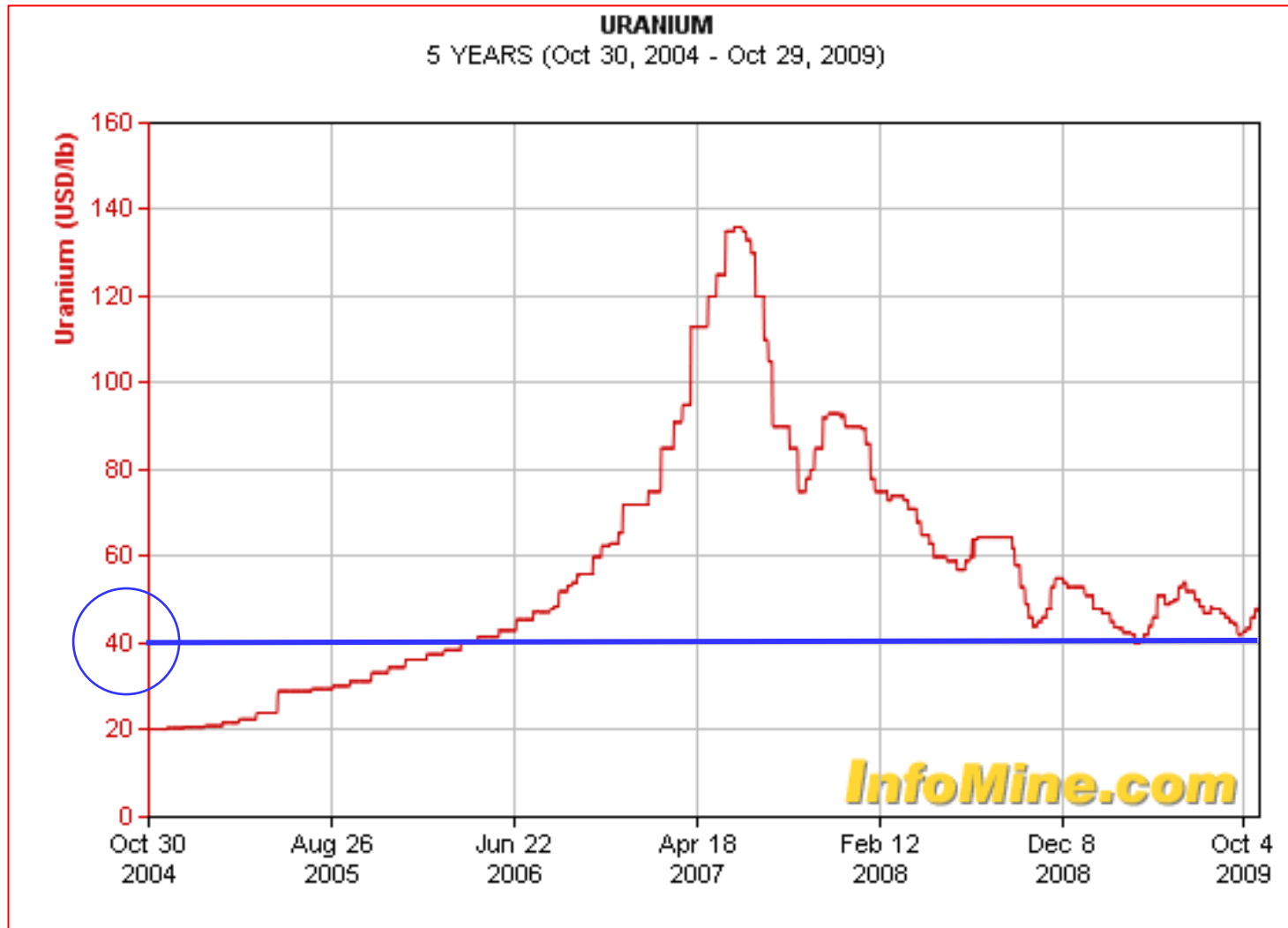
- April 1st, 2009: Dow and Rohm and Haas companies merge together
- Creation of the BU Dow Water and Process Solutions which encompass the membranes and ion exchange resins business of Dow and the ion exchange resin business Rohm and Haas
- ~\$0.7-1 billion sales
- Focus on hydrometallurgy segment with broad portfolio:
 - Uniform particle size gel resin for ISL and heap leach
 - Uniform particle size MR resin for RIP process
 - Chelating resins (IDA, APA, picolylamine, Minix)
 - Process knowledge – numerous partnership in the industry at global level



