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SO YOU HAVE FOUND A URANIUM DEPOSIT – NOW WHAT

By

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ABSTRACT

Uranium exists in a seemingly myriad of minerals (>150 known), further complicated by different valencies. While there may be one or two dominant species in a deposit, there are often a variety of minor minerals which need to be treated in order to achieve a high recovery. On top of this, uranium minerals occur in a wide variety of host rocks.

STEP ONE MUST BE TO carry out initial thorough and systematic geological and mineralogical studies and detailed chemical analyses of drill samples in order to classify the ore deposit versus other known types of deposits and Identify ore types within the deposit with potentially different metallurgical properties.

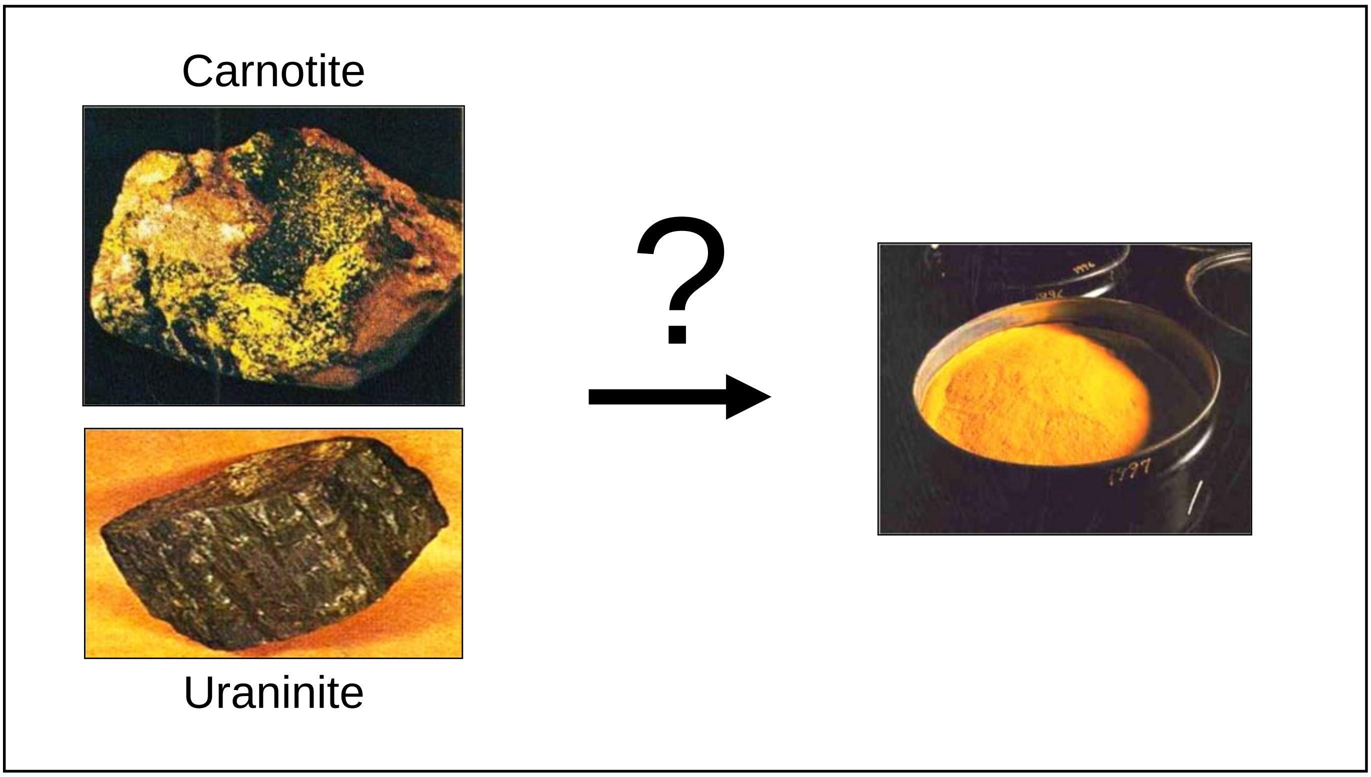
STEP TWO – SOMETIMES OVERLOOKED - IS TO benchmark the deposit against other past and present commercial operations and/or projects attaining feasibility study level for similar deposits to gain information on successful and unsuccessful geological interpretation, resource assessment, and mining and treatment methods.

