Prayon s.a.

EXTRACTION OF URANIUM FROM PHOSPHORIC ACID

THE GOOD PRACTICE

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Stake in term of Resources

Uranium Resources (in 10^3 tons U)

- In 2003, classical resources known :

  < 130 USD/Kg U : 4588
  < 80 USD/Kg U : 3537
  < 40 USD/Kg U : 2523

- Resources contained in phosphates :
  < 130 USD/Kg U : 22000

- Resources contained in Moroccan phosphates :
  < 120 USD/Kg U : 6500

To invest nowadays in Uranium extraction from phosphoric acid

1. STAKE IN TERM OF ECONOMY

In 1980 : PRAYON invests in the following economic environment :

SPOT PRICE NUEXCO :	42 US$/lb U_3O_8	=	109 US$/kg U
SALES PRICE :	3400 FB/kg U_3O_8	=	137 US$/kg U
COMPLETE COST PRICE :	2800 FB/kg U	=	96 US$/kg U

In 1998 : PRAYON stops this activity in the following economic environment:

SPOT PRICE NUEXCO :	10 US$/lb U_3O_8	=	26 US$/kg U
SALES PRICE :	1200 FB/kg U_3O_8	=	39 US$/kg U
COMPLETE COST PRICE :	2590 FB/kg U	=	71 US$/kg U

To invest nowadays in Uranium extraction from phosphoric acid

2. ACTUAL SITUATION

Spot price NUEXCO : 40.5 US$/lb U_3O_8 = 105 US$/kg U

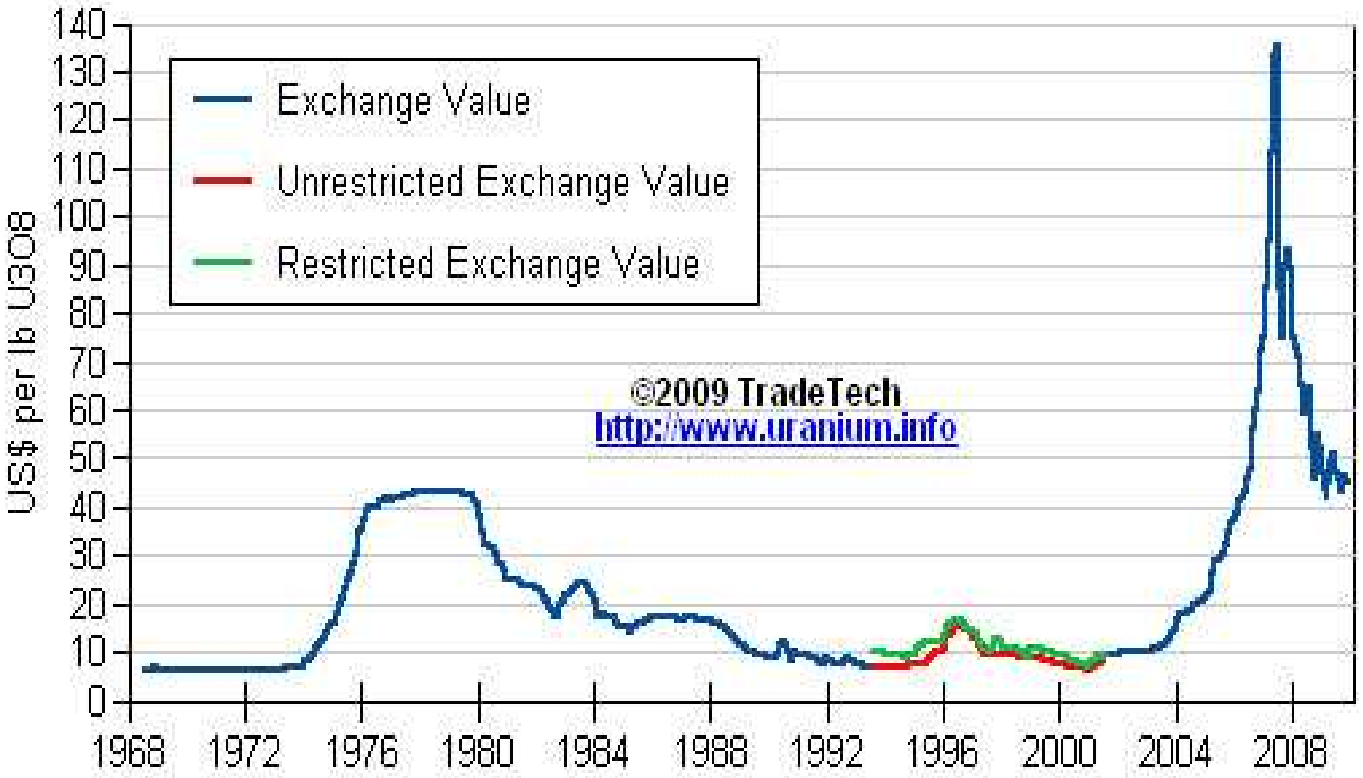
A long term sales contract could be concluded at 65 US$/lb U_3O_8 = 168 US$/kg U

