Dewatered Tailings Management
ARD Aspects

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Overview

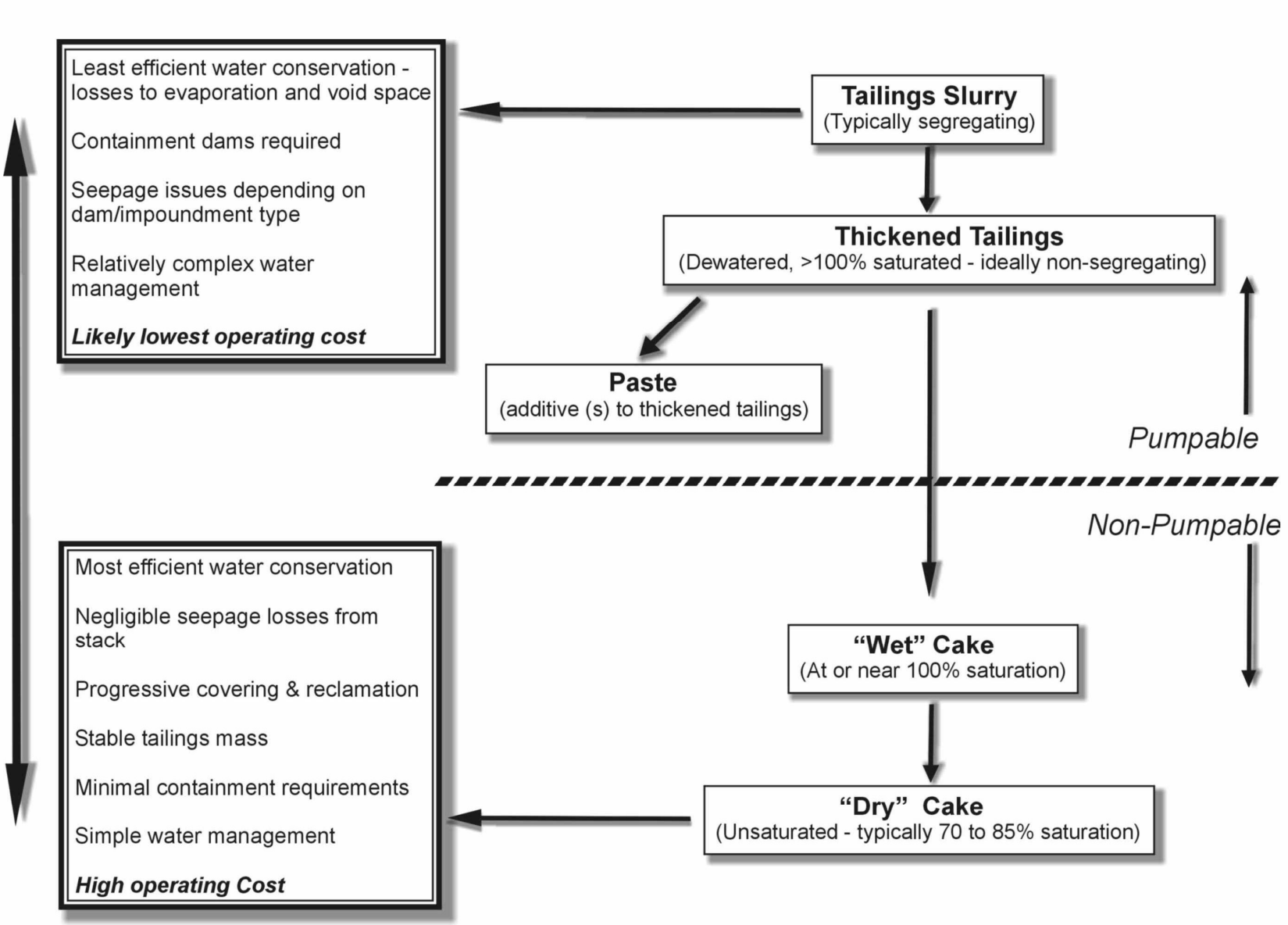
- This presentation will more introduce the tailings continuum and nature of dewatered tailings
- Expectation is all present know ARD process
- Most ARD literature regarding tailings deals with conventional slurried impoundments
- Literature available that discusses ARD and dewatered tailings is generally misleading (e.g. that dewatered tailings have lesser or no ARD concerns)
- All related to a thorough site-specific understanding and overall water balance/geochemistry

