



Council for Mineral Technology



**A global leader in mineral and
metallurgical innovation**

The Resurrection of Hydrometallurgy's Own RIP van Winkle: Uranium

Marthie Kotze

Introduction

- Why RIP van Winkle??
- Title character in a story by Washington Irving:
 - ❖ slept for 20 years and didn't recognize the world when he woke up
 - ❖ Uranium developments woke up after 25 years: is everything different?
- **RIP** currently very topical for uranium
- In 1959 17 plants in RSA; only 1 remained
- Revival in Southern Africa
 - ❖ biggest activity in Namibia



Uranium in Namibia

Extract Resources Limited

Forsys Metals Corp.

Dunefield Mining Company

Galahad Gold Plc

Rössing Uranium Ltd

Namura Mineral Resources

Metals Australia Ltd

West Australian Metals Ltd

Corporate & Resource Consultants

Nam-China Minerals and Development

Philco Twenty (Pty) Ltd

Jaco Floris Smith

Pitchstone Exploration Ltd.

Atomredmetzoloto OJSC

Mineral Commodities Ltd

Kalahari Minerals Plc

Westport Resources Namibia (Pty) Ltd.

Ancash Investments (Pty.) Ltd.

Paladin Resources Ltd

Areva (Uramin)

Xemplar Energy Corp.

Bannerman Resources Limited

Cheetah Minerals Exploration

Etruscan Resources Namibia

Namibia Mineral Mining Plants & Products

Reptile Investment Four

Nova Energy Ltd.