THIS LAYS A SOUND FOUNDATION FOR STEP THREE which is undertake a THOROUGH Scoping Study covering ALL aspects of the project to make a decision whether to move on to a Prefeasibility Study (PFS), undertake further scoping level work, bring in a partner, sell the project, or walk away.

If proceeding with a PFS, the recommendations should specify the preferred or short listed mining methods and treatment processes, incorporate metallurgical and mineralogical input to the procedures for the drilling program and geological model, and prepare a project development plan, schedule and cost. Sometimes there are opportunities for by-products, such as vanadium, molybdenum, base metals, REEs which may add value.

Finally, the temptation to take short cuts <u>SHOULD BE AVOIDED AT ALL COSTS!</u>

Keywords: Uranium Deposits, Project Development, Process Selection, Scoping Study, Prefeasibility Study, Key Steps



- Uranium exists in a seemingly myriad of minerals (>150 known).
- Further complicated by different valencies.
- While there may be one or two dominant species in a deposit, there are often a variety of minor minerals which need to be treated in order to achieve a high recovery.
- On top of this, uranium minerals occur in a wide variety of host rocks.

So Step One must be to:

Carry out initial geological and mineralogical studies, and detailed chemical analyses of drill samples to:

- Classify the ore deposit versus other known types of deposits.
- Identify ore types within the deposit with potentially different metallurgical properties based on chemical and physical properties of gangue and uranium minerals.

Step Two – sometimes overlooked - is to:

Benchmark the deposit against other past and present commercial operations and/or projects attaining feasibility study level for similar deposits to:

- Gain information on successful and unsuccessful geological interpretation, resource assessment, mining and treatment methods, metallurgical testwork and scale-up strategies, climatic effects, logistical, political and social issues, and performance data.

- Activities can include site visits, searching for available reports and published papers, and talking to personnel and consultants involved.

This lays a sound foundation for Step Three:

Undertake a THOROUGH Scoping Study covering ALL aspects of the project including:

- Initial resource tonnage and grade estimates at various cut-offs.
- Identification of potential ore types.
- Development of conceptual mining strategy and costs.
- Identification of most likely treatment methods.

- Identification of potential impurity problems and/or by-product opportunities.
- Assessment of ore upgrading potential.
- Development of conceptual flowsheets.
- Development of preliminary strategies for disposal of waste, residue, tailings or solution bleed streams.

- Identification and preliminary assessment of potential water sources.
- Preliminary testwork for most likely processes based on mineralogy, grade and benchmarking.
- Conceptual flowsheet, key equipment sizing, conceptual layout.
- Preliminary assessment of logistics and infrastructure.
- Preparation of order-of-magnitude capex and opex.

- Identification of possible climatic, environmental, social and political issues.
- Preliminary marketing study.
- Preliminary economic and risk analysis covering all aspects of the project.
- Selection of preferred or short listed mining methods and treatment processes.

Then make a decision whether to:

- Move on to a Prefeasibility Study (PFS).
- Undertake further scoping level work.
- Bring in a partner.
- Sell the project.
- Walk away.

Factors influencing decision include:

- Marginal economics due to refractory ore, low grade or insufficient ore reserves.
- Lack of funding.
- Lack of reliable water supply
- Major environmental issues.
- Remote location and/or difficult logistics.
- High risk social and/or political issues.

If proceeding with a PFS:

- Specify preferred or short listed mining methods and treatment processes for the PFS.
- Incorporate metallurgical and mineralogical input to procedures for drilling program and geological model.
- Prepare project development plan, schedule and cost.

Factors to consider when selecting possible treatment routes include:

- Basic processes are virtually unchanged from the previous uranium boom in 50s – 80s.
- Various process steps and equipment were “borrowed” from the initial uranium flowsheets and further developed in the treatment of copper, gold and nickel-cobalt ores. These developments can now be transferred back into the new wave of uranium operations.
- There are also some new innovations which can be considered.

Also…

- Current deposits are typically lower grade and/or more mineralogically complex. (except of course the very high grade Canadian deposits).
- Environmental and decommissioning regulations are generally more stringent.
- On the positive side – Uranium price is higher.

