Sulfur Polymer Stabilization/Solidification of Elemental Hg and Hg Contaminated Soil,Sludge and Debris

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Presented at
Breaking the Mercury Cycle: Long Term Management of Surplus & Recycled Mercury & Mercury-Bearing Waste
Boston, May 1 –3, 2002

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Overview

- *Background*
- *Technology Description*
- *Technology Status*
- *Applications/Treatability Studies*
- *Summary/Conclusions*

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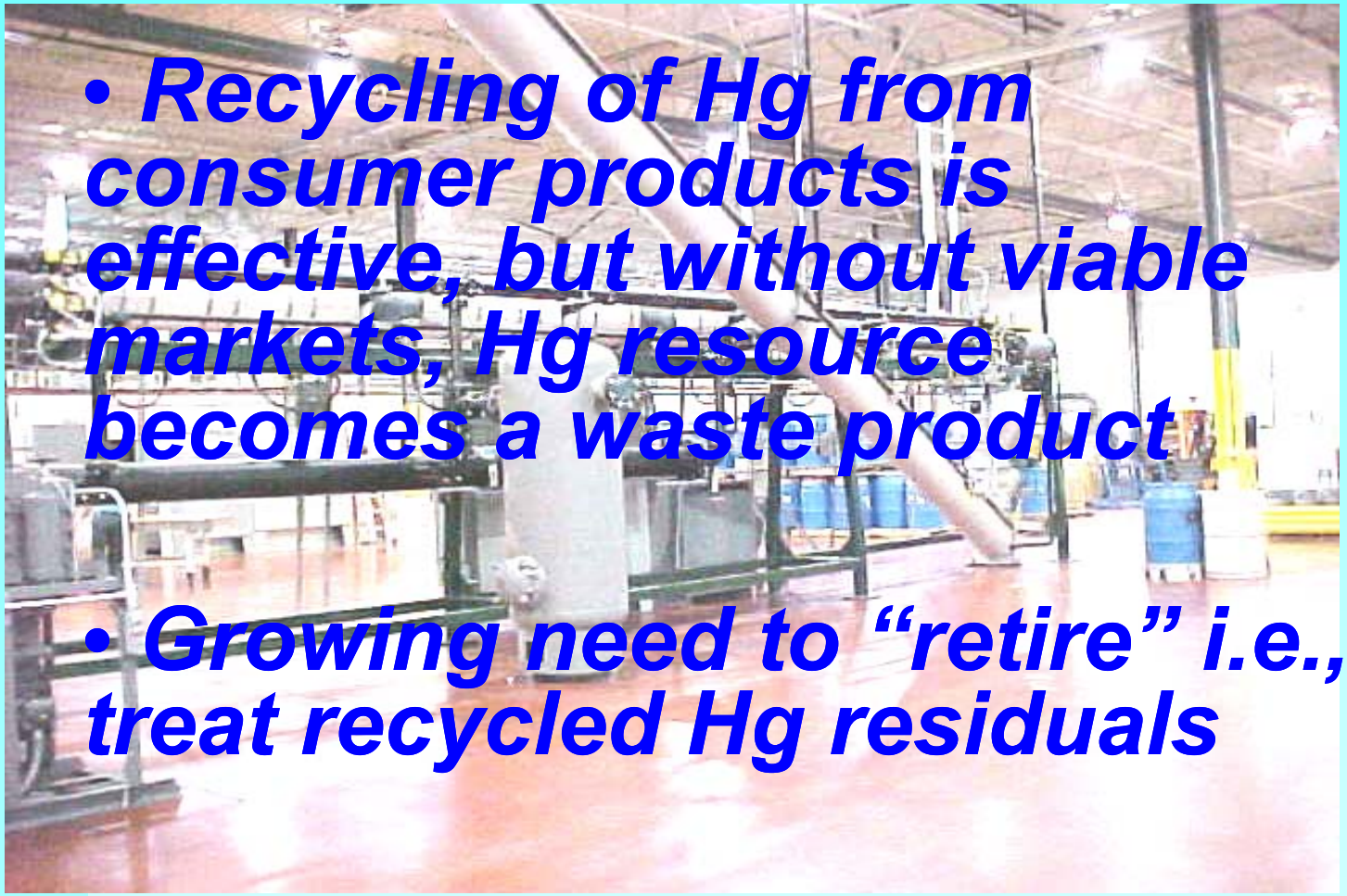
Background

- *Elemental Hg and Hg contaminated wastes are found at most DOE facilities*
- *Hg is highly toxic, readily leachable and has high vapor pressure*
- *Conventional techniques (amalgamation):*
  - *Reduce Hg solubility but result in highly dispersible powders*
  - *Do not reduce mercury vapor pressure*
  - *Do not chemically or physically immobilize radionuclides*

Understanding the Problem



- *Recycling of Hg from consumer products is effective, but without viable markets, Hg resource becomes a waste product*
- *Growing need to "retire" i.e., treat recycled Hg residuals*