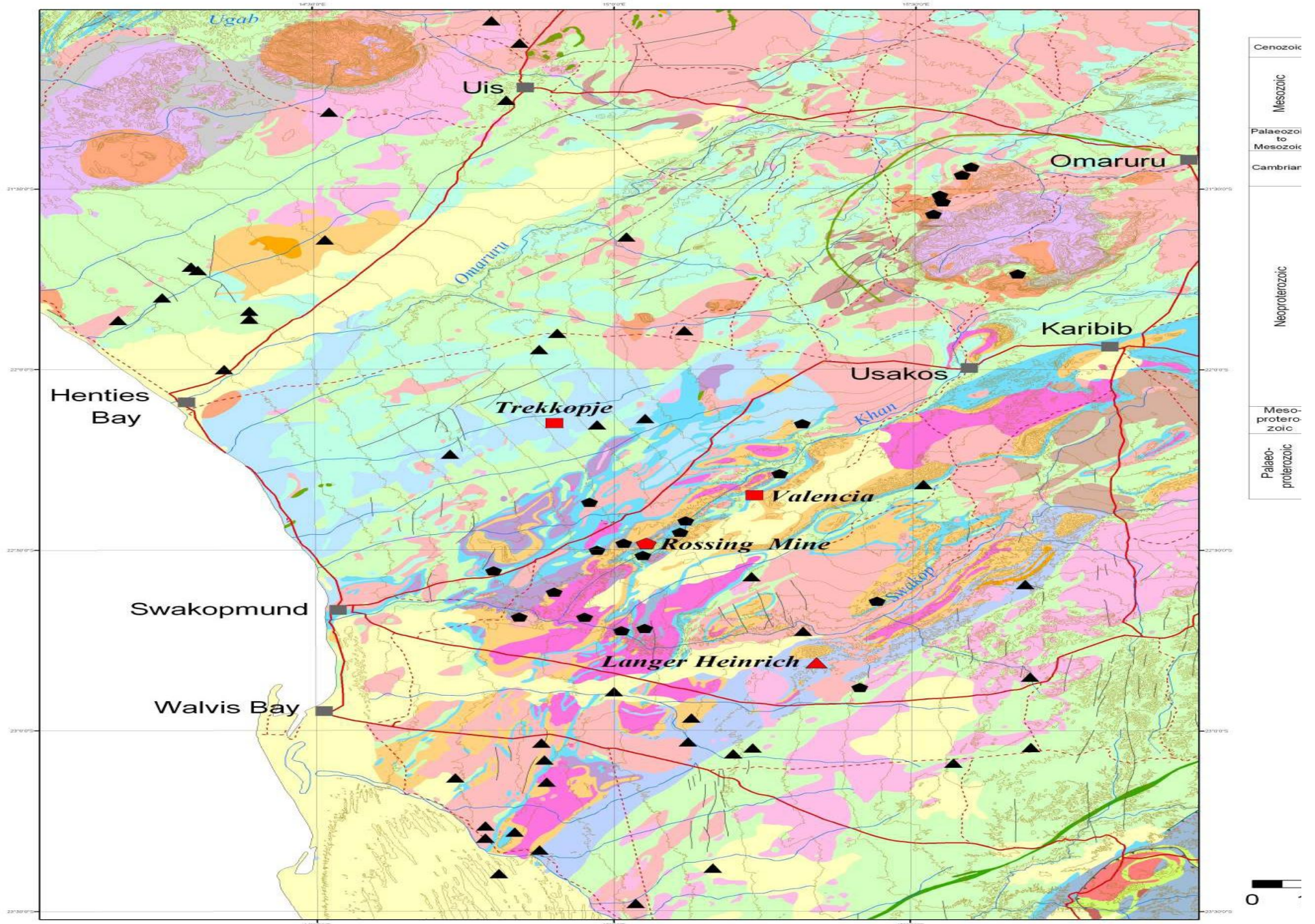
Manica Minerals Ltd., Erongo Energy Ltd

Reptile Uranium Namibia (Pty) Ltd

Africa Uranium Ltd



CENTRAL DAMARA URANIUM I



Mineralogy

- 185 uranium minerals according to US Geological Survey
- Mineralogy can be complex
- Associated metals such as V, Mo, Ti
- Multitude of processing routes
- Process selection is done carefully
- Active industry from early 1950's
 - ❖ Learn from lessons in previous cycle and other industries, eg heap leaching



Uranium in HMD

➤ Past 4 years: major increase in demand for uranium project work at Mintek due to price hike/demand

- ❖ Langer Heinrich, Kayelekera, Dominion Reefs, Buffelsfontein, Rand Uranium, Harmony, Valencia, Anglo Gold Ashanti, others
- ❖ Carbonate, sulphuric acid leaching: since 1920's
- ❖ Pressure leaching
- ❖ S/L: flocculants, paste thickening, etc
- ❖ Direct SX, direct IX, IX + SX (incl. RIP)

➤ HMD activities:

- ❖ Resin evaluations, incl. silica issues
- ❖ Resin durability
- ❖ MetRIX™ demonstration
- ❖ HPGR: leaching efficiency?
- ❖ Diagnostic leaching
- ❖ BPC stripping: neutralization into column



Leach Aspects

- 28% of all production via ISL
 - ❖ Rather hydrometallurgical mining
- Process improvements in Leninabad: 2 stage leach
 - ❖ Initial generation of ferrous via acid leach of Fe
 - ❖ Subsequent aeration and acid leach
- Carous acid as oxidant
 - ❖ Decrease in acid consumption
- Acid pugging at Somair and Cominak, Niger
- Heap leaching: Trekkopje, Somair
- Bioleaching: tank and heap
- Pressure leaching



Pressure Leaching

- Since 1950's
- Refractory minerals such as brannerite, davidite
- Production of acid from associated S-minerals via flotation
- In combination with atmospheric leach
- 5 alkaline and 5 acid pressure leach plants globally
- Dominion Reefs in Klerksdorp: 2008
- Knowledge-base larger



Some Flowsheet Options

- Uranium One, Klerksdorp: CCD → **BPC SX** → ADU
- Ezulwini: CCD → **NIMCIX** → **SX** → ADU ppt
- Langer Heinrich: CCD → Clarification → **FBIX** → Ppt
- Vaal River South: CCD → **NIMCIX** → **MS SX** → ADU
- Trekkopje: Heap leach → **NIMCIX** → SDU
- Kayelekera: **RIP** → direct ppt
- AngloGold Ashanti: South Uranium upgrade, new plant at Kopanang: **NIMCIX / RIP**



Uranium One: BPCs Klerksdorp



AngloGold Ashanti: Vaal River South

CCIX Column replacement

- ✓ *Replace stainless steel columns with GRP columns*
 - ✓ Rapid corrosion of stainless steel columns
- ✓ *CAPEX US\$2 m*
- ✓ *Three columns installed, delivered and commissioned*
- ✓ *Further two columns to be completed by mid 2009*



RIP: Gold/Uranium Recovery

- RIP not novel technology:
 - ❖ Early 1950's proposed by USA Atomic Energy Commission
 - ❖ Implemented by Anaconda Co: 3000 t/d
 - ❖ being used in FSU for decades for Au and U_3O_8
 - ❖ previously applied in some form in USA (baskets)
 - ❖ Relix process: inverted fluidised bed (resin floating at top)
 - demonstrated in pachuca tank, Stilfontein Gold Mine 1970
 - West Driefontein: over 2 years
 - Small scale demonstration run at NIM
 - Mechanically operable, performance poor due to back mixing
- Use in Western World limited
- Some Au RIP plants in Western World:
 - ❖ but resins different; also operational demands for uranium higher
- Major potential CAPEX and OPEX savings for RIP vs CCD/filtration, so
 - ❖ large drive to consider RIP especially for low grade ores
- Major resin improvements by most large resin manufacturers
- Kayelekera installing agitated carousel-based RIP, direct ppt
- **Cost model for MetRIX™: RIP generally more cost effective for uranium recovery from lower grade ores and large throughput**