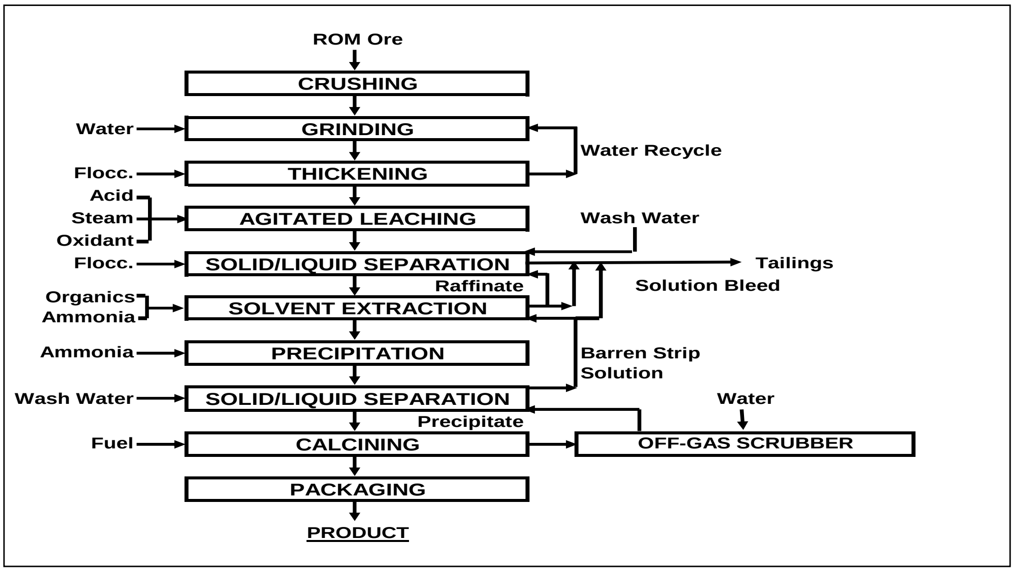
Basic processes are:

- Agitated leaching with sulphuric acid solution at atmospheric pressure and low to medium temperature.
- Agitated leaching with sodium carbonate-bicarbonate solution at atmospheric pressure and medium to high temperature.
- In-situ leaching with sulphuric acid or bicarbonate solution.

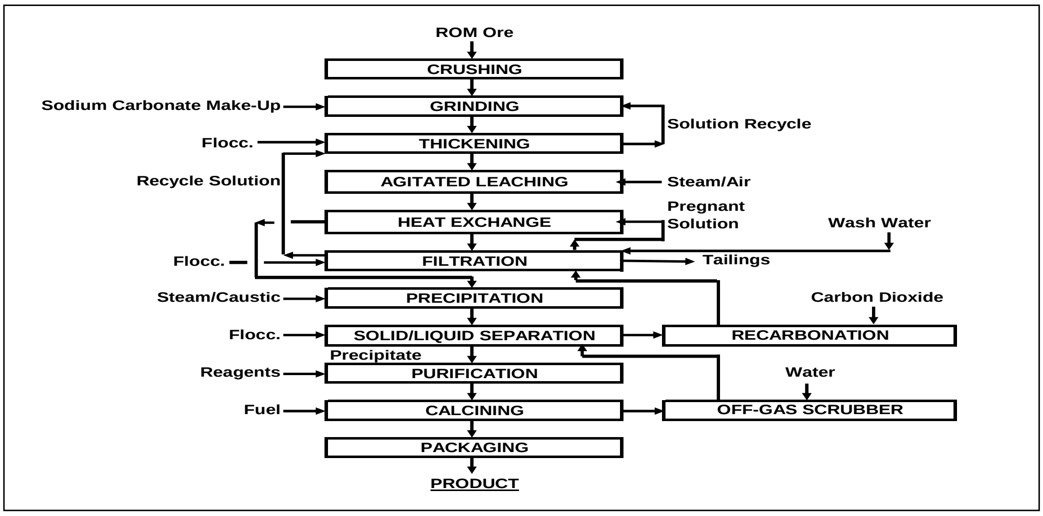
And…

- Strong acid pugging and curing.
- Pressure leaching with sulphuric acid or bicarbonate solution.
- Heap leaching with sulphuric acid or bicarbonate solution.
- Vat leaching with sulphuric acid solution.