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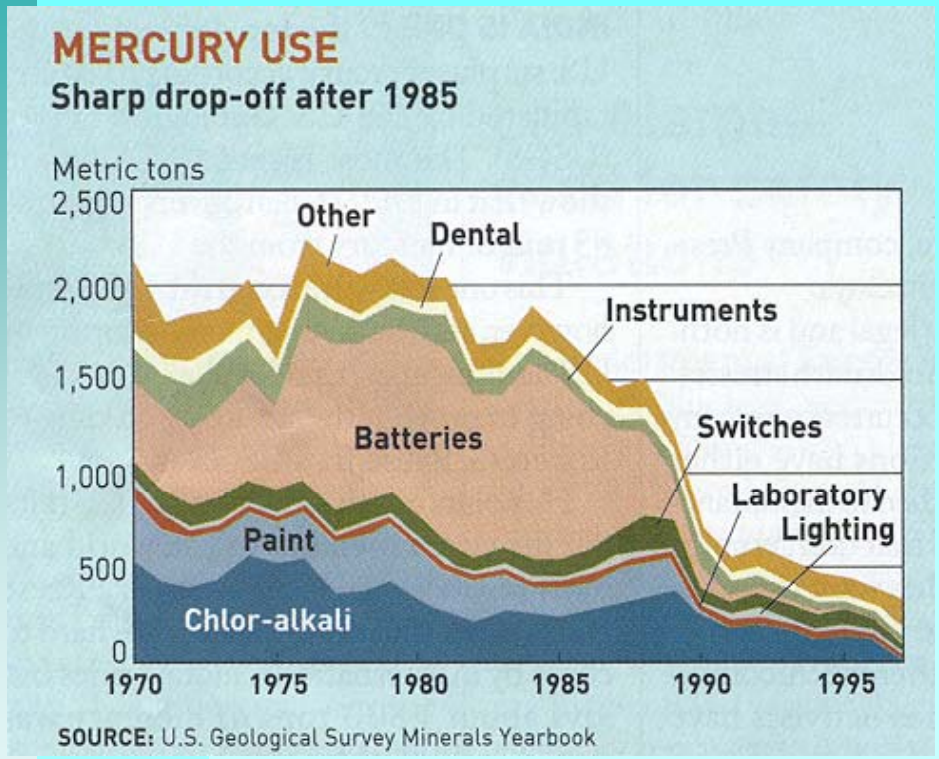
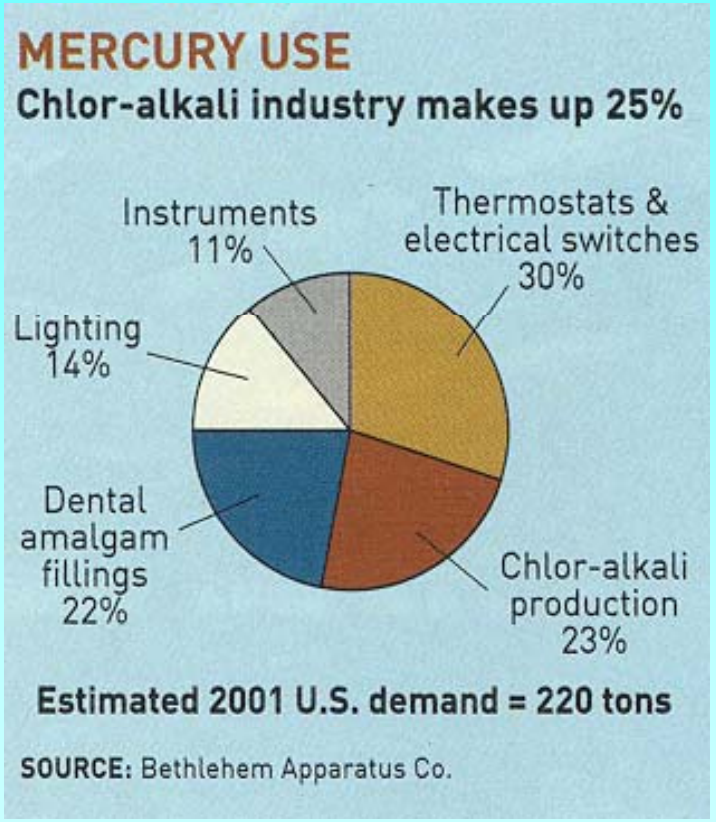
Declining Hg Market





Industrial use has declined 250% in 20 years, sharply reducing the demand for recycle Hg

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Understanding the Problem

Even greater volumes of Hg have contaminated soil, air and water or are being stored pending treatment

- ***9 million lbs of Hg stockpiled by DOD***
- ***5 million lbs from obsolete chlor-alkali plants***
- ***>50,000 yd^3 Hg contaminated soil at Oak Ridge National Laboratory***
- ***>7000 yd^3 soil at BNL Chemical Holes***

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Regulatory Requirements

Hg Category	Radioactive	Non-Radioactive	Leaching Std.
Elemental	AMALGM	NO TREATMENT STD (recycle only)	Not required
< 260 ppm	STABIL	STABIL	UTS limit 25 ppb
> 260 ppm	RMERC/ AMALG	RMERC	TCLP limit 200 ppb (soil)
> 260 ppm (w organics)	IMERC/ AMALG	IMERC	TCLP limit 200 ppb (ash)

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Technology Description

- *SPSS developed at BNL to provide improved, cost-effective treatment of Hg wastes*
- *Based on patented BNL Sulfur Polymer Microencapsulation technology for treatment of a variety of hazardous, radioactive, and mixed wastes*
- *Meets NRC criteria for long-term performance of low-level radioactive waste*
  - *Mechanical integrity*
  - *Long-term leachability*
  - *Biostability*
  - *Thermal stability*
  - *Radiation stability*

