Ablation

Background on the Development of Technology for the Conventional Mining Industry

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PRESENTATION TO U.S. NUCLEAR REGULATORY COMMISSION STAFF

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Discussion Overview

Our goal today is to answer the following questions

- What is Ablation?
- How does Ablation work?
- What does an Ablation system look like?
- Which uranium deposits are amenable to Ablation?
- What happens when uranium deposits are Ablated?
- What are the benefits of Ablation?

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What is Ablation?

- Ablation is a rapid hydro-mechanical method of disassociating the components of a mineralized material from each other.
- Ablation is a purely mechanical process:
  - No physical changes to the ore;
  - No chemicals are added.
- Ablation is environmentally friendly.
  - Ablation uses only water with the material being ablated - no reagents are added.
  - As a result, there is no chemical change to the materials being ablated.

How and Why Does Ablation Work?

To understand how and why Ablation works, it is necessary to understand:

- The principle that makes Ablation possible.
- The goal of Ablation.
- How Ablation exploits this principle to accomplish its goal.

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The Physical Principle that Makes Ablation Possible

- The principle underlying Ablation is that the bond strength between the discrete fractions in almost all composite materials are weaker than the internal strength of each fraction.
- In sandstone hosted ores, where mineralization forms a crust on individual grains, bonds between the mineralized crust and the underlying grains in the sandstone are weaker than the internal strength of the sand grains themselves.

The Goal of Ablation

- The goal of Ablation is to mechanically disassociate the mineralized uranium-bearing crust from the pre-mineralized, underlying grains in the host sandstone.
- By doing this, any fraction can be separated from the other fractions based on each fraction's unique physical properties.
- Ablation makes it possible to mechanically separate the mineralized crust from the pre-mineralized grains in sandstone hosted deposits.

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How Ablation Achieves this Goal

- The material to be Ablated is mixed with water creating a slurry.
- This slurry is pumped through opposing injection nozzles.
- These nozzles create accelerated jets of the slurry that collide with each other creating a high energy impact zone.
- The energy generated by particle to particle collisions in this impact zone disassociate various fractions from each other.
- This leaves a post-impact slurry stream that contains the disassociated fractions.

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The Physics of the Particle Collisions

Looking at a particle collision in detail shows how Ablation is a strictly mechanical process.

- Contact
  - Individual particles, sandstone grains with a mineralized crust, contact each other.
- Compression/Distortion
  - The particles distort, compressing slightly due to the energy of the collision. This fractures the mineralized crust and momentarily distorts the underlying grain.
- Rebound
  - As the energy in the collision is consumed, the particles rebound. This spalls off the fractured mineral crust, leaving the grain intact. This results in a mineralized crust that is disassociated from the underlying, intact grain.

Muddy Tennis Ball Analogy

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Post Collision Slurry Stream

Important characteristics of the post collision slurry stream.

- Chemically identical to the material introduced into the Ablation system, either to the water or the solids.
- Mineralogy is identical to the pre-Ablated slurry.
- Elementally identical to the pre-Ablated slurry.
- The only difference is that the mineralized crust is separated from the underlying grain.

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What Does the Ablation System Look Like?

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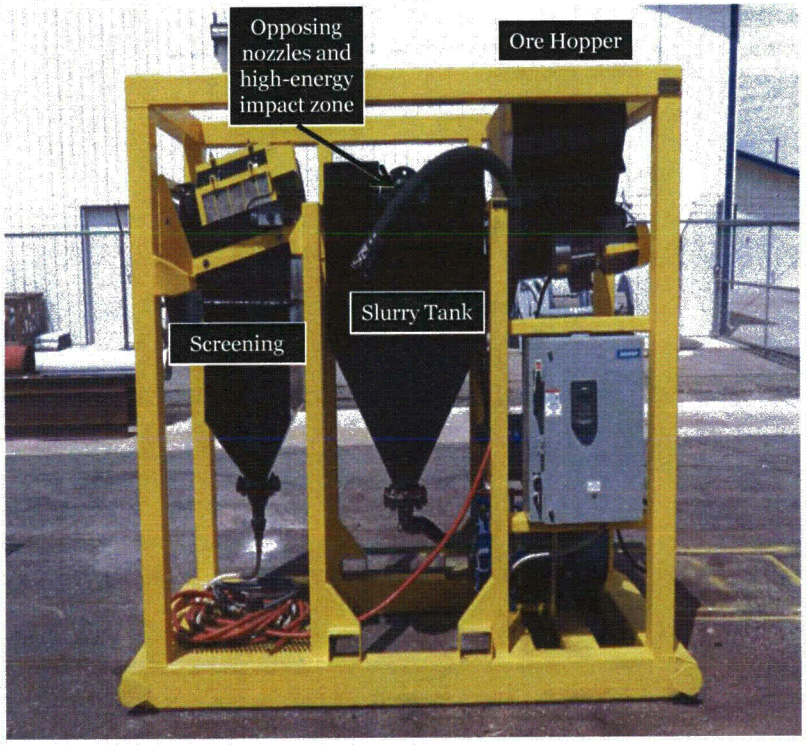
The Ablation System