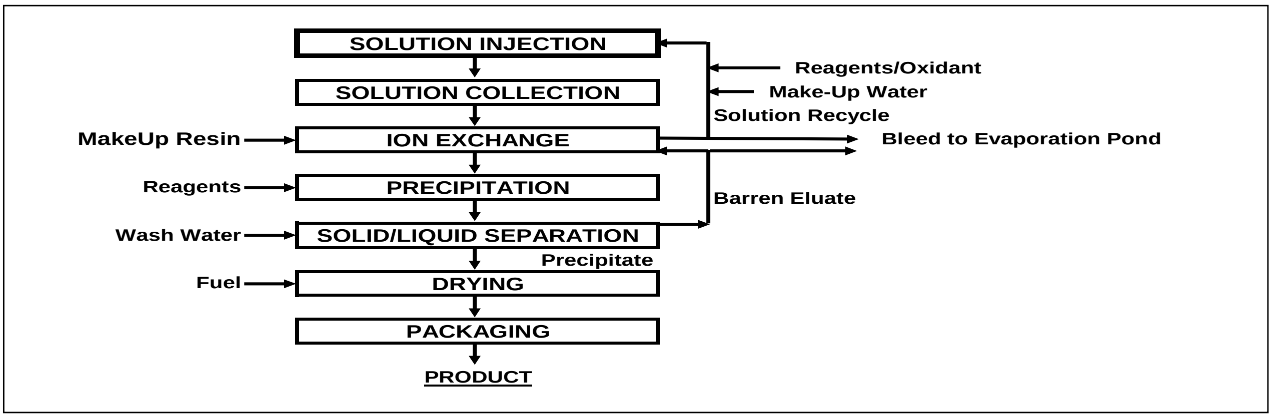
Agitated Atmospheric Acid Leach Flowsheet



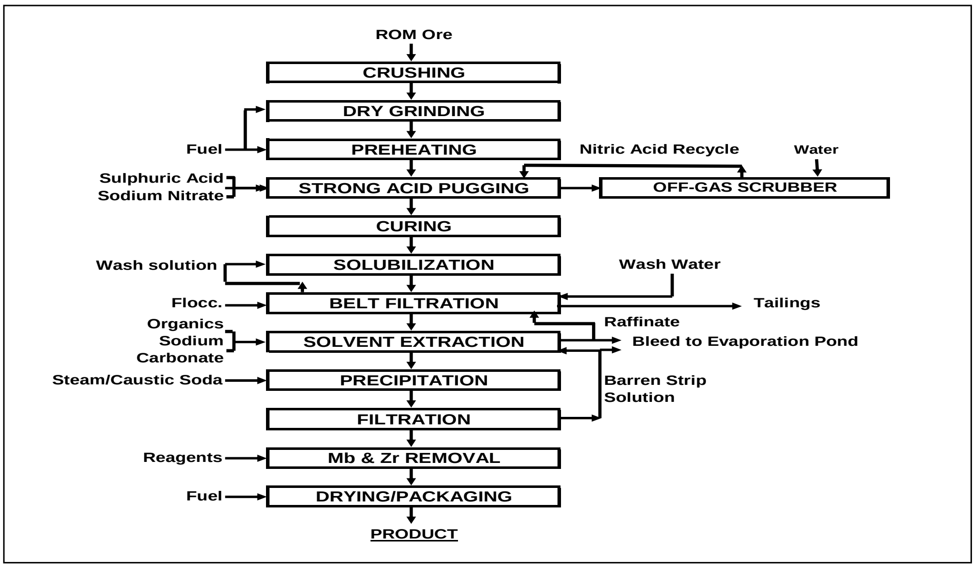
Agitated Atmospheric Carbonate Leach Flowsheet