A unit of recovery of the uranium from phosphoric acid, with an annual capacity of minimum 100 tons of U and a 20 years amortization, will show a cost price that may vary from 75 and 130 US$/kg U

This cost price will depend on :

* the U and organic matter content in the natural phosphate
* the local economic environment

Spot Price Evolution of NUEXCO



Historical Background

- In the Fifties : First industrial realizations with solvent extraction of Uranium in Florida

- End of the Sixties : Elaboration of a range of solvents made out of neutral or acidic esters of phosphoric acid by a team of the National Oak Ridge Laboratory (USA)

- Birth of a range of processes named according to the solvent used

- Building of plants using one process or another, in the USA, in Belgium, In Canada, in Iraq and in Taiwan.
  - First operational one : Grace's Plant in Bartow, Florida (1976)
  - Last to stop its activities : Prayon Plant in Engis, Belgium (1998)

Historical Background

- DEHPA/TOPO appeared to be the most efficient process and plants converted to it.
- DEHPA/TOPO system revealed itself as the best one thanks to its great stability and very good selectivity.
- Despite works performed with new solvents, DEHPA/TOPO process in its latest evolutions remains THE REFERENCE PROCESS

Prayon and the uranium extraction from phosphoric acid

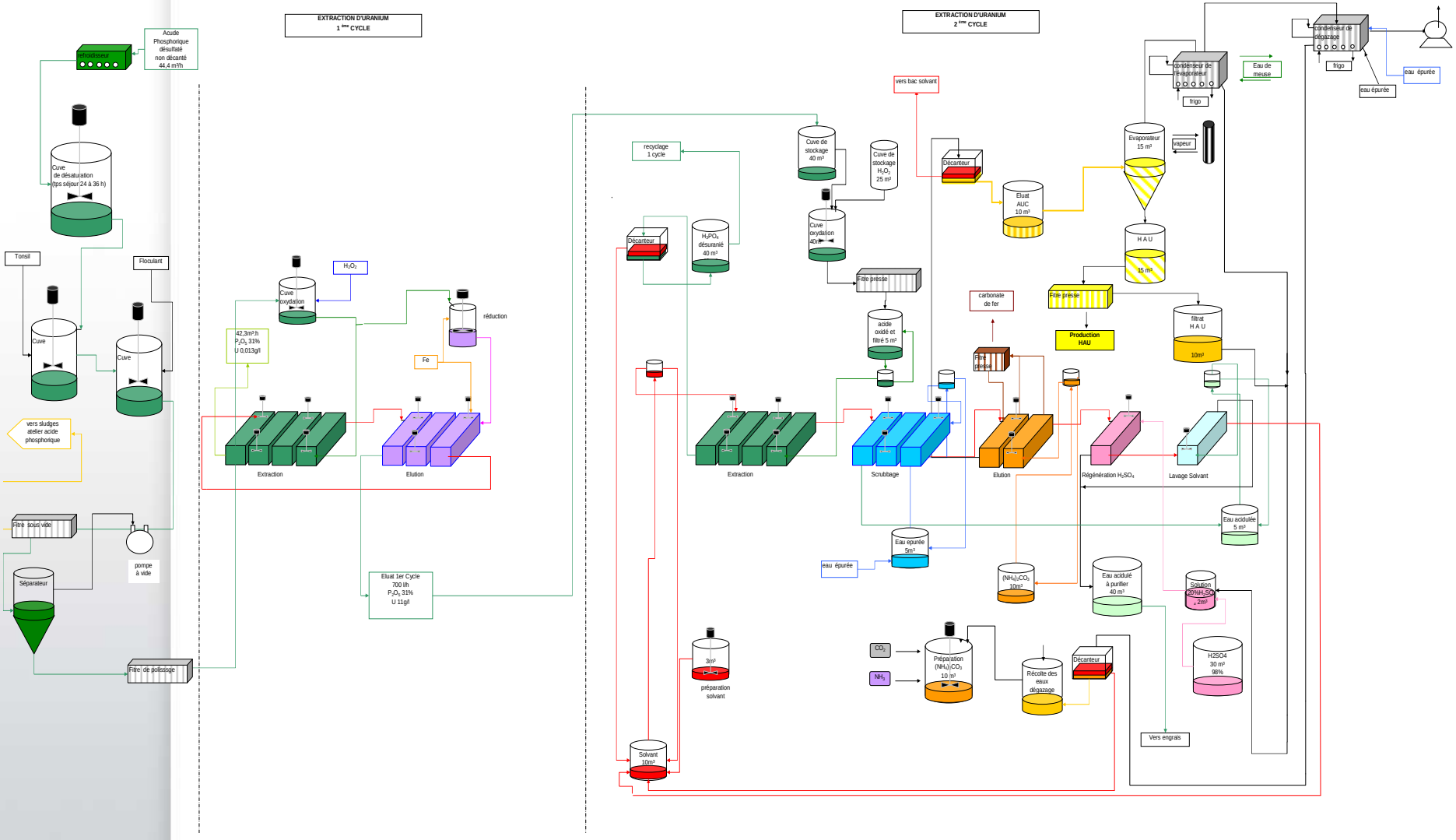
- **End of the Seventies** : Prayon and Union Minière shared their expertise to develop the industrial application of the DEHPA/TOPO Process for uranium-bearing Moroccan acid.
- Based on pilot test results, building of 2 plants in Belgium, operating **from 1980 until 1998** with an average production amounting to 50 tons U_3O_8/year
- **In 1981**, Prayon and Mechim succeeded in a industrial project of uranium extraction in Iraq on every stage to the start up in 1984
- **In 1998**, definitive stoppage of industrial activity in Belgium for Prayon and Puurs
- **Prayon : an indisputable and inescapable asset for project in Uranium recovery field**