Tailings Management Basics

- Conventional Tailings Impoundments?
  - High water consumption - not sustainable in many regions of the world
- Dewatering Technologies
  - Dewatered tailings – can range from high slump → low slump → “solid”
  - At maximum dewatering, can form stable, compacted stack with no need for dam construction
  - Useful in recovery of process water constituents
  - Useful for projects with cold climates, arid conditions, high seismicity, sensitive water balance, etc.
  - Applicability at large scale mining slowly developing
- Oxidation Process and ARD – Compatible with Dewatered Tailings?
  - Yes and No
  - Site specific
  - Need to fully understand climate, hydrogeochemistry, tailings properties, cover design, etc.

Tailings Continuum

- More than just a dilute slurry available to present day tailings operations
- Some nomenclature confusion (e.g. saying paste = thickened that cannot be pumped without positive displacement)
- Dewatered tailings are increasingly common


Least efficient water conservation - losses to evaporation and void space
Containment dams required
Seepage issues depending on dam/impoundment type
Relatively complex water management
Likely lowest operating cost
Tailings Slurry
(Typically segregating)
Thickened Tailings
(Dewatered, >100% saturated - ideally non-segregating)
Paste
(additive (s) to thickened tailings)
Pumpable
Non-Pumpable
"Wet" Cake
(At or near 100% saturation)
"Dry" Cake
(Unsaturated - typically 70 to 85% saturation)
Most efficient water conservation
Negligible seepage losses from stack
Progressive covering & reclamation
Stable tailings mass
Minimal containment requirements
Simple water management
High operating Cost
Continuum

Case for Dewatered Tailings
Related to Water Content

Water Content (decreasing water losses)