Background

- Extraction of uranium with chelating resin from phosphoric acid studied 30 years ago by Duolite (later Rohm and Haas and now Dow) – Pilot plant at the Negev Nuclear Research Center with Duolite ES467 (1984-86).
- At the time the process was not economical vs. solvent extraction
- In the 90's uranium recovery from phosphoric acid abandoned due to higher cost vs. Uranium market price.
- More recently Dow has improved the process and the resin used
- Ion Exchange Resins have the advantage to be environmentally friendly and safer than solvent extraction

Uranium price trend





WPA – typical analysis range

U	mg/l	100-300
Th	mg/l	0-200
Fe ³⁺	g/l	2-15
Fe ²⁺	g/l	0.1-1.0
Al ³⁺	g/l	2-8
Mg ²⁺	g/l	2-6
K ⁺	g/l	1-3
Na ⁺	g/l	1-3
Si	g/l	2-8
F ⁻	g/l	2-40
TOC	g/l	0.5-2
P ₂ O ₅	%	25-35



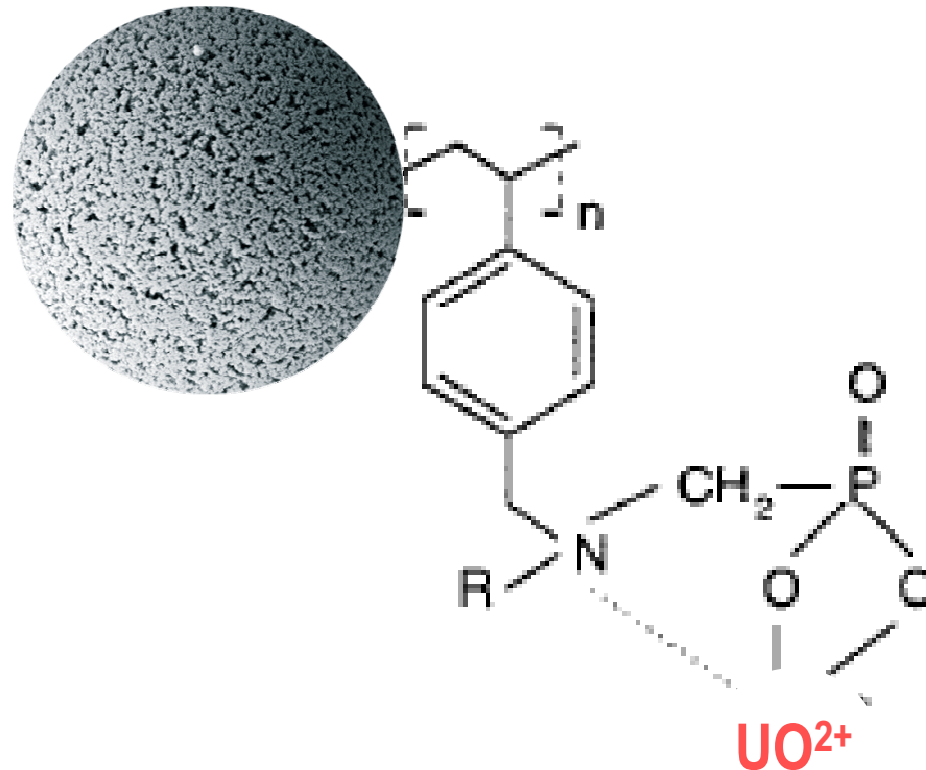
Challenges

- Selective removal from Uranium
- Iron III reduction in iron II
- Phosphoric acid concentration
- Separation from other ions (Thorium, vanadium...)
- Desired Uranium concentration for further processing
- Resin inventory - Capex