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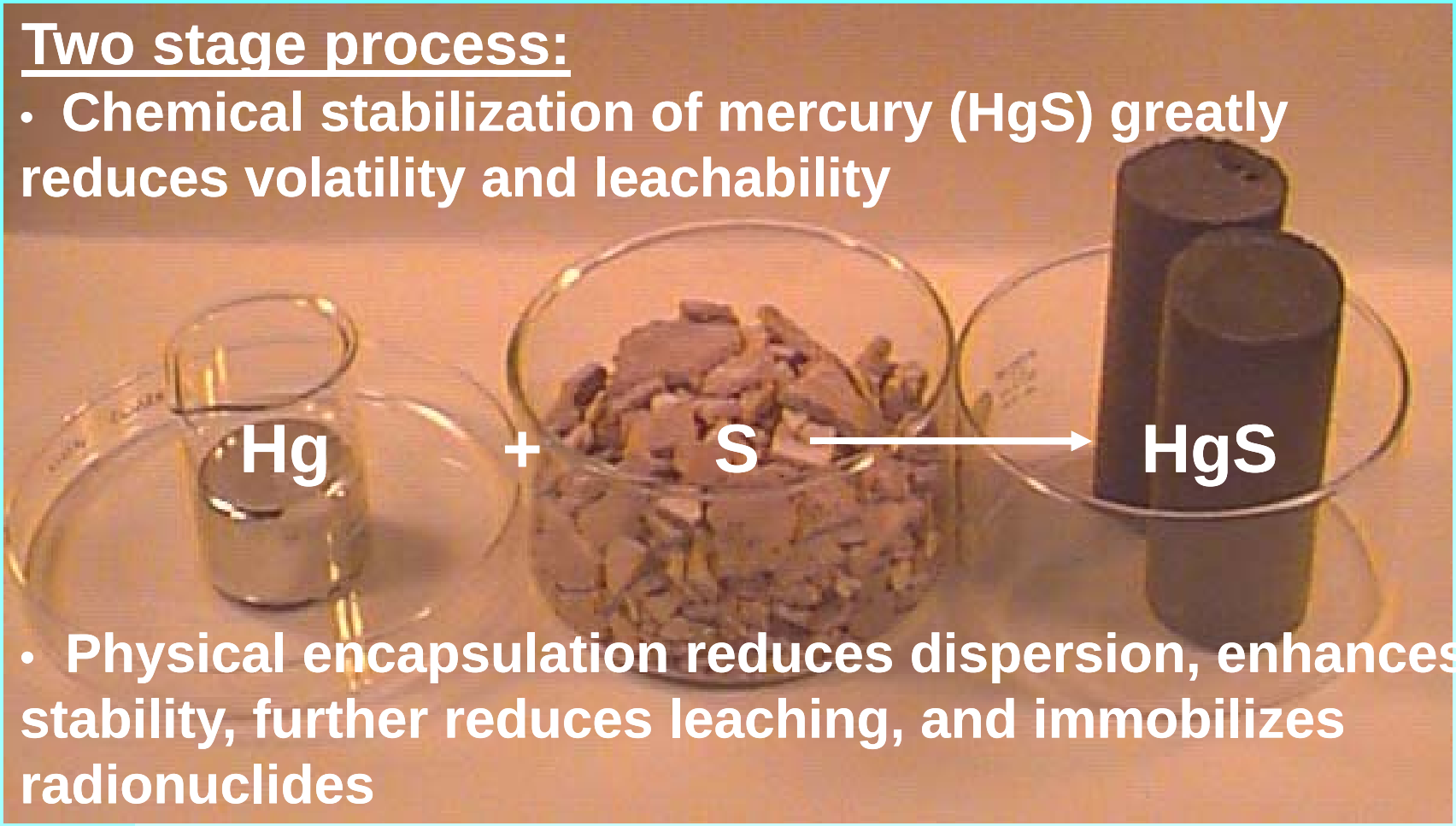
Stabilization/Solidification of Mercury



Two stage process:

- **Chemical stabilization of mercury (HgS) greatly reduces volatility and leachability**

Hg + S → HgS

- **Physical encapsulation reduces dispersion, enhances stability, further reduces leaching, and immobilizes radionuclides**

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Sulfur Polymer

- *Sulfur Polymer Cement (SPC) was developed by the USBM as a low-cost alternative construction material (approx. $0.12/lb)*
- *Produced from by-product, waste sulfur*
- *Contains 95% elemental sulfur, 5% organic modifiers to enhance stability*
- *Low-temperature, low viscosity thermoplastic process results in high waste loadings*
- *BNL adapted SPC for radioactive and mixed waste microencapsulation. U.S. Patent issued in 11/97*