The Ablation system consists of three primary components:

1. Mixing
   - In this section of the system, the material to be Ablated is mixed with water to form a slurry which is continuously fed into the Ablator.
2. Ablator
   - This is the portion of the system where Ablation occurs.
3. Separation
   - This is the portion of the system where conventional mining equipment, such as screening, can be used to isolate mineralized material (ore) from pre-mineralized host rock.

Bench Scale Test Ablation System



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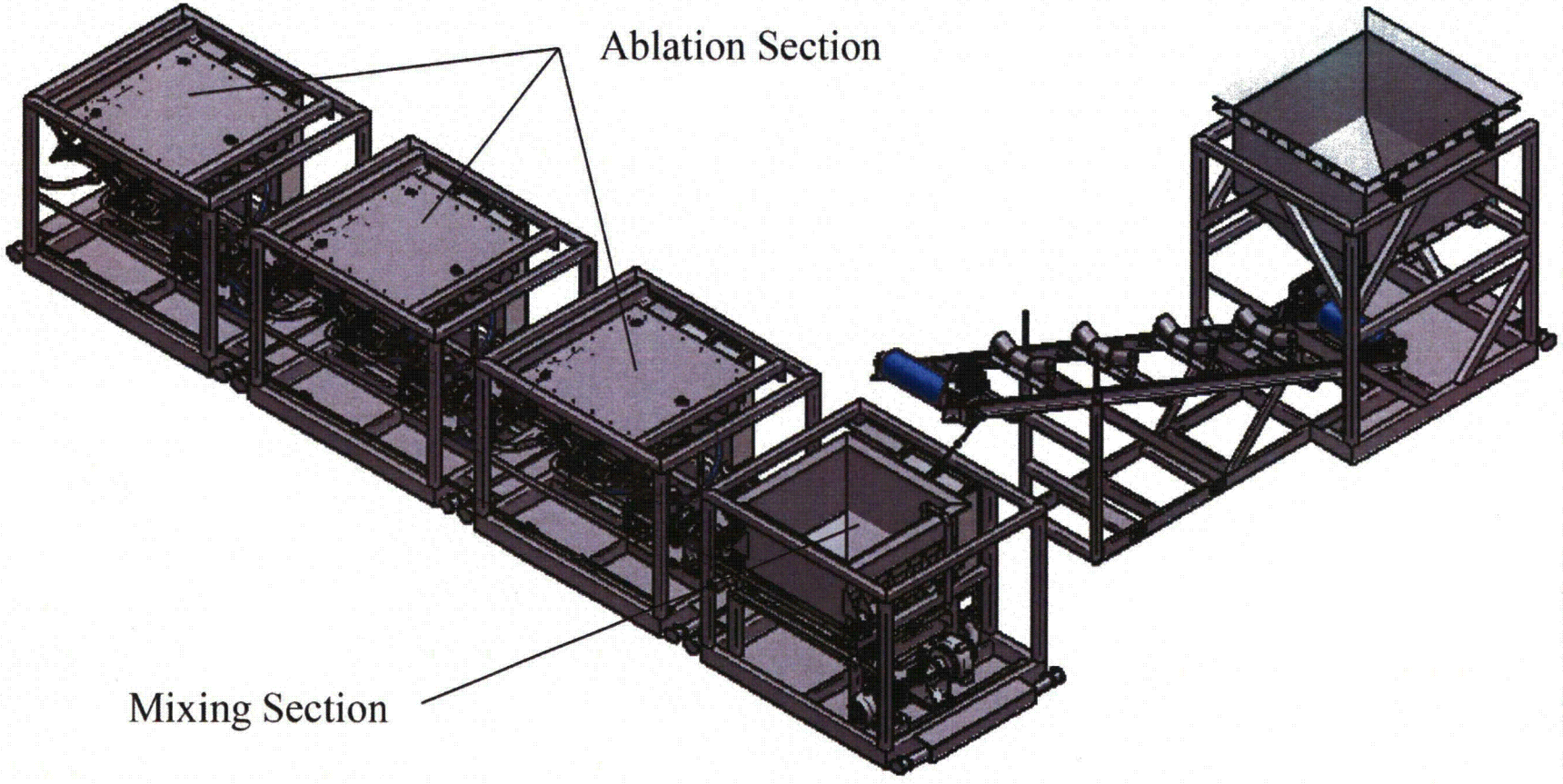
Pilot Scale System – 5 to 20 tph