RIP: Opportunities & Concerns

Opportunities

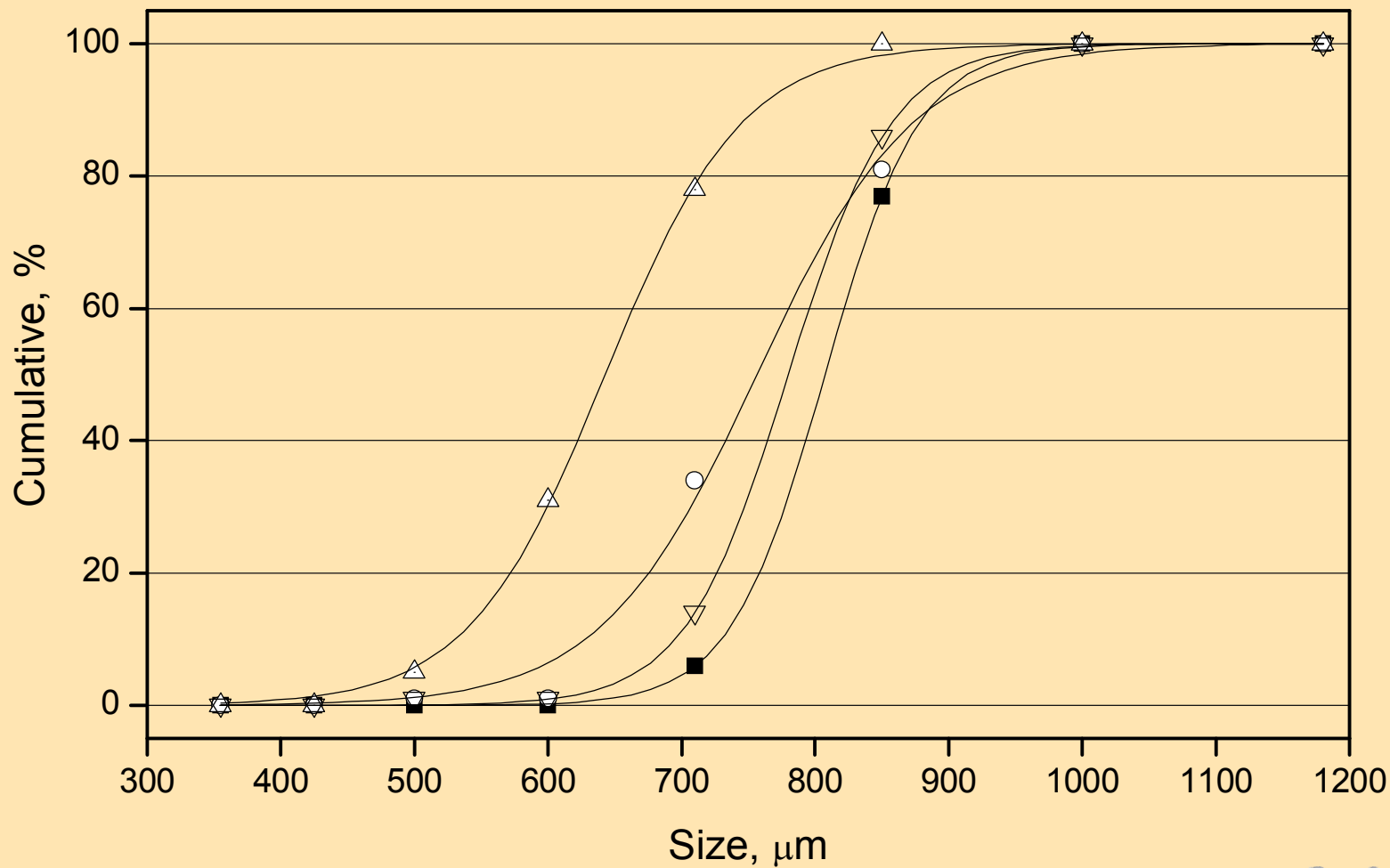
- No solid/liquid separation
- No PLS clarification as for fixed bed IX and SX
- Direct precipitation
 - ❖ **Continuous elution: higher grade LSL, purer uranium product**
 - ❖ **can this consistently provide required product quality??**

Major Concerns

- Silica fouling and impact on OPEX
 - ❖ **Resin life**
 - ❖ **Rate of fouling and concomitant regeneration requirement**
 - ❖ **Effect of silica on resin life**
 - ❖ **Management strategy around silica – design to limit uranium losses to barren**
 - ❖ **Optimise resin residence time**
- Resin durability or potential loss: sensitivity of economics to resin loss



RIP Grade Resins



■ MP1 ▽ GT1 ○ MP2 △ GT2



Silica Fouling

- Very little information from literature

Rate of silica fouling

- Silica concentration in PLS
- Temperature of leach
- Leach: pressure vs ambient
- pH or acid content of leach
- Time before PLS is contacted with resin: RIP probably worse
- Resin residence time in leached pulp
- Silica content on resin