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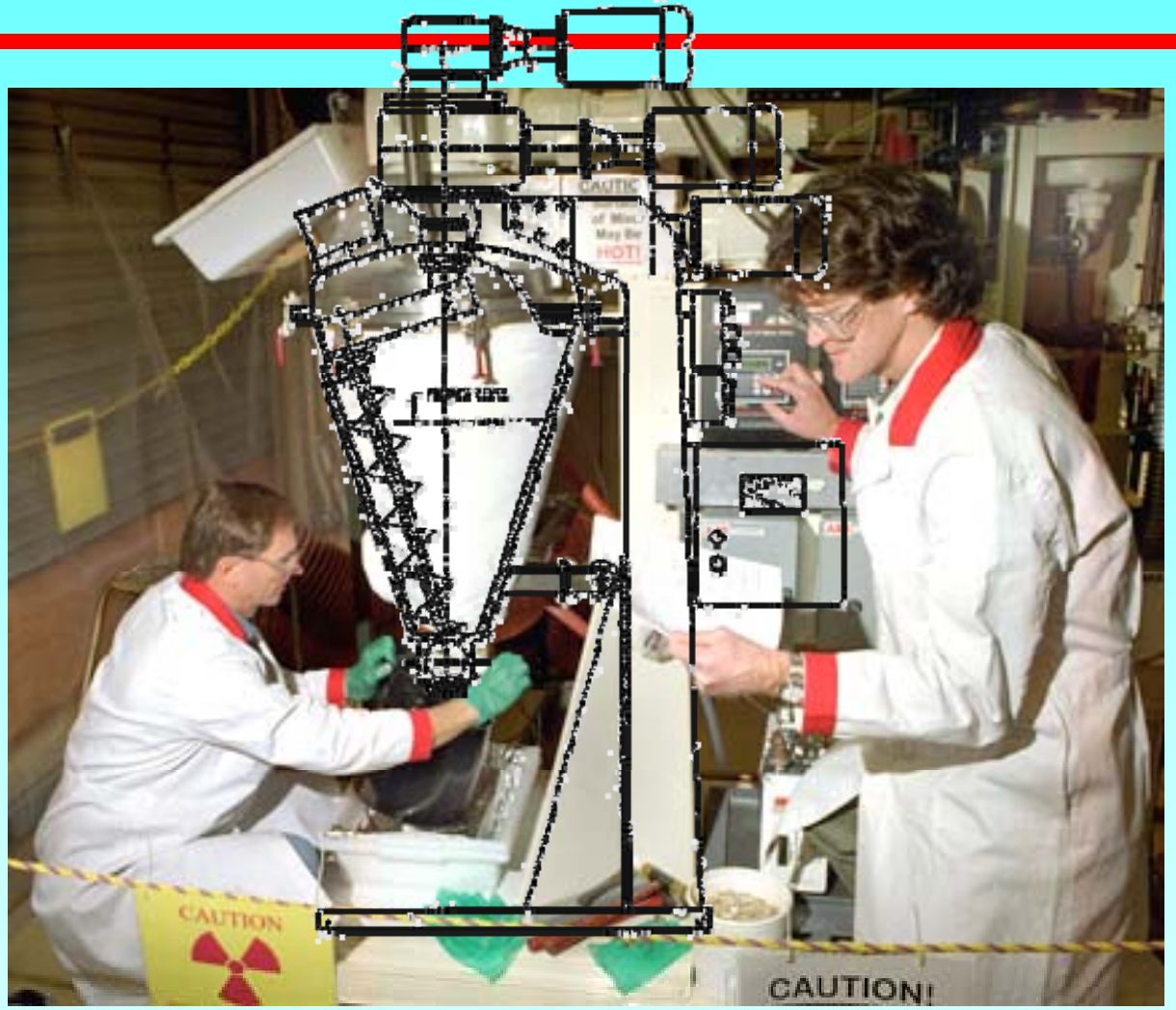
BNL Pilot-Scale SPSS Process



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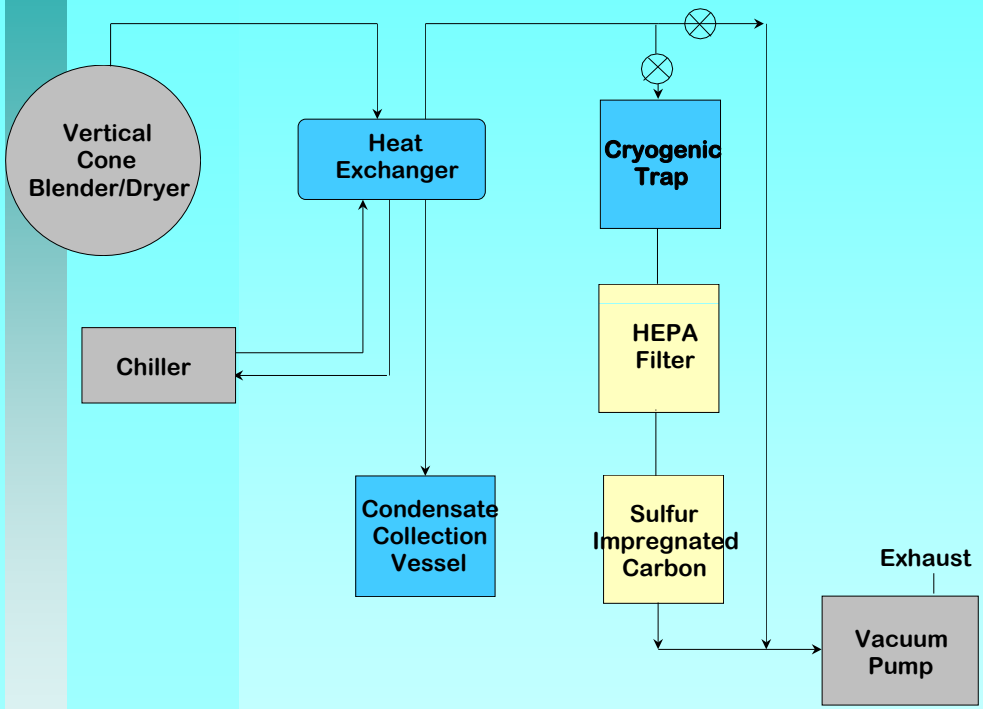
Pilot-Scale Off Gas System



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Mass Balance: Hg Capture Efficiency

Off Gas Component	Hg, g Drum E-1	Hg, g Drum A-4	Total Hg, g
Chiller Trap	1.442	2.791	4.233
Cryogenic Trap	0.504	0.229	0.733
Total Condensate	1.943	3.02	4.966
Carbon Trap			0.089
Total Hg in Off Gas			5.055
% Hg Trapped			**0.33**
Capture Efficiency			**99.67 %**