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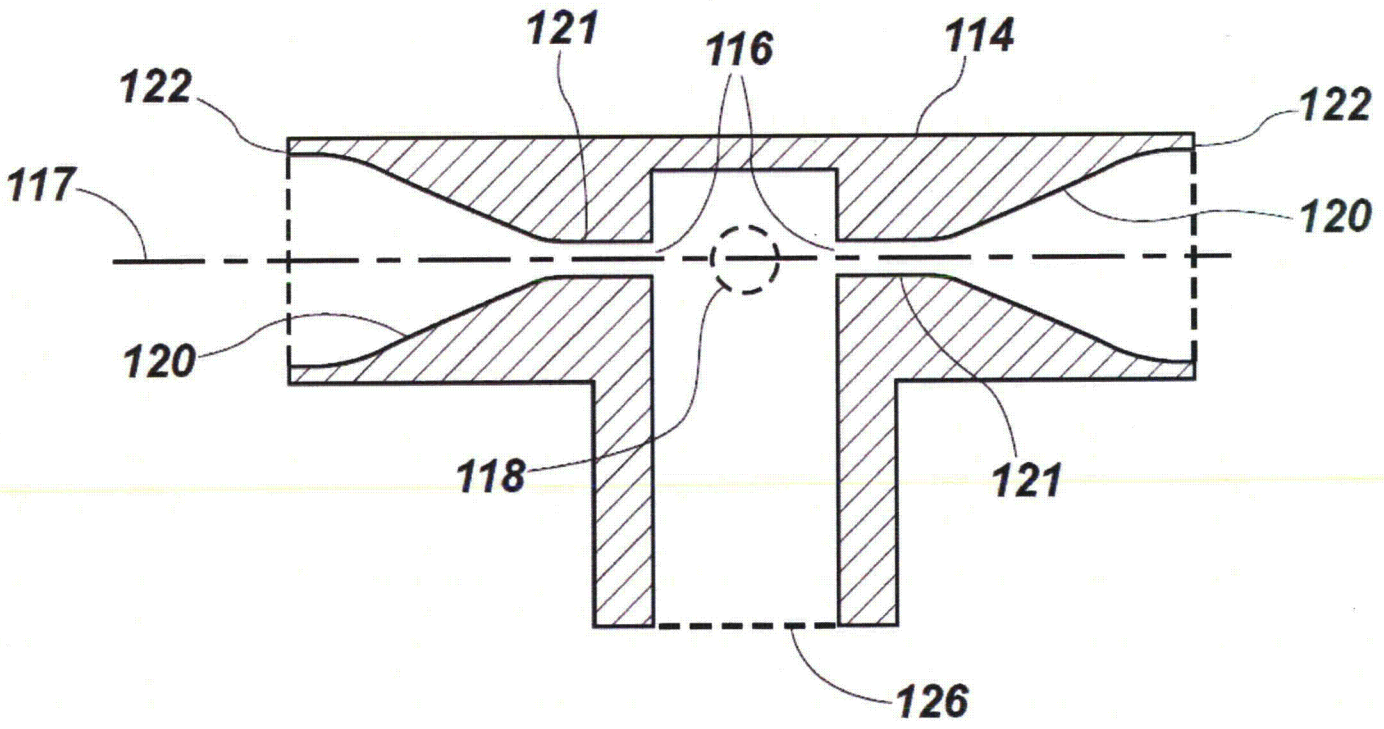
Nozzle Cut-Away