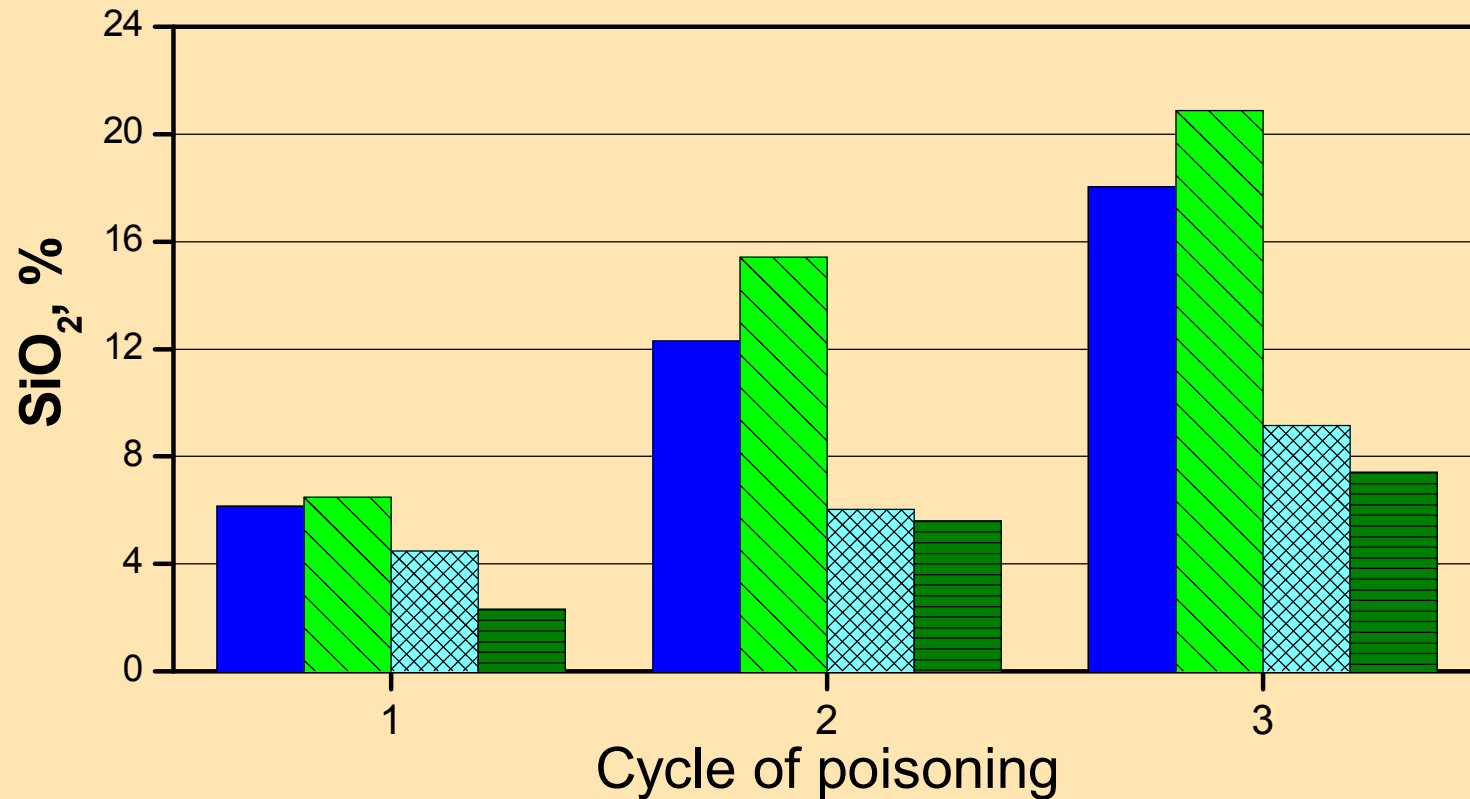


Impact of Silica Fouling

- Slows down kinetics of loading
 - ❖ Lower operating capacity
 - ❖ Larger resin flow required to maintain uranium recoveries
- Slower rate of stripping
 - ❖ Longer residence time in stripping
 - ❖ Often lower stripping efficiency
 - ❖ Lower recoveries in adsorption
- Increase in reagent consumption due to larger resin flowrates
- Cause crud formation in SX (SX on eluate)
- Poorer quality ADU due to silica content