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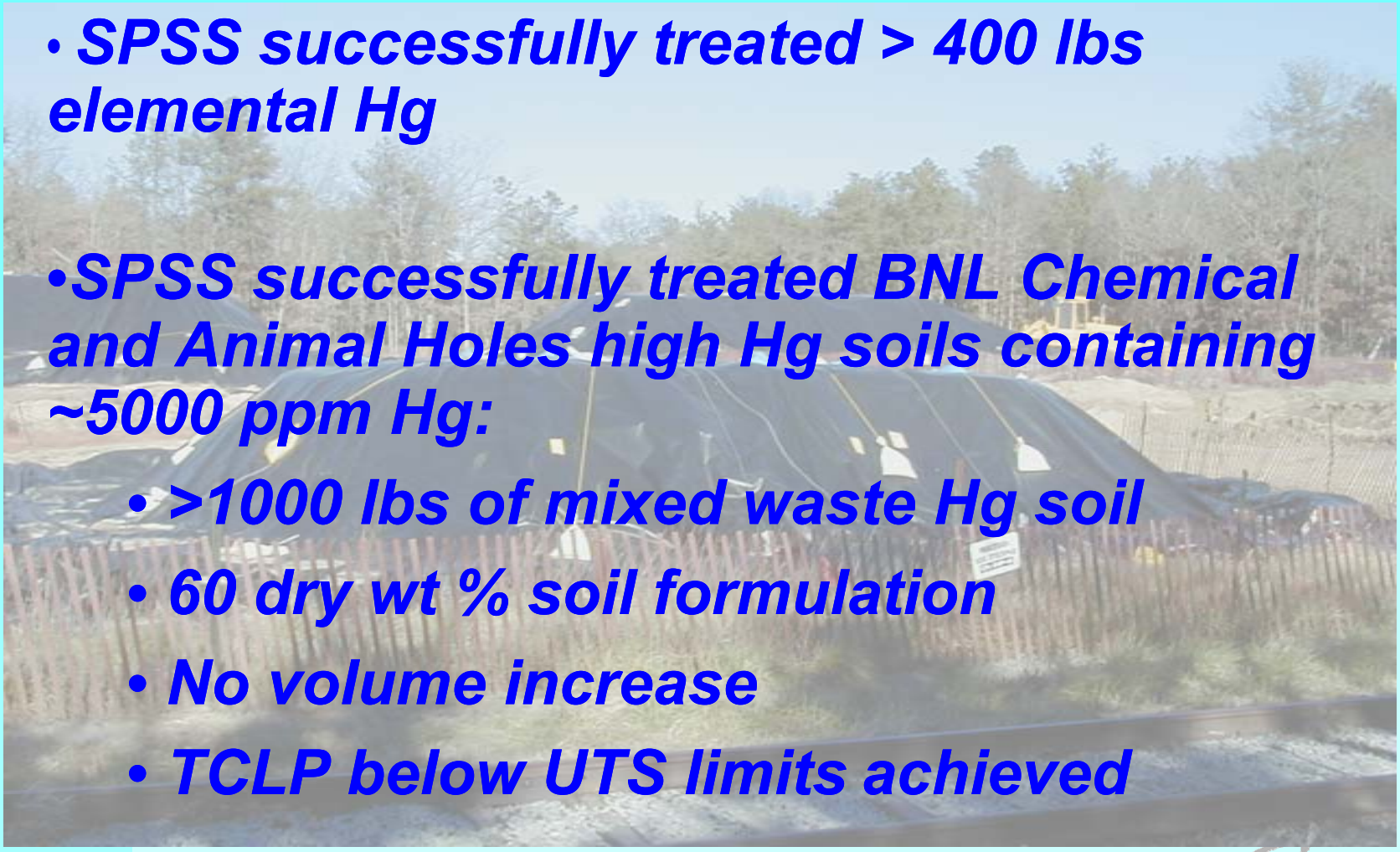
Technology Status

- ***Bench- and Pilot-scale testing have been completed at BNL:***
  - ***BNL Hg contaminated soil***
  - ***BNL elemental Hg***
  - ***Los Alamos National Laboratory elemental Hg***
  - ***Los Alamos National Laboratory Hg contaminated debris***
  - ***DOE/EPA simulated Hg sludge***
  - ***Hg residuals from gold mining operations***

Technology Status

- *Second patent pending*
- *Commercial license issued for treating elemental Hg resulting from gold mining operations*
- *BNL negotiating additional commercial license agreements for treatment of other Hg wastes*
- *Full-scale deployment for treatment of elemental Hg planned*

Treatment of BNL Elemental Hg And Hg Contaminated Soil



- *SPSS successfully treated > 400 lbs elemental Hg*

- *SPSS successfully treated BNL Chemical and Animal Holes high Hg soils containing ~5000 ppm Hg:*
  - *>1000 lbs of mixed waste Hg soil*
  - *60 dry wt % soil formulation*
  - *No volume increase*
  - *TCLP below UTS limits achieved*

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LANL Mixed Waste Mercury for SPSS Treatibility

Glass and plastic containers containing radioactively contaminated elemental Hg

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LANL Mixed Waste Mercury for SPSS Treatibility

TCLP pellets of SPSS treated elemental Hg

Flasks of mixed waste elemental Hg for processing

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SPSS Macroencapsulation

Crushed glass debris

Modified Processing System

Treated glass debris

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SPSS Macroencapsulation

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Mercury Sludge Treatability Study

- *Direct stabilization of high Hg (>260 ppm) contaminated sludges (MER 04)*
- *Sponsored by DOE TMFA*
- *Collaboration with EPA OSW*
  - *Data to support ANPR for Hg treatment*