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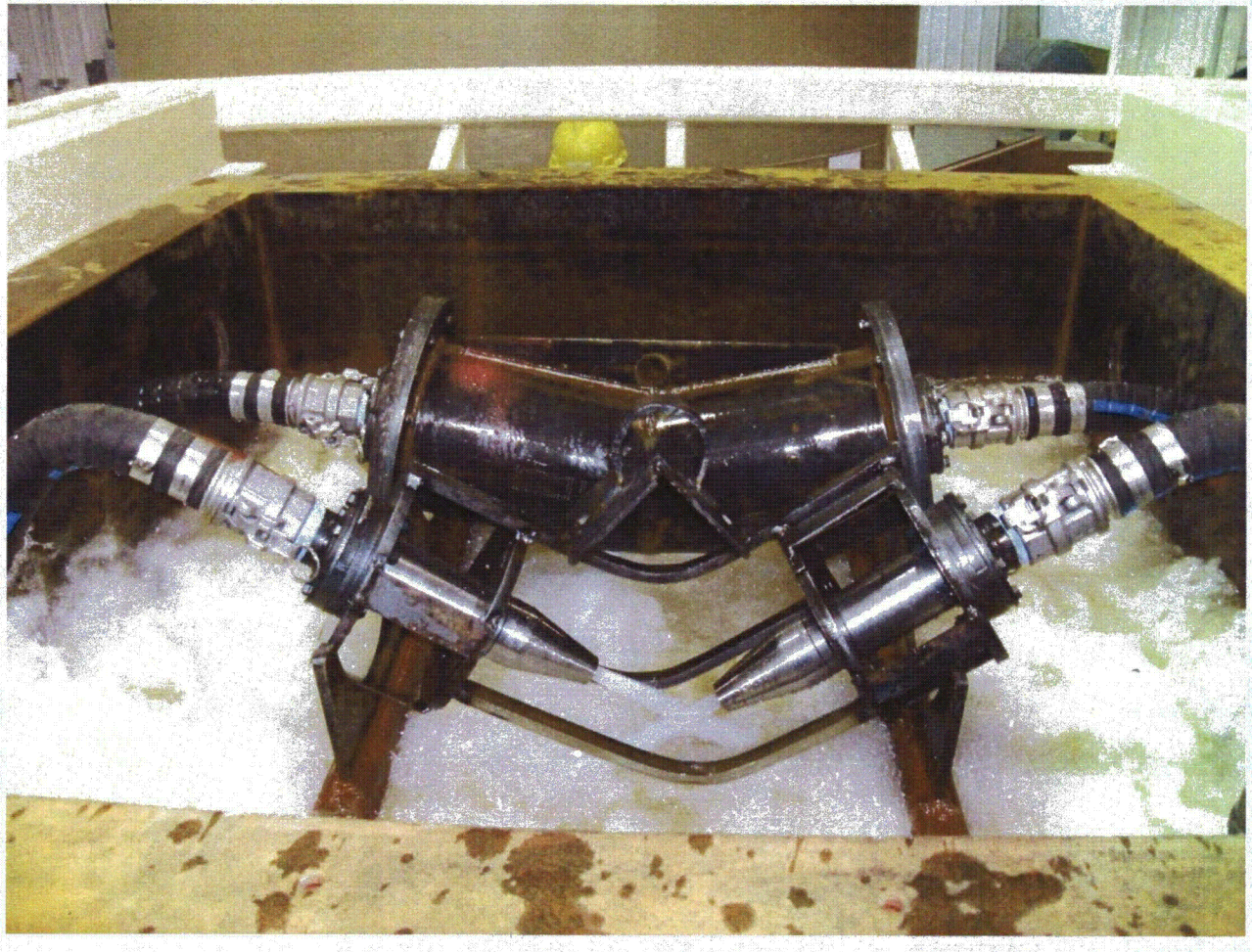
Open Nozzle to Show Accelerated Slurry Streams



3 - Separation

- Separation is the section of the system where conventional "off the shelf" mining equipment can be used to recover the mineralized fraction (ore).
- Equipment is selected based on physical characteristics of the ore fraction to be separated from the pre-mineralized host rock, such as density, magnetic susceptibility or size.
- Examples: vibratory screens, cyclones, density concentrator.