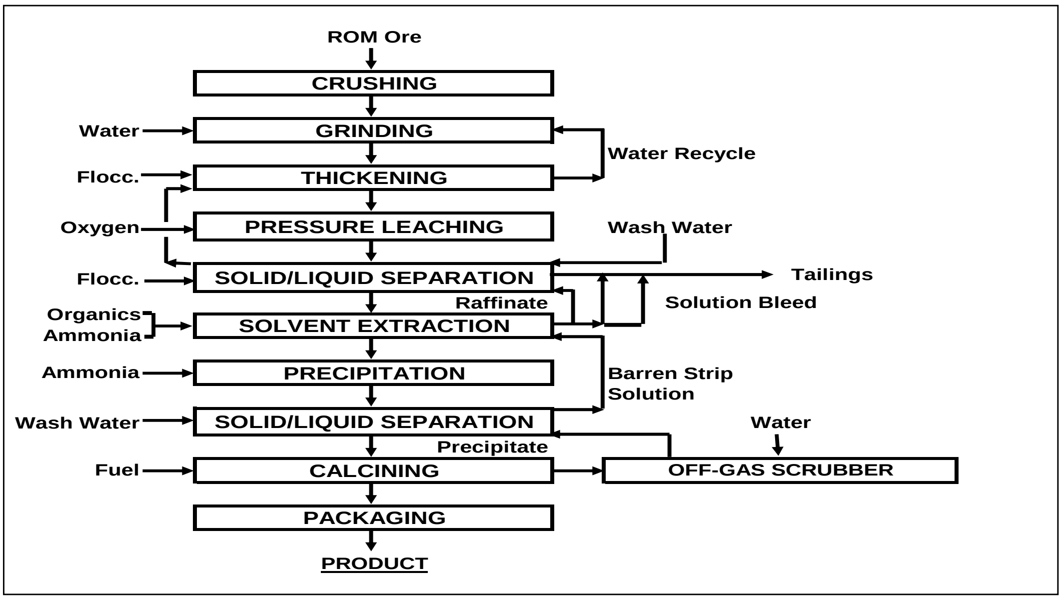
In-Situ Leaching Flowsheet



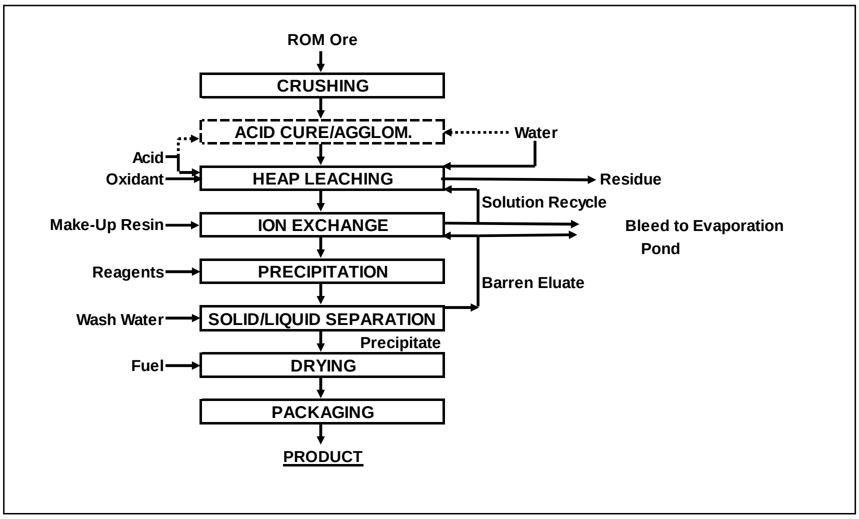
Strong Acid Pugging Flowsheet (Somair, Niger)



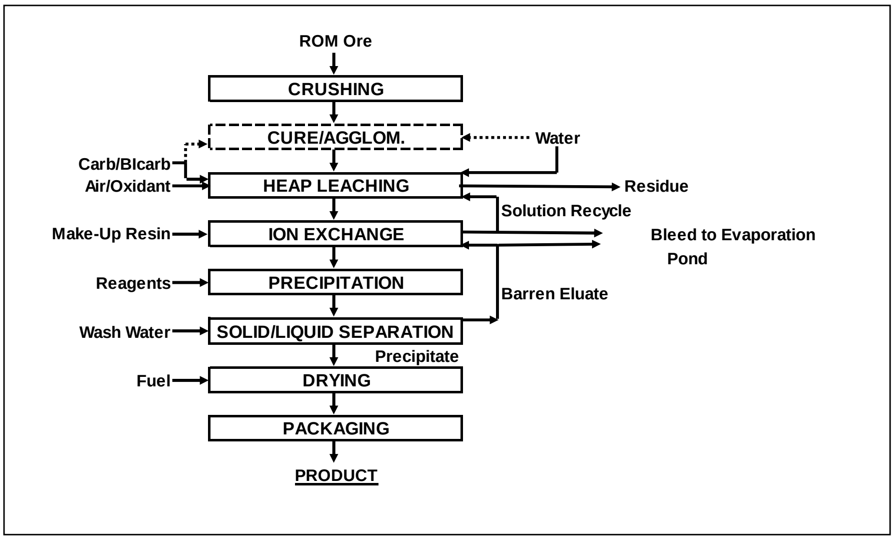
Pressure Acid Leach Flowsheet



Typical Uranium Acid Heap Leaching Flowsheet



Typical Uranium Carbonate Heap Leaching Flowsheet



Pre-concentration or pre-treatment can sometimes be used, including:

Radiometric Ore Sorting to:

- Increase grade and possibly reduce acid consumers.