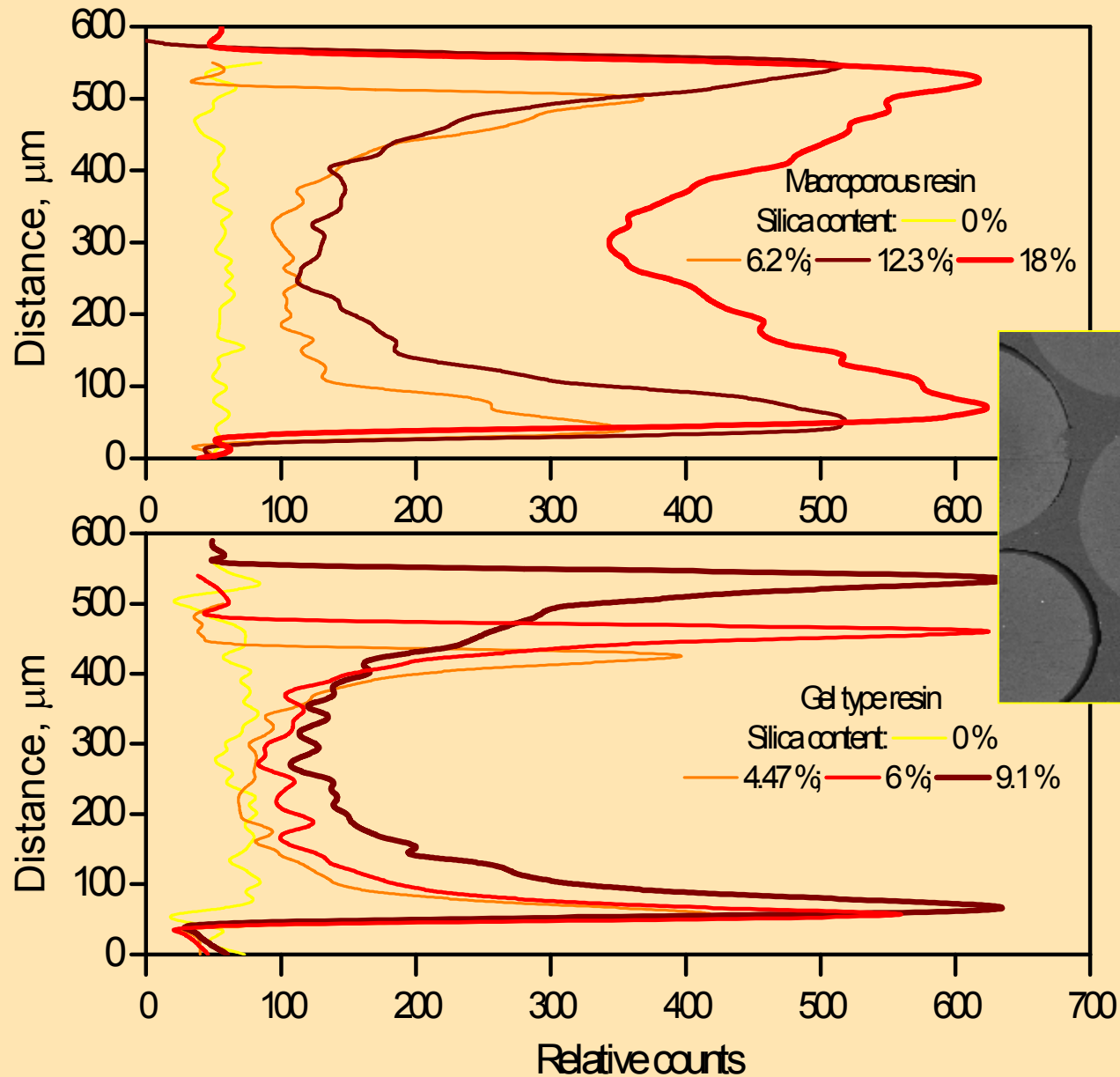
Silica Fouling



MP1; MP2; GT1; GT2

SEM Analysis

SEM+BEI+EDS

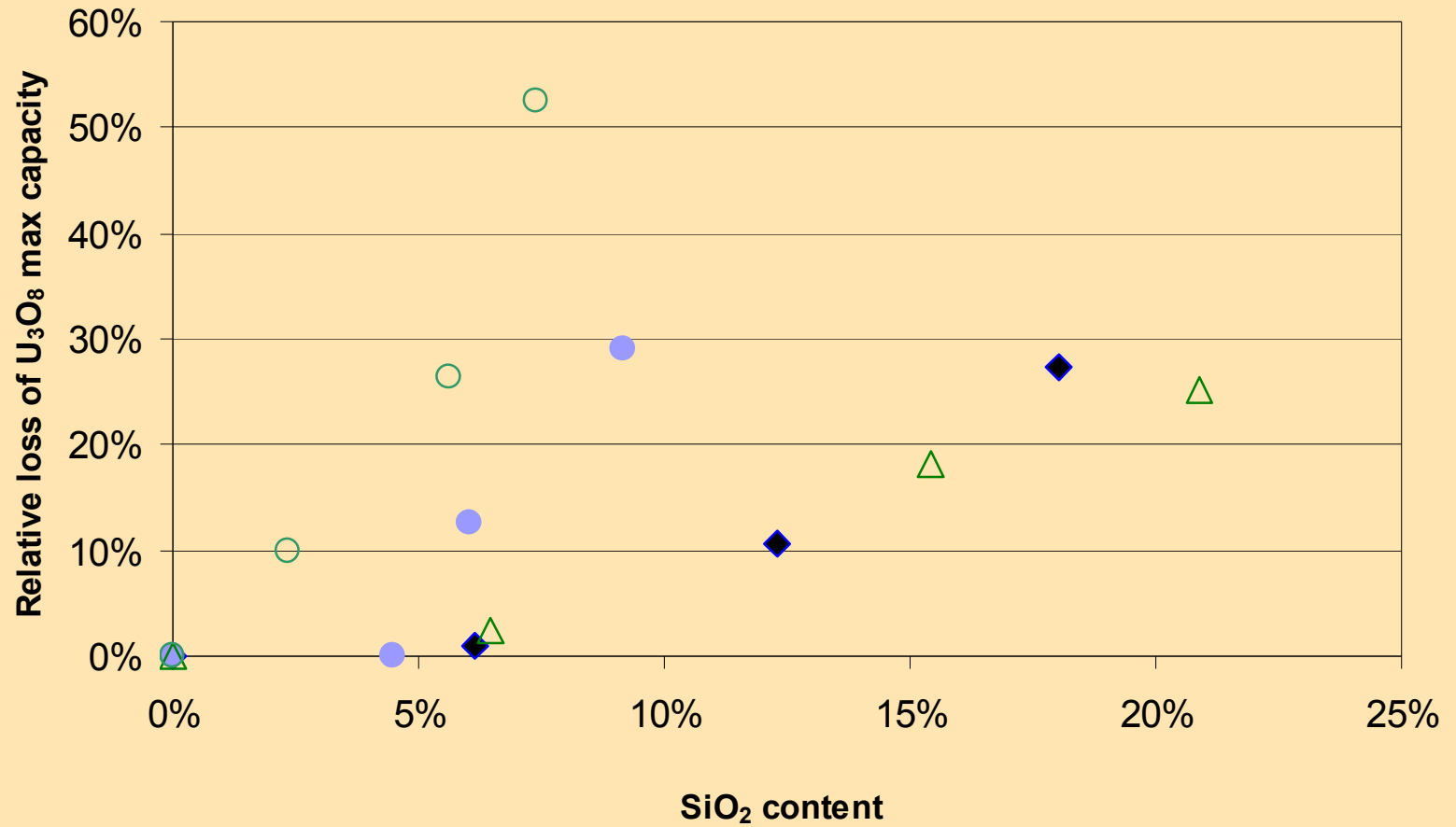


Silica Fouling – How?

- $\text{Si}(\text{OH})_4$ is neutral specie at pH 2 –
 - ❖ enter resin as non-electrolyte
 - ❖ lower degree of crosslinking more favourable
- quarternary ammonium acts as a precipitant
 - ❖ why not throughout resin??
- HSO_4^{2-} counter-ion on resin – hydrogen bonding
- Surface phenomenon – part of solution precipitation
 - ❖ this would indicate that smaller resin with higher surface area should have higher rate of silica ppt