Uranium Geology

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WHY ARE SANDSTONE HOSTED URANIUM DEPOSITS AMENABLE TO ABLATION?

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Uranium Geology

To understand why sandstone-hosted uranium deposits are amenable to Ablation, we need to consider two factors.

1. How these deposits were formed.
2. Formation permeability on a large and small scale.

Uranium Deposition Sequence

Fluid Migration

Uranium bearing solutions migrate through permeable subsurface channels into the host rock formation

Deposition

Uranium bearing solutions reach a reduction zone, typically created by the presence of carbon in the formation. This difference in the geochemistry of the formation often causes minerals to precipitate out of solution.

Deposit formation

Uranium and other minerals precipitate out of solution forming a crust on the individual grains of the pre-mineralized sandstone host rock.

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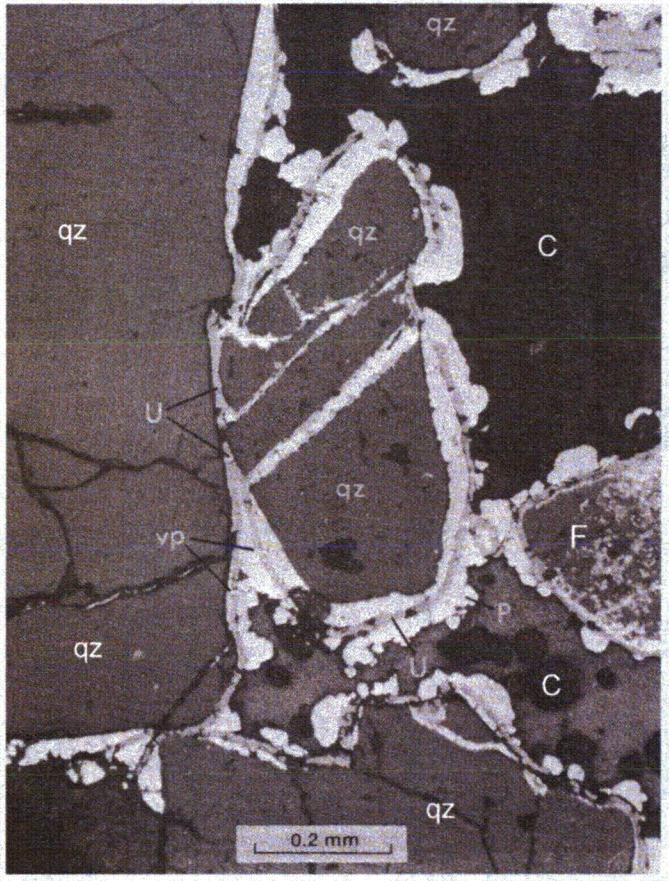
Photomicrograph of Uranium in Sandstone Formation



Id	Mineral
qz	quartz
U	uraninite
P	pyrite-marcasite
vp	veinlet pyrite-marcasite
C	calcite
F	feldspar