Traditional Slurry

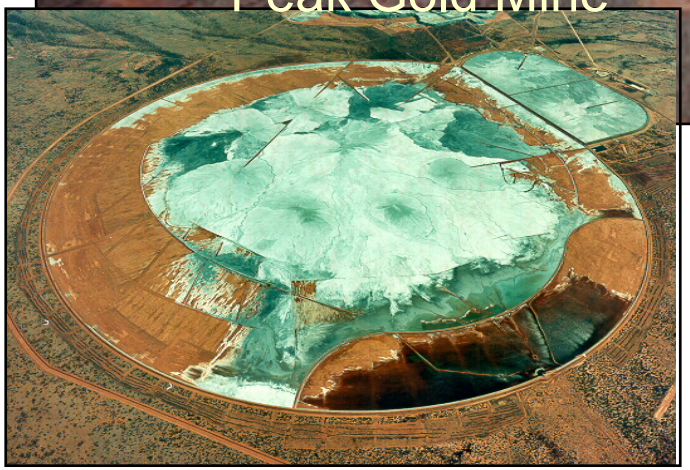
Thickened/Paste

Filtered

Thickened and Paste Tailings

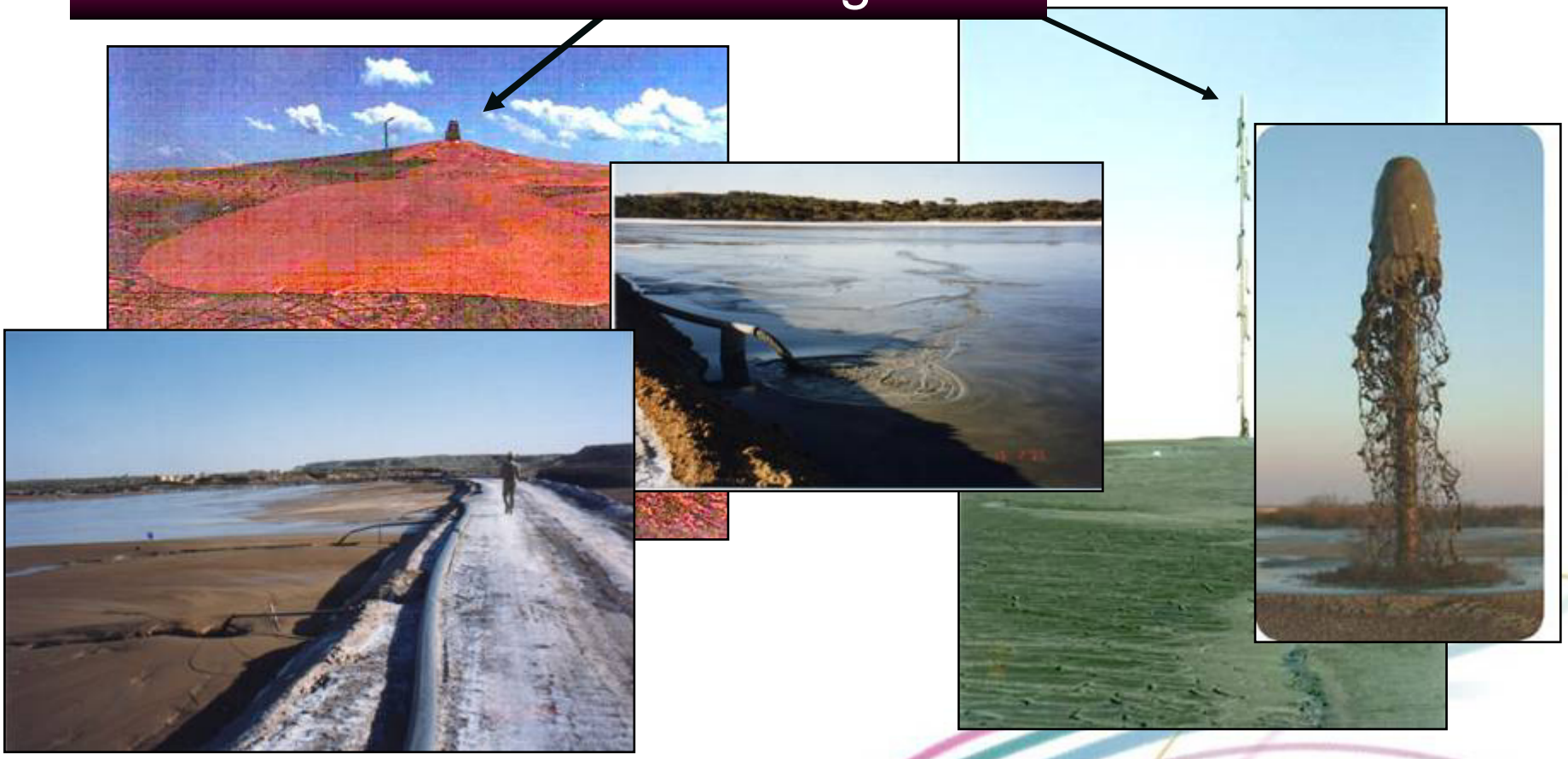
- Dewatered but still a slurry
- Thickened
  - First thickened piles were far from panaceas
  - Taking what happens inefficiently in tailings impoundment and doing it in the process circuit
- Paste
  - A nomenclature challenge – pumping boundary is artificial
  - Underground paste backfill where much of the research/experience occurred
- Thickened and paste – to obtain benefits, must remain non-segregating