The Resin

Aminophosphonic resin



Polystyrene-DVB Macroporous Resin with Aminophosphonic functional groups



Amberlite™ IRC747 - Key properties

- Ionic affinity
 - $H^+ > Fe^{3+} > Al^{3+} > Pb^{2+} > UO_2^{2+} > Cu^{2+} > Zn^{2+} > Fe^{2+} > Mg^{2+} > Ca^{2+} > Cd^{2+} > Ni^{2+} > Co^{2+} > Sr^{2+} > Na^+$
- pH
 - Stability: 0-14
 - Minimum operating pH: 2
- Temperature
 - Maximum: 80°C
- Resistance to oxidation
 - Avoid prolonged contact with oxidants (<1ppm as O_2)

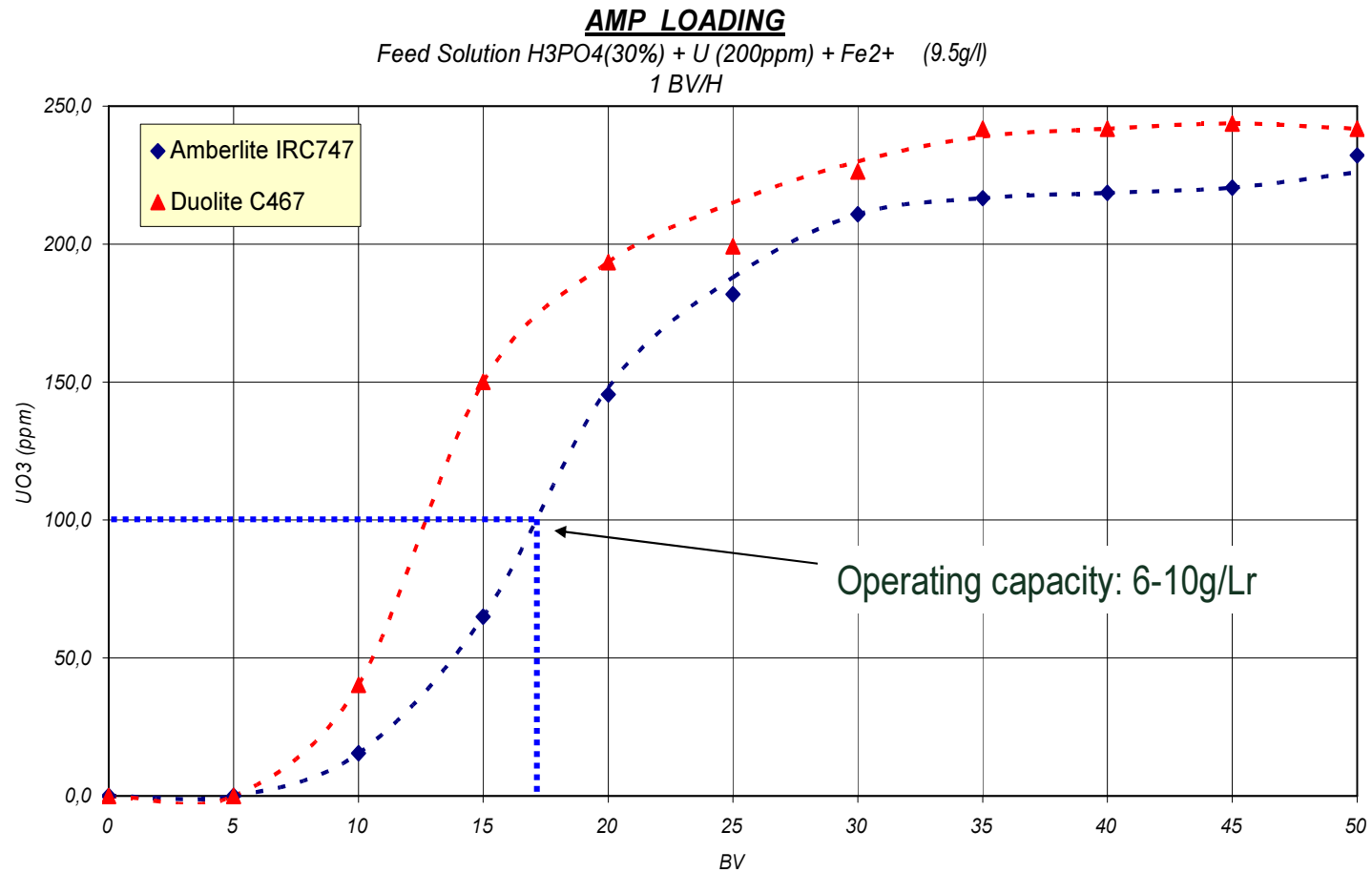


Amberlite™ IRC747 vs. Duolite™ C467

Properties	Amberlite IRC747	Duolite C467
Matrix	Styrene divinylbenzene copolymer	Styrene divinylbenzene copolymer
Functional groups	-CH ₂ -NH-CH ₂ -PO ₃ Na	-CH ₂ -NH-CH ₂ -PO ₃ Na
Total exchange capacity	1.75 eq/Lr (Na⁺ form)	1.00 eq/Lr (Na⁺ form)
Moisture Holding capacity	64-69% (Na ⁺ form)	65-70% (Na ⁺ form)
Harmonic mean size	520-660μ	500-700μ
Max. reversible swelling	H ⁺ ⇌ Na: 45%	H ⁺ ⇌ Na: 35%