White areas indicate epigentic mineralization

Harshman, E. N. *Geology and Uranium Deposits, Shirley Basin Area, Wyoming*

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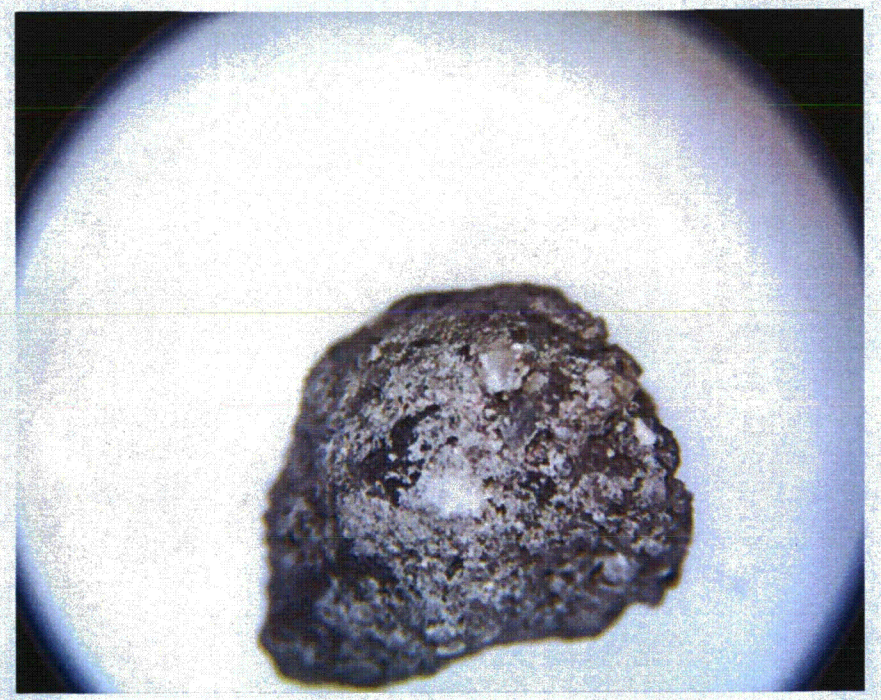
What Happens in Detail

- During Ablation, collisions in the impact zone disassociate the mineralized crust from the pre-mineralized host sand grains, which remain intact.
- Because the crust is actually a collection of very fine individual minerals grains, once separated from the host grain, this mineralized crust has nothing to keep the individual mineral grains together so they separate into their individual mineral grains, each typically smaller than 400 mesh.
- Because only water is used, nothing is taken into solution (i.e., no physical or chemical changes to the ore).

Comparison of Grain With and Without Crust

Pre Ablation



Post Ablation

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Pre and Post Ablation

Pre Ablation

Post Ablation

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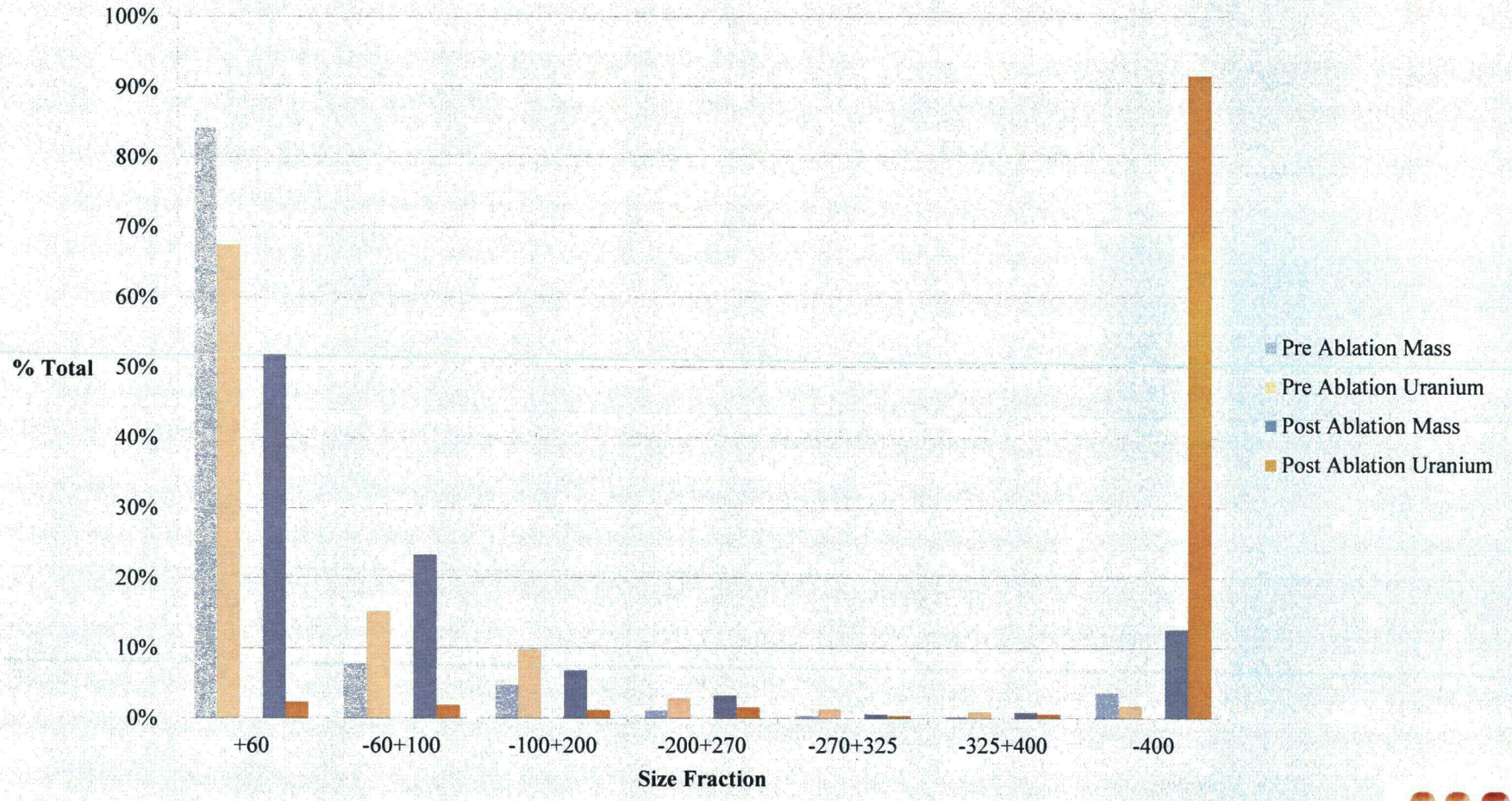
What Does this Do?