Thickened Tailings Examples - Australia



Thickened Tailings – Subaerial Beaching

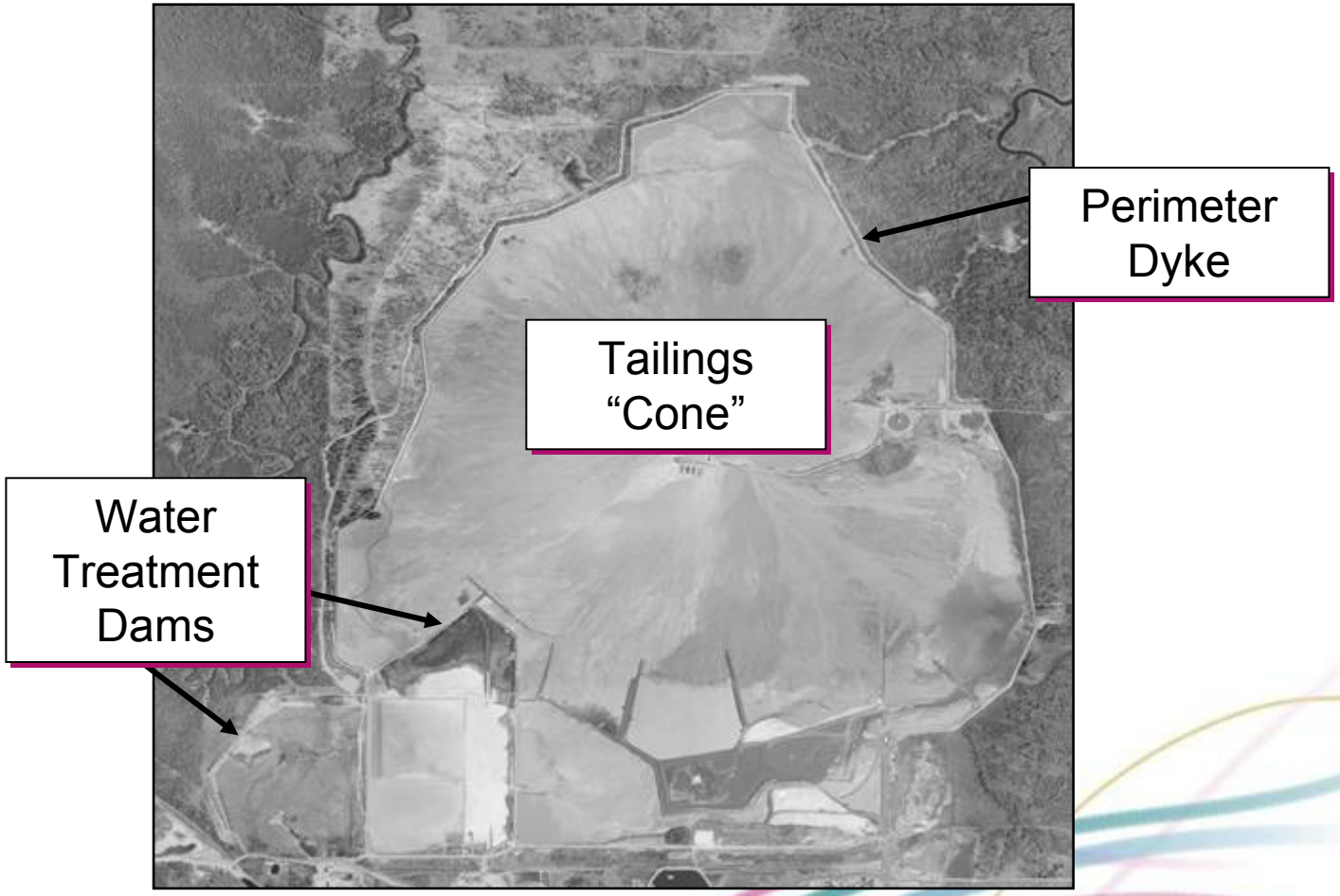
Note –tower “valves” for rising mass



Thickened Tailings have Runoff/Seepage

- Central Thickened Discharge at the Peak Gold Mine, Australia

Kidd Metallurgical Site - Ontario



Kidd Metallurgical Site - Ontario

Thickened Tailings at its best

- Sunrise Dam gold mine in W.A.

Thickened Tailings on a large scale

- Sar Cheshmeh Mine, Iran

Paste Tailings

- There is a “grey” area between thickened/paste tailings nomenclature
- Paste tailings are often defined as tailings that have been significantly dewatered to a point where they:
  - require positive displacement versus centrifugal pumping
  - do not have a critical flow velocity when pumped
  - do not segregate as they deposit
  - produce minimal (if any) bleed water when discharged

Underground Paste Backfill

Surface Paste

- Myra Falls, Vancouver Island, British Columbia
- Relatively low tonnage, very wet environment