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Simulated Hg Sludge Description

- *5000 ppm Hg (0.5 wt%)*
  - *Elemental*
  - *Nitrate*
  - *Chloride*
  - *Oxide*
  - *Organo-chloride*
- *50 wt% inorganic solids (DE, $Al(OH)_3$, $FeCl_3$, NaCl)*
- *49.5 wt% H_2O*

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Pilot-Scale SPSS Processing

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SPSS Processing of Hg Sludge

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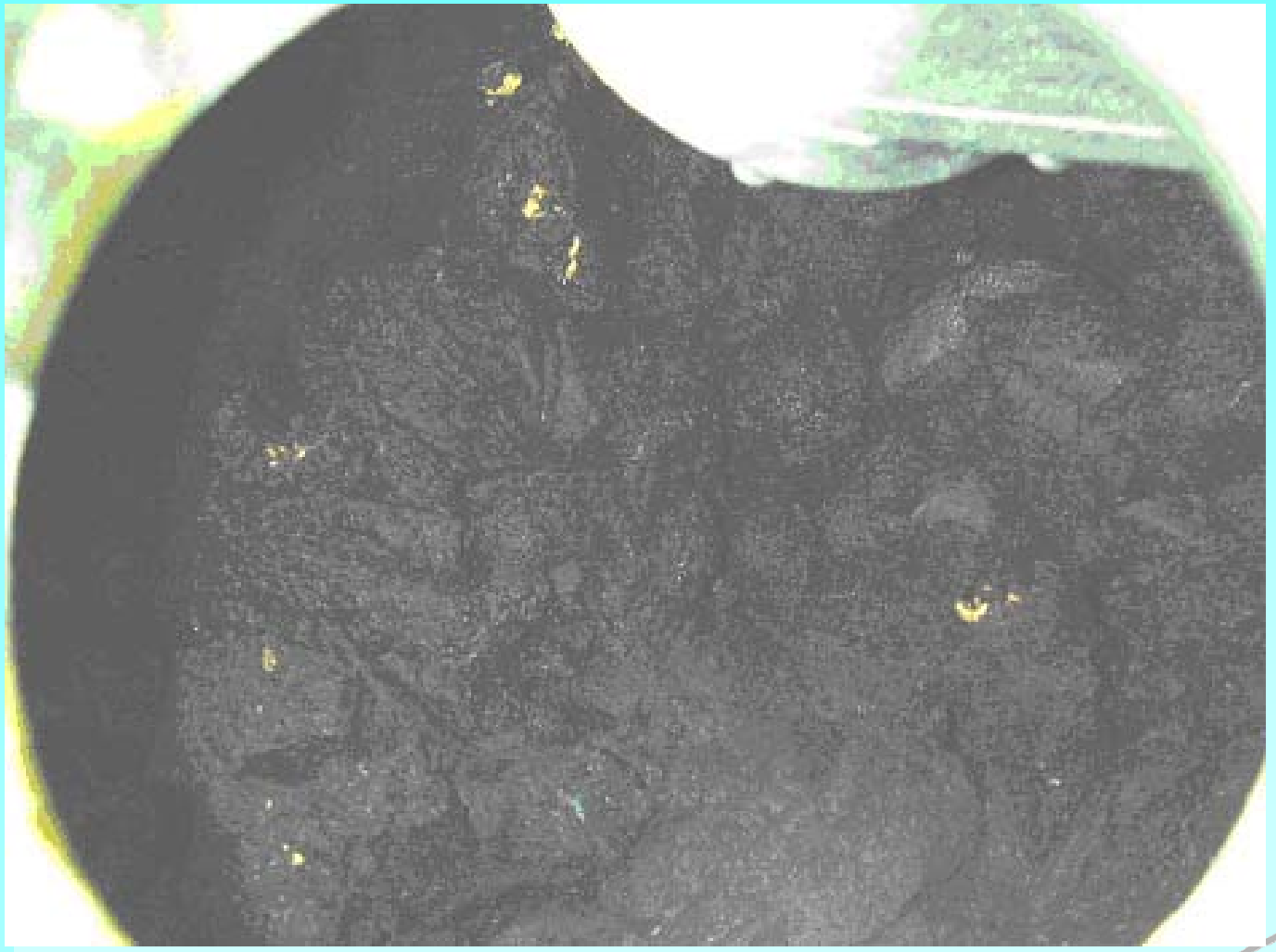

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SPSS Processing of Hg Sludge

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Processing and Performance Results

- *Limited bench-scale process optimization of formulas and parameters*
- *Maximum waste loadings:*
  - *60 wt % wet sludge*
  - *30 wt % dry sludge*
- *Lower loading efficiency compared with soil due to particle size/viscosity effects*
- *Waste form volume increase of 36%*