DEHPA/TOPO : Process Description

The Process consists in 4 steps or 4 sections :

- The pre-treatment of phosphoric acid
- The 1st cycle of extraction
- The 2nd cycle of extraction
- Precipitation and conditioning of yellow cake

Flowsheet


EXTRACTION D'URANIUM
1 ère CYCLE
EXTRACTION D'URANIUM
2 ème CYCLE
Acide Phosphorique désulfaté non décanté 44,4 m³/h
refroidisseur
Cuve de désaturation (tps séjour 24 à 36 h)
Tonsil
Floculant
Cuve
Cuve
vers sludges atelier acide phosphorique
Filtré sous vide
pompe à vide
Séparateur
Filtre de polissage
H2O2
Cuve oxydation
42,3m³/h P2O5 31% U 0,013g/l
réduction
Fe
Extraction
Elution
Eluat 1er Cycle 700 l/h P2O5 31% U 11g/l
vers bac solvant
recyclage 1 cycle
Cuve de stockage 40 m³
Cuve de stockage H2O2 25 m³
Cuve oxydation 40 m³
Décanteur
H3PO4 désuranié 40 m³
Filtre presse
Eluat AUC 10 m³
acide oxidé et filtré 5 m³
carbonate de fer
Production HAU
Evaporateur 15 m³
vapeur
H A U 15 m³
filtrat H A U 10m³
Condenseur de vapeur
Condenseur de évaporateur
Eau de meuse
frigo
eau épurée
Extraction
Scrubbage
Elution
Régénération H2SO4
Lavage Solvant
Eau acidulée 5 m³
Eau epurée 5m³
(NH4)2CO3 10m³
Eau acidulé à purifier 40 m³
Solution 20%(NH4)2SO4 2m³
H2SO4 30 m³ 98%
3m³
préparation solvant
Solvant 10m³
CO2
NH3
Préparation (NH4)2CO3 10 m³
Récolte des eaux dégazage
Vers engrais

Pre-treatment of phosphoric acid

- Raw Phosphoric acid :
  - Is cooled and desaturated in agitated tank with suspended solids (up to 36 hours residential time)
  - Added with some adsorpting material (clay) to catch the organic matters
  - Added with flocculating material.
- Solids are separated by filtration or settling. Target : < 50 ppm solid
- Particular operations depending of acid quality

- Additional advantage : better quality of acid in downstream activities.