Flotation to:

- Produce sulphide concentrate for leaching.
- Reject sulphides prior to carbonate leach to avoid high carbonate consumption.
- Produce sulphide conc. to reject acid consuming carbonate gangue minerals.
- Reject consumers in a flotation concentrate.

Sizing for:

- Sand/slime separation with rejection or separate leaching of sands.
- Attrition grinding followed by classification, with screens or cyclones
- Dry grinding and air classification.

Magnetic Separation for:

- Dry beneficiation for arid regions.

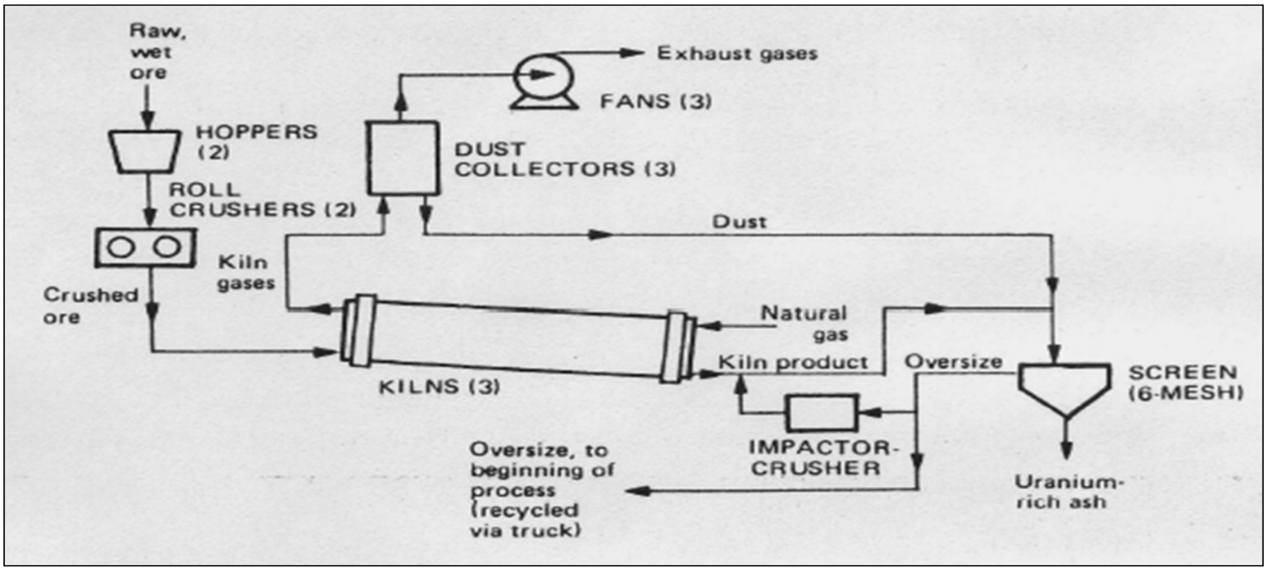
Gravity Separation to:

- Make sand/slime split to produce a sand reject.
- To produce HG uranium conc. With separate treatment of tails.
- To scavenge base metal float tails.
- Methods used include jigs, spirals, Reichert cones, tables, and heavy media,

Pre-roasting sometimes used including:

- Salt roasting with sodium chloride to improve recovery of vanadium from carnotite ores.
- Oxidizing roast to improve uranium recovery from tetravalent minerals.
- For clayey ore to improve solid-liquid separation characteristics after leaching (utilized before availability of effective flocculants).
- To remove troublesome carbonaceous materials.
- To pre-treat uraniferous lignites to produce U rich ash for further treatment.

Lignite Calcination Flowsheet



Warning: Leaching testwork must
be carried out with upgraded or pre-treated ore

not always easy!!!

Sometimes there are opportunities for by-products, such as:

- Vanadium
- Molybdenum
- Base metals
- REEs

A starting point for recovery can be gained from benchmarking against previous operations.

Finally,

the temptation to take short cuts should be avoided at all costs!