The key effect of Ablation on uranium deposits can be understood by looking at the mass and uranium distribution of a typical sandstone hosted deposit pre- and post-Ablation.

Typical Mass Distribution – Pre- & Post-Ablation



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Benefits of Ablation

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Benefits of Ablation - 1

- Mechanical, not chemical separation.
  - Ablation makes it possible to separate (high-grade) particular fractions of rocks mechanically rather than chemically.
  - Ablation does not alter the physical or chemical nature of the ore.
  - Achieves higher recoveries than leach mining.
  - As a mechanical separation method, it has low operating costs.

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Benefits of Ablation - 2

- Environmentally beneficial
  - Water only technology
  - No reagents are introduced into the system
    - Significantly reduced environmental impacts and remediation requirements.
  - Not uranium-specific

    Can remove the heavy metals along with the uranium.

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Benefits of Ablation - 3

- Site Disturbance
  - Because only a small fraction of the mineralized sandstone has to be milled, this material can be milled offsite, potentially eliminating the need for a mill at the mine.
  - Mills can be smaller, as considerably less material needs to be added into leach tanks.
  - Smaller tailings impoundments are required at the mill sites.
- Time
  - Ablation is a rapid recovery technology. Typically, it can be done in minutes.

Benefits of Ablation - 4

- Waste Reduction
  - Reduces low grade waste rock and protore piles at the mine site.
  - Since the ore volume is reduced, this significantly reduces the amount of 11e(2) material at the mill site and consequently reduces the size of tailings facilities.

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Benefits of Ablation - 5

Transportation - With Ablation, only about 10% of the mined material has to be transported to an offsite mill or other facility. This results in significant transportation related benefits.

- Reduced traffic, road impact, costs, and fuel usage by approximately 90%.
- Makes it possible to transport ore to offsite milling facilities, eliminating the need for onsite mills in most cases.

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Summary Conclusion

- Ablation is a mechanical way to separate mineralization from host rock in sandstone hosted formations.
- Ablation is an environmentally beneficial approach to uranium mining.
- Ablation is a best practices approach to uranium mining.
  - Higher recoveries than conventional uranium mining without Ablation.
  - Lower cost.
  - Environmentally friendly.

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