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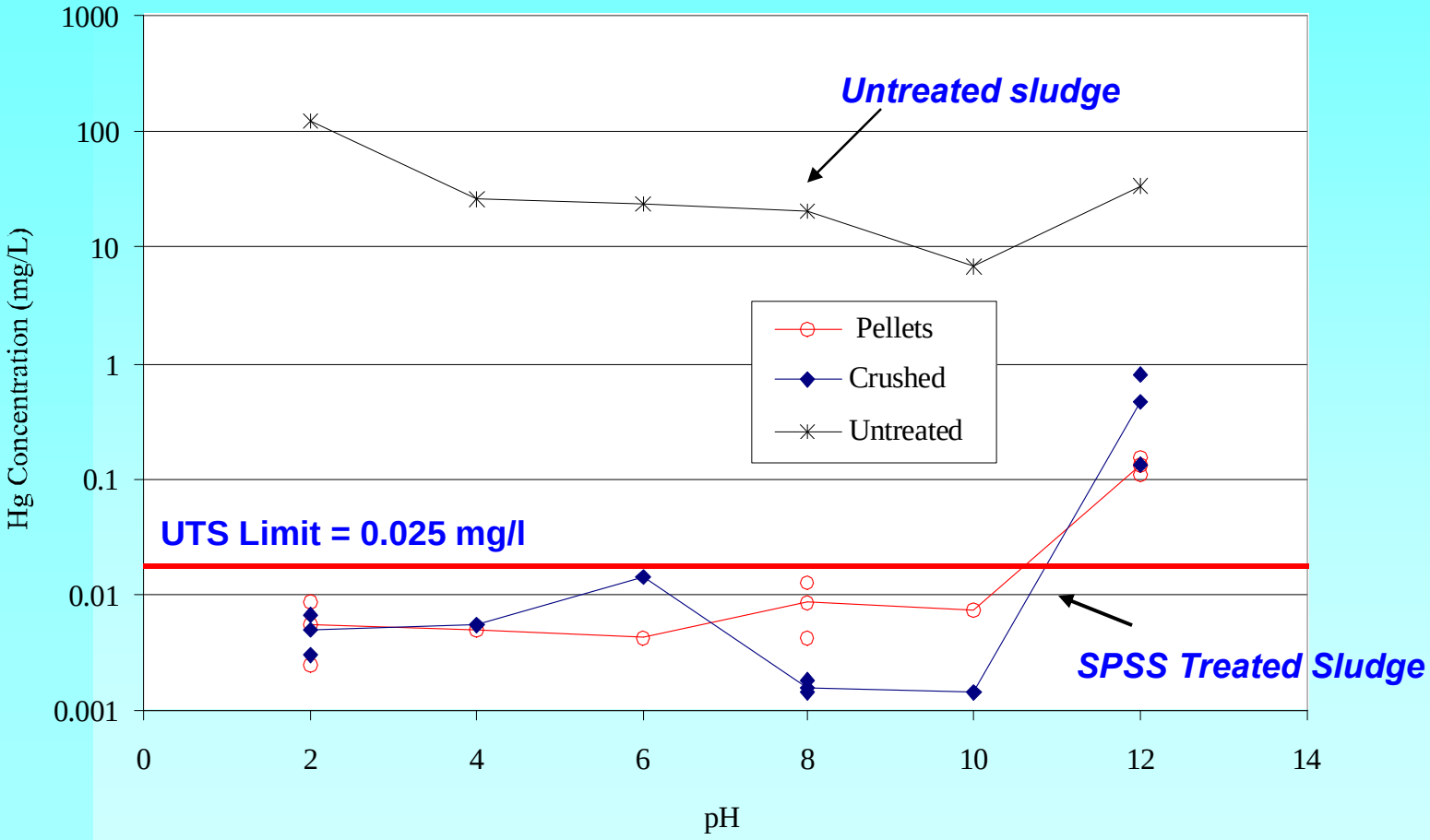
Processing and Performance Results

- *TCLP = Toxicity Characteristic Leaching Procedure*
  - *Target performance: ≤ 25 ppb, Universal Treatment Standard*
  - *Results from certified lab: <10 ppb*
- *EPA seeking additional info beyond TCLP for proposed rulemaking*
- *Constant pH leach test at broad range of pH (2 –12) conducted at U of Cincinnati*

Performance Testing: Constant pH*



* *Conducted by the Univ of Cincinnati*

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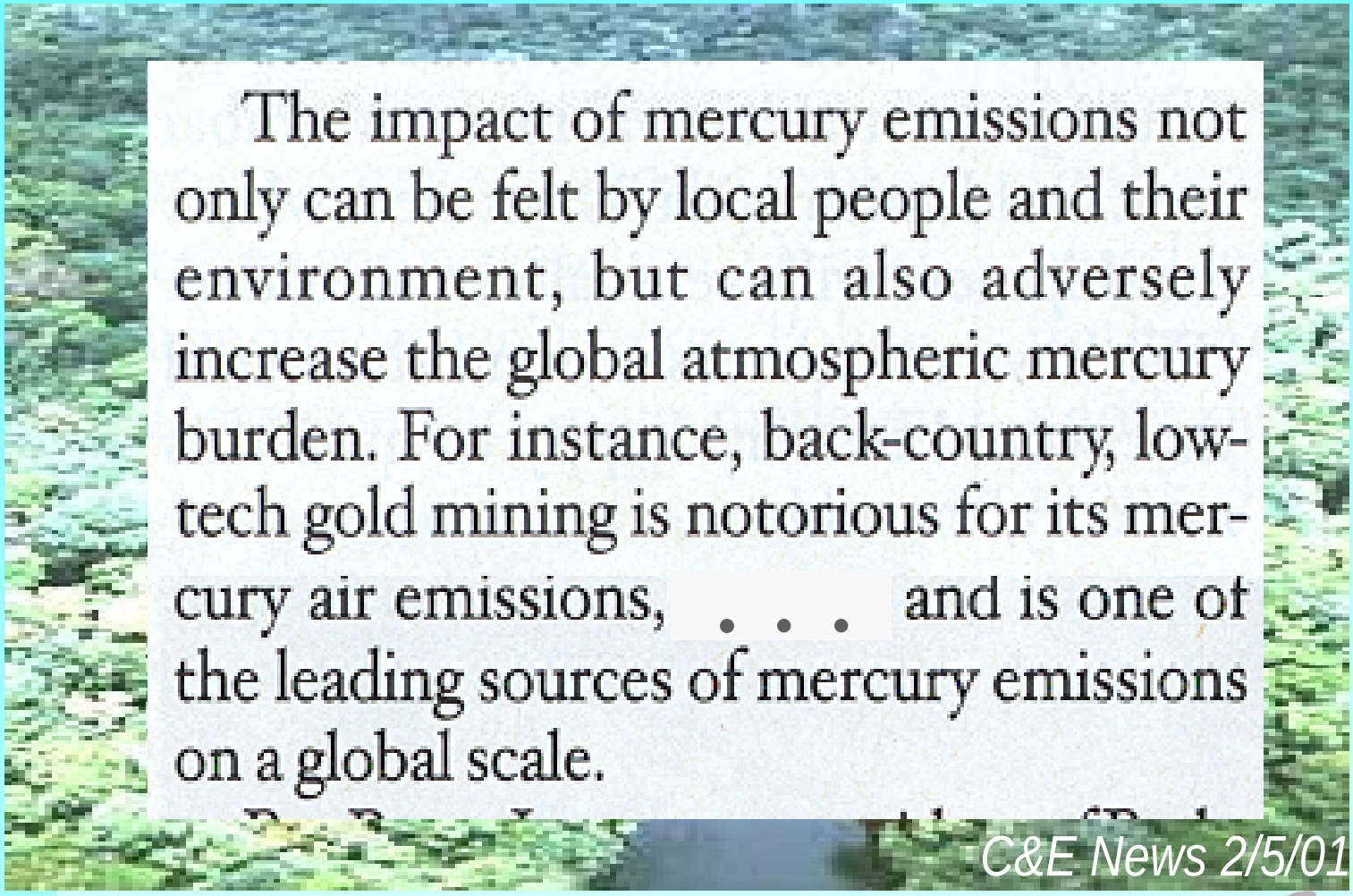
SPSS Commercialization