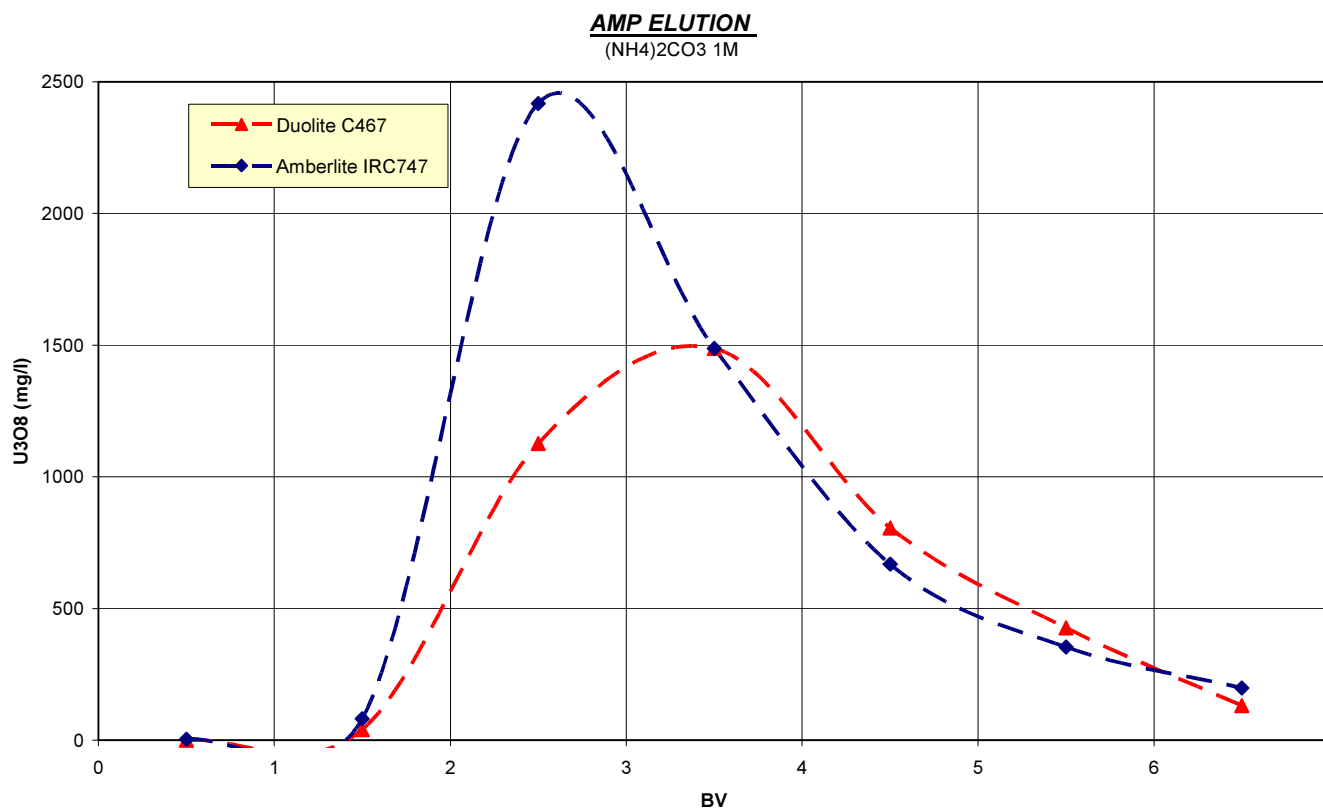


Loading





Elution



Elution of the Uranium can take place with ammonia followed by ammonium carbonate. As shown below, Amberlite™ IRC747 gives not only the highest concentration in the concentrated eluate because of its higher operating capacity, but also a very good elution profile