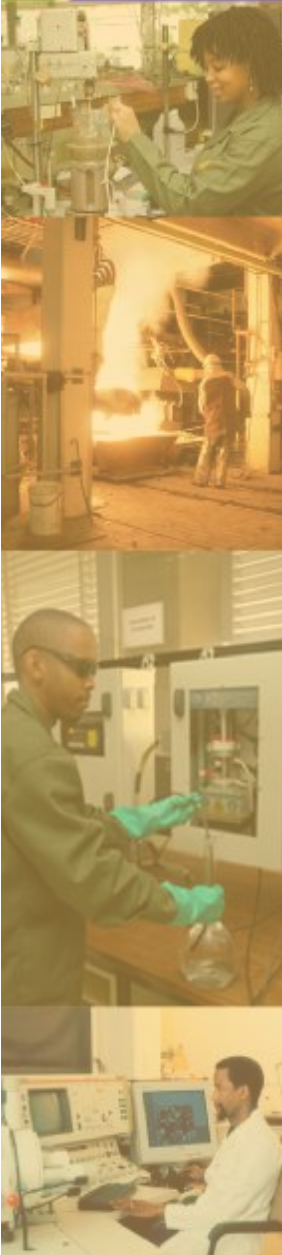
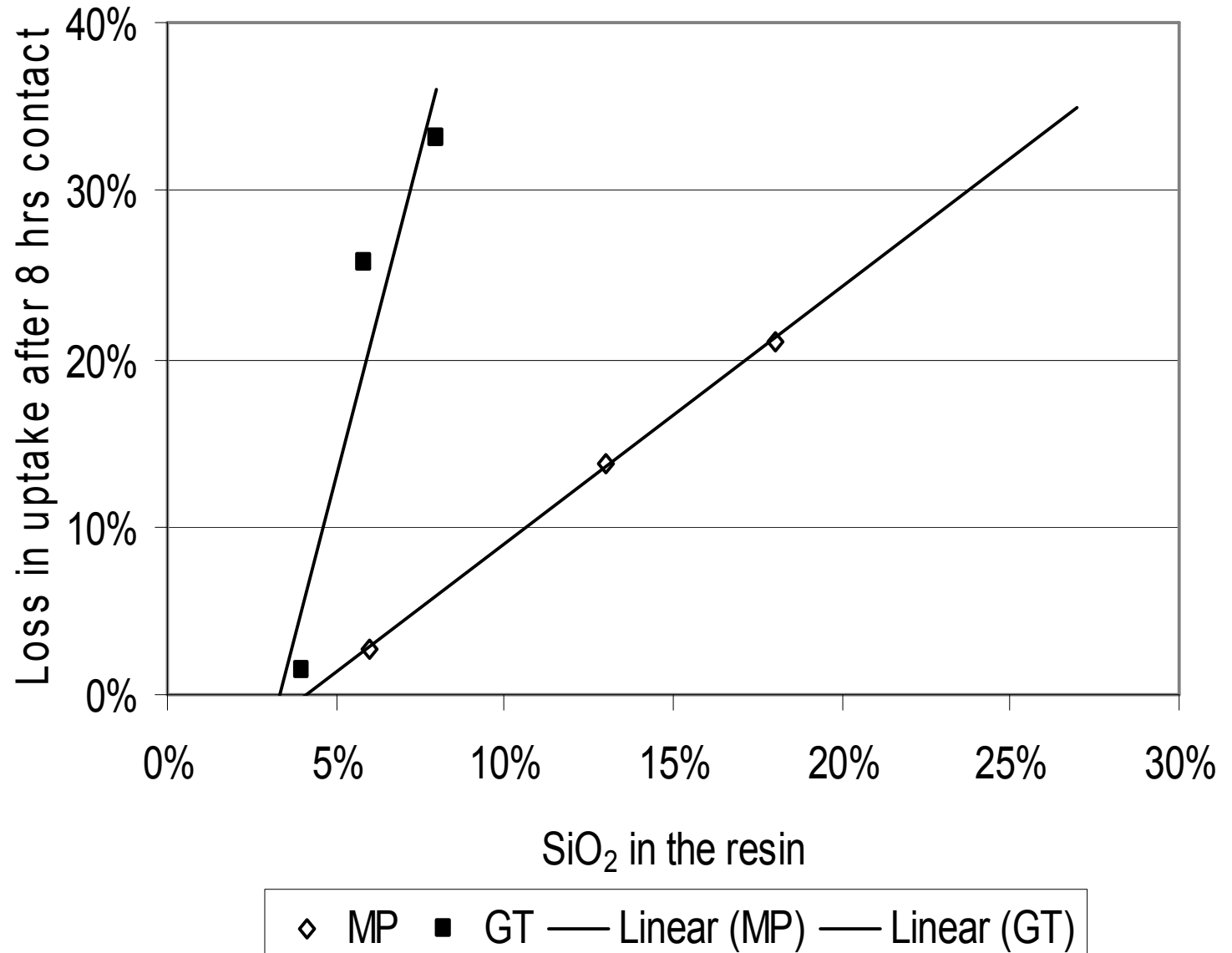
U₃O₈ Loading- 24 hrs