- *BNL issued license to Newmont Mining for application to treat Hg wastes in mining industry*
- *Working with Bethlehem Apparatus for commercial application to treat elemental Hg*
  - *DoD Hg stockpile*
  - *Formerly recycled Hg*
- *Commercialization for treatment of radioactively contaminated Hg (mixed waste Hg)*

Mercury Use in the Third World



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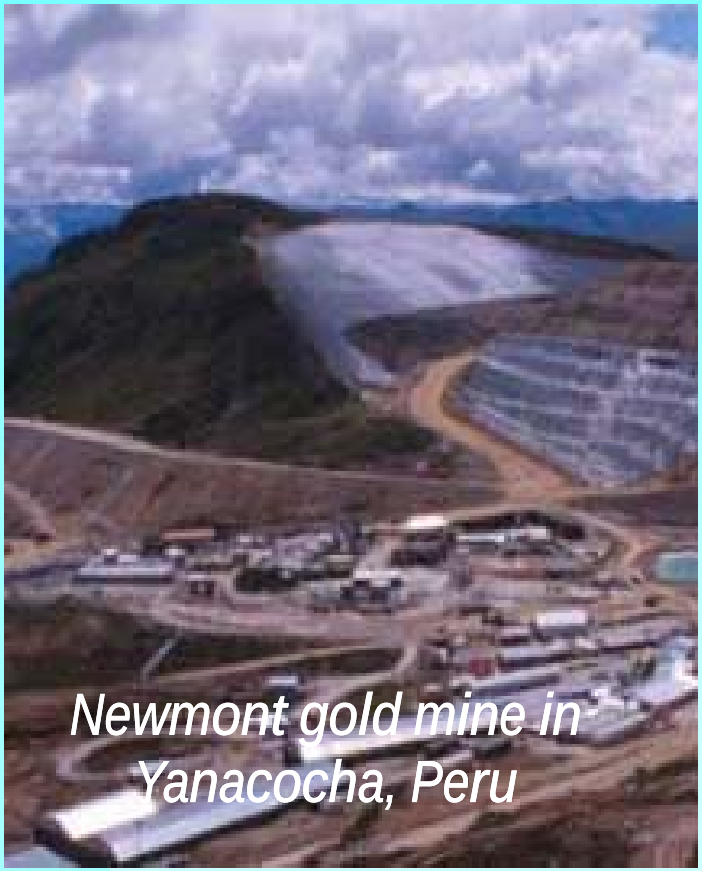
Newmont Mining SPSS License



Newmont gold mine in Yanacocha, Peru

- *Largest gold producer in Latin America (1.8 mil oz. produced in 2000)*
- *5 tons of Hg/month*
- *Currently recycling Hg, but concern over potential mis-use of recycled Hg*
- *BNL conducted treatability study*
- *Exclusive license for SPSS applications to mining*

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Summary/Conclusions

- *SPSS is a cost effective, simple process to treat broad range of Hg wastes*
- *SPSS Micro effectively treats:*
  - *Elemental Hg*
  - *High Hg contaminated soils (~5,000 ppm Hg)*
  - *High Hg contaminated sludge with a broad range of inorganic and organic Hg salts (~5,000 ppm Hg)*
- *SPSS Macro effectively treats Hg contaminated debris*

Summary/Conclusions

- *Hg is chemically stabilized and solidified - Solidification reduces leachability and eliminates dispersibility of radionuclides and Hg*
- *Exceeds regulatory performance requirements*
- *Licensed to treat Hg residuals from mining operations*
- *Negotiating with commercial partners for treatment of elemental Hg (e.g., DoD stockpile) and mixed waste Hg*