The process

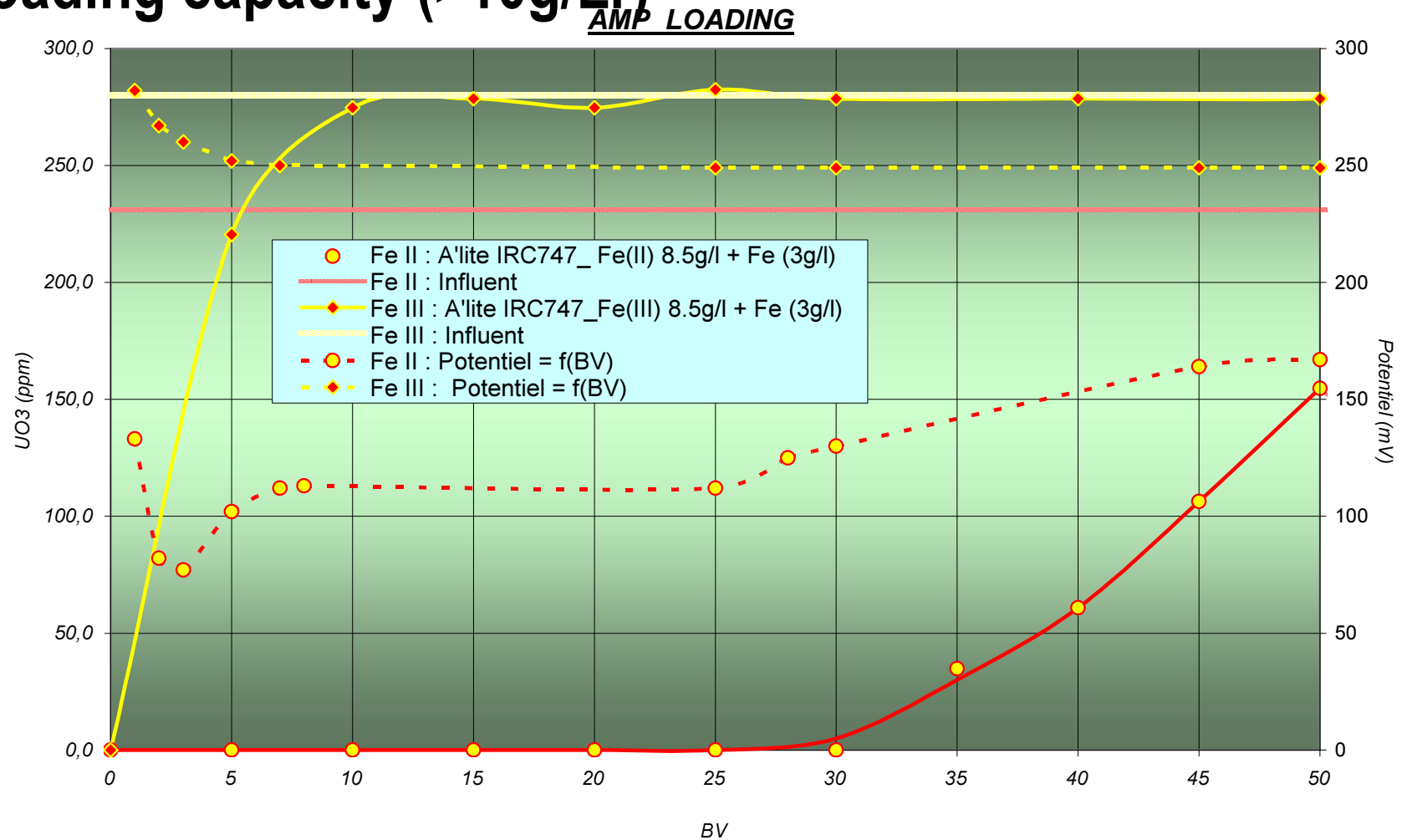


Requirements

- Adjustment of Phosphoric acid concentration to 30% max.
- Feed: Reduction of Iron III in iron II by metal addition (iron, zinc) or by electrochemical process.
- Temperature 50-60°C
- Prevention of feed oxidation (nitrogen blanket)
- Loading at 1 BV/h
- Elution: neutralization with NH₃ followed by elution with a solution of 1M Carbonate de Sodium.