1st cycle of extraction

- Extraction and stripping made out of 3 or 4-stages battery of rectangular mixer-settler units
- For DEHPA/TOPO solvent : U^{+6} state for extraction and U^{+4} state for reductive stripping
- Use of scrap iron added to small flow of phosphoric strip acid to lower Redox potential = major factor for operation of the plant
- After extraction step and separation of solvent entrained, 1st raffinate (main flow of phosphoric acid) returns to the phosphoric acid production plant

2nd cycle of extraction

- Uranium oxidation : U^{+4} → U^{+6} before extraction
- Filtration to catch iron phosphate
- Scrubbing to avoid any P2O5 contamination in final YC
- Chemical reextraction : use ammonium carbonate solution to produce AUC
- Solvent acidification with sulfuric acid
- Solvent washing

Precipitation and conditioning

From AUC to yellow cake :

- Evaporation of AUC solution :
- AUC → CO_2g + NH_3g + HAU which precipitates
- Filtration
- Drying at 120℃

Site integration

Contemplated unit adjacent to existing plant of phosphoric acid plant

Constraints :

- 1st cycle close to storage = location or lay out problems
- Activity of extraction uranium can’t be no threat to objectives and/or long-lasting of phosphoric acid plant
- Industrial culture of supervisory and execution staff different to teach to the staff in charge of the new unit

Site integration

Contemplated unit adjacent to existing plant of phosphoric acid plant

Assets :

- Equipments allocated to pre-treatment section
- Quality of phosphoric acid greatly improved thanks to pre-treatment and to the removal of uranium
- Staff with very good knowlegde of phosphoric acid

Prayon's experience : new risks

- Any phosphoric acid producer who invests in a unit of uranium extraction has to aware of new risks to manage :
  - Radioactivity contamination
  - Workers irradiation
- New activity to be done under control of National Approved Organisation : respect of regulatory or legal measures
- From 1980 to 1998, Prayon's staff of 2nd cycle of extraction zone was fitted with personal dosimeter, monthly read and analysed by the National Approved Organisation.
- During 18 years of operation and supervision, Prayon never had to move a worker away, neither for body contamination nor for irradiation.

  To reach that result, it is essential to integrate the management of risk from the design to the implement of a strict organisation of work during the operation.

  The risks linked to the use of organic solvent have to be managed as well.

Prayon's experience : design

General conception of 2ne cycle extraction unit

1. **Keep control on all outgoing flows and particularly to avoid leak of uranium in environment** :

   - containment wall for storage tanks
   - sump that enables pumping of eventual leak

   - slightly oblique floor towards gutters for part of the plant where extraction take place

   - isolation and placement under slight depression for part of the section containing the yellow cake.

Prayon's experience : design

General conception of 2ne cycle extraction unit

2. **Keep all the working zones free of any contamination** :

   - wall and grounds made out or covered with non porous material

   - finishing works of civil engineering to avoid location difficult to clean or decontaminate

   - gutter covering with removable pieces made out of material resistant to acids and fuel and easily cleanable

   - Section fitted with decontamination post

Prayon's experience : design

General conception of 2ne cycle extraction unit

3. **Allow strict access control of this section** :

   - Access allowed from control room by security camera

   - Two locker-rooms : a green changing-room (for civil clothes) and a red changing-room (for working clothes and protection equipment)

     Between them :

     - One « humid » locker-room with showers
     - One « dry » locker-room to allowed access exit to potential visit and staff

     Both locker-rooms fitted with Geiger counter

Prayon's experience : Work Organisation

Work organization strictly limited to authorized people

- Operating teams composed of
  - A process operator (chemist-technician)
  - A maintenance operator (electromechanical technician) able to internally repair small devices
- Visits of external people strictly limited
- Visitor will wear dosimeter. Date, name of the visitor and number of dosimeter noted in a visit book. At the exit, visitors will be checked with Geiger counter

Prayon's experience : Decommissioning and decontamination

- If activity stopped, the site have to be decontaminated before dismantling and re-affectation of freed areas
- Decontamination is easier if principles followed during plant design phase
- Prayon had built its 2nd cycle of extraction in a 19th century building. Walls, 80 cm thick, were made up of extremely porous bricks => not a good choice.
- After the equipment decontamination by washing with sulphuric acid, decontamination required squaring 800 m^2 of walls. Each square was numbered and radioactivity had to be brought back to background level

  Locally, this required removal of 30 cm of the wall thickness to reach this level

PRAYON

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Thank you

for your attention !