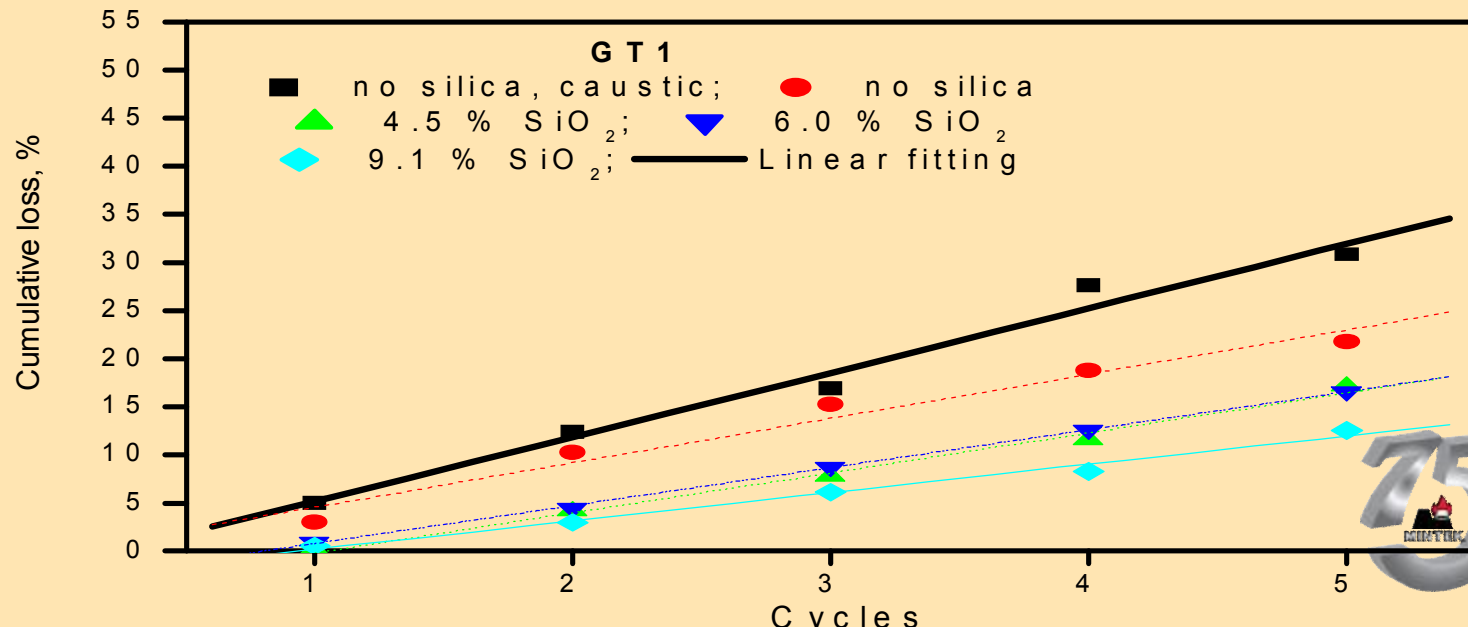
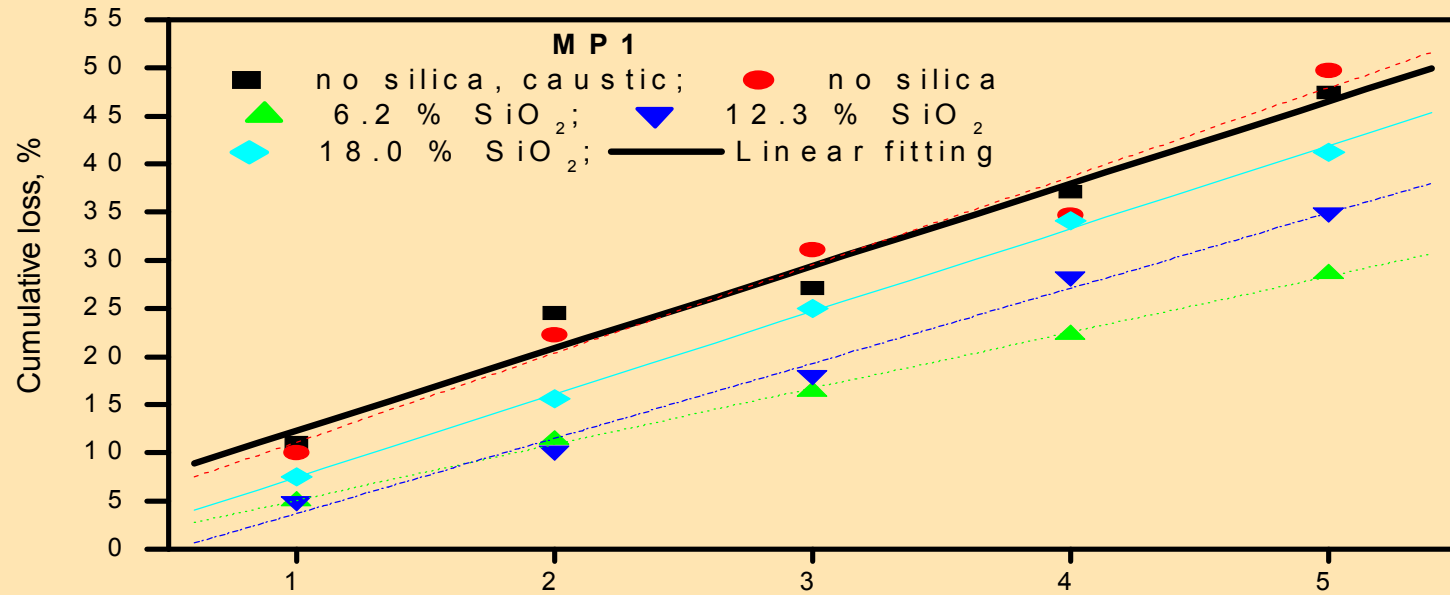
◆ MP1 ● GT1 ▲ MP2 ○ GT2



Adsorption: 8 hrs



Sand Attritioning



MetRIX™ Demonstration plant



Conclusions

- What did RIP find?
- Very different world, eg communication, etc.
- Very little 'novel' in uranium hydromet
 - ❖ BPCs for direct SX, even lower grade
 - ❖ Heap leaching, incl. bio
 - ❖ Others eg. radiometric sorting
 - ❖ Flotation for S-minerals and/or uranium
 - ❖ S/L separation: PBCs, paste and high rate thickeners, etc

In HMD

- Further work required to select optimum resin type
 - ❖ What is optimum SiO₂ content on resin: durability, reagent consumption, residence time ?
- Silica management – solution and resin
- Further durability work in MetRIX™ demonstration plant – to be published in July
- Direct precipitation from RIP eluate – main drivers:
 - ❖ CAPEX and OPEX for SX circuit (fire issues)
 - ❖ Lower acid concentration required to minimise neutralisation costs
 - ❖ Purity??



Mintek Site



Thank you