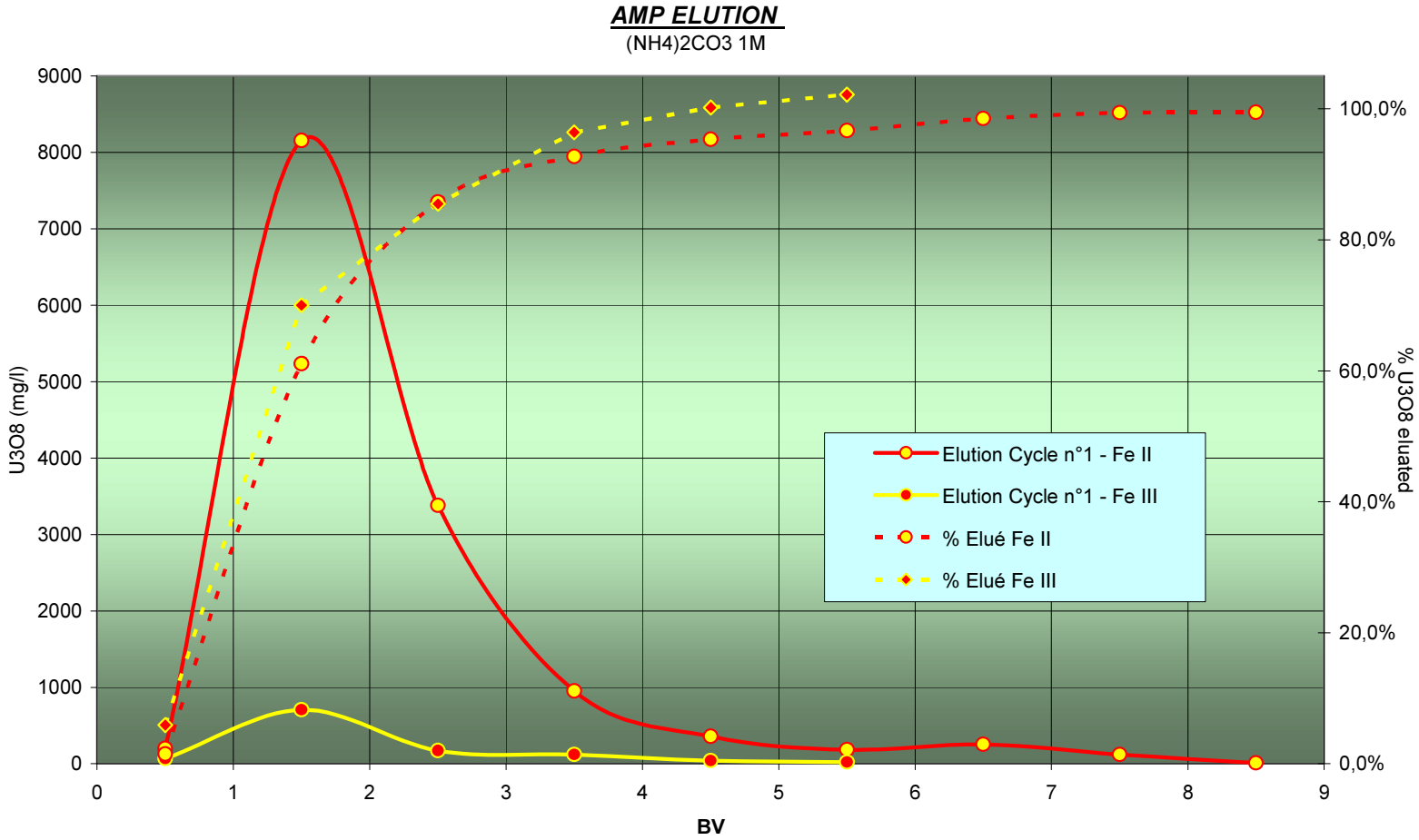


Dramatic effect of iron reduction on loading capacity (>10g/Lr)





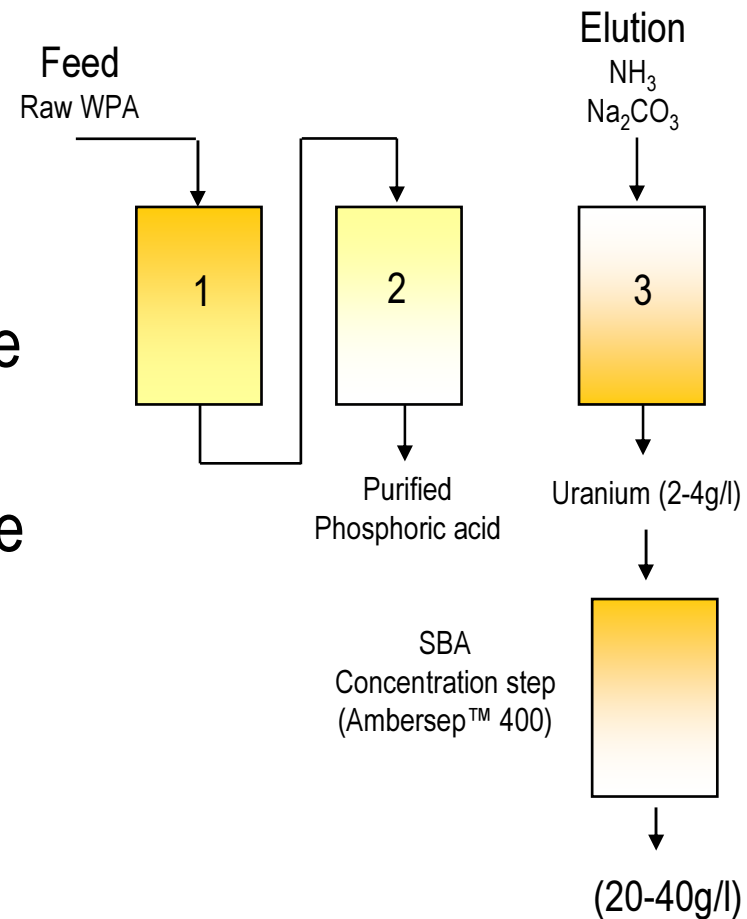
Elution: 99% Uranium eluted in 4 BVs





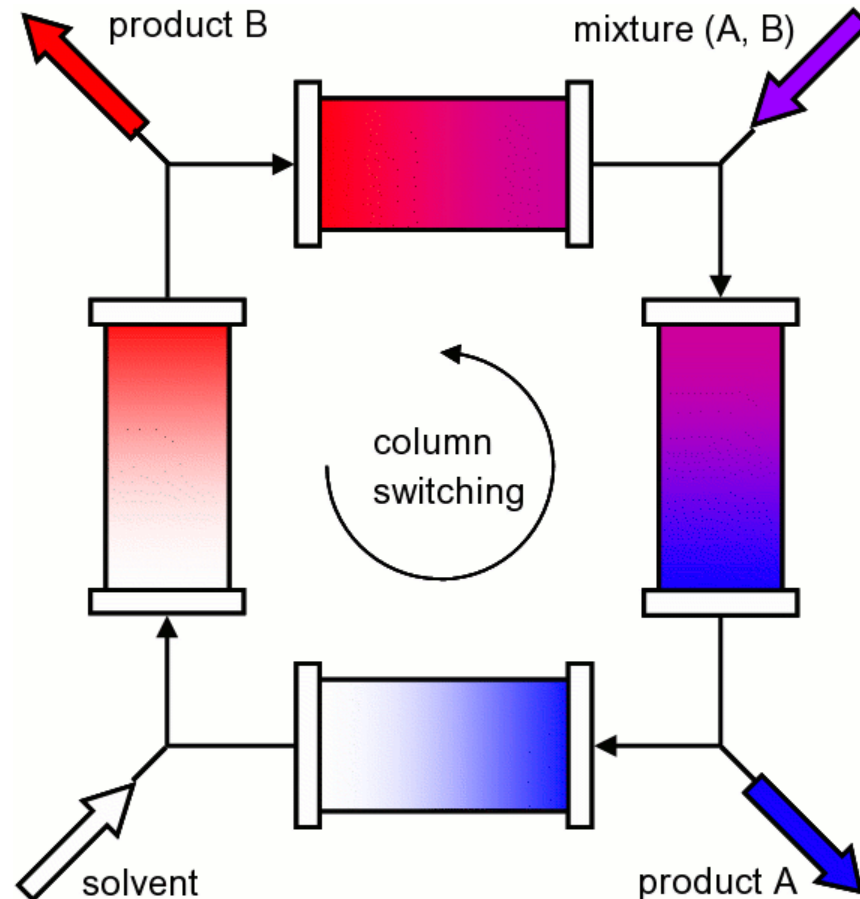
Merry go round system

- 4 columns systems
- Two in series for loading and one in regeneration or standby
- Fourth column with a strong base resin for over-concentration



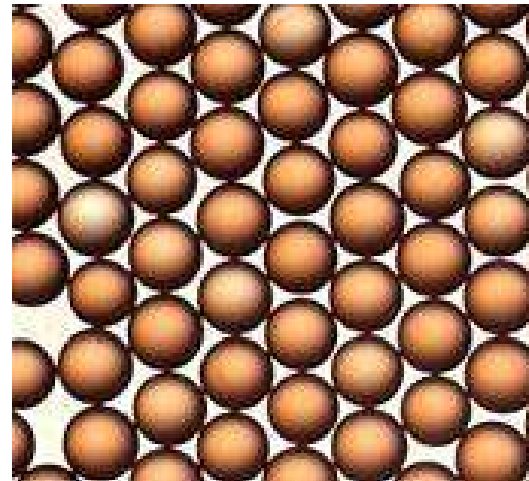
Simulated Moving Bed system

- Advantages:
 - Continuous process
 - Sharper separation: for instance Uranium vs. Thorium
 - Higher purity
 - Less resin inventory
 - Less waste



What next?

- Several joint development programs with key partners
- Uniform particle size capability
- New chelating resin with higher selectivity vs. Iron





Q&A



Thank you!