Surface Paste – Myra Falls

- Surface oxidation between lifts

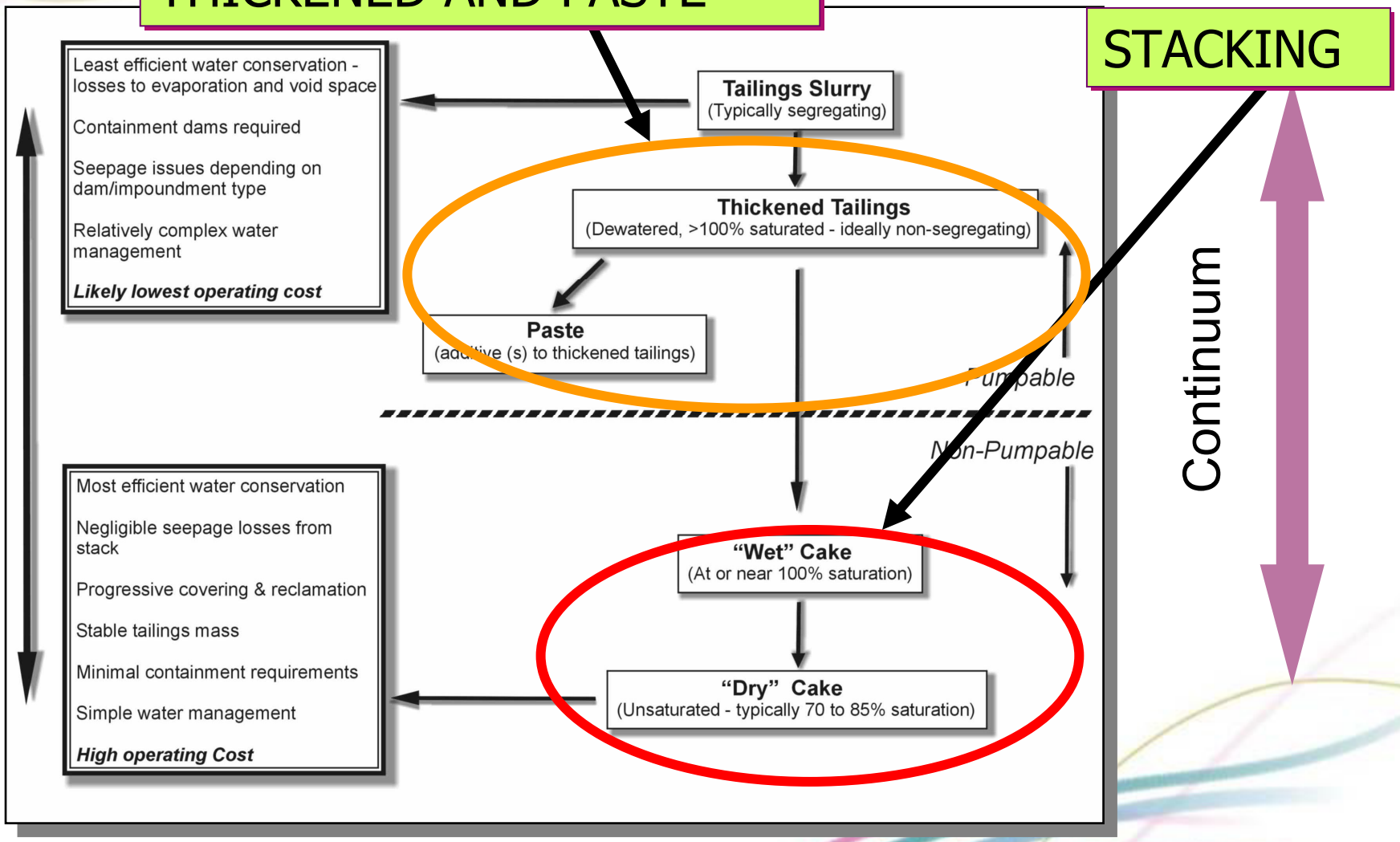
Surface Paste

- Bulyanhulu, Tanzania
- Relatively low tonnage, arid environment

Surface Paste

- Bulyanhulu, Tanzania
- Surface geochemical processes between beach lifts

THICKENED AND PASTE



Dry Stacking - Filtered Tailings

- Filtering concentrate is a commonplace activity at mines
- Paste plants often include tailings filtration
- In past 10 to 15 years, advances in filter technology has seen
  - wider range of stacked tailings (most often metal mines, particularly mid-sized gold properties)
  - increased tonnage potential
  - decreased CAPEX/OPEX on per tonne basis

Dry Stacking Economics

- **Not inexpensive, but…**
  - Regulatory expedience
  - Low closure costs
  - Compatibility with paste backfill
  - Less costly than surface paste
- **Capital Costs**
  - Filtration Units
  - Transport Equipment (Trucks/Conveyors)
  - Placement Equipment (Spread/Compact)
- **Operating Costs**
  - Range in costs from $1 to $10 per tonne (USD)
  - Average appears to be $1.50 to $3.00 per tonne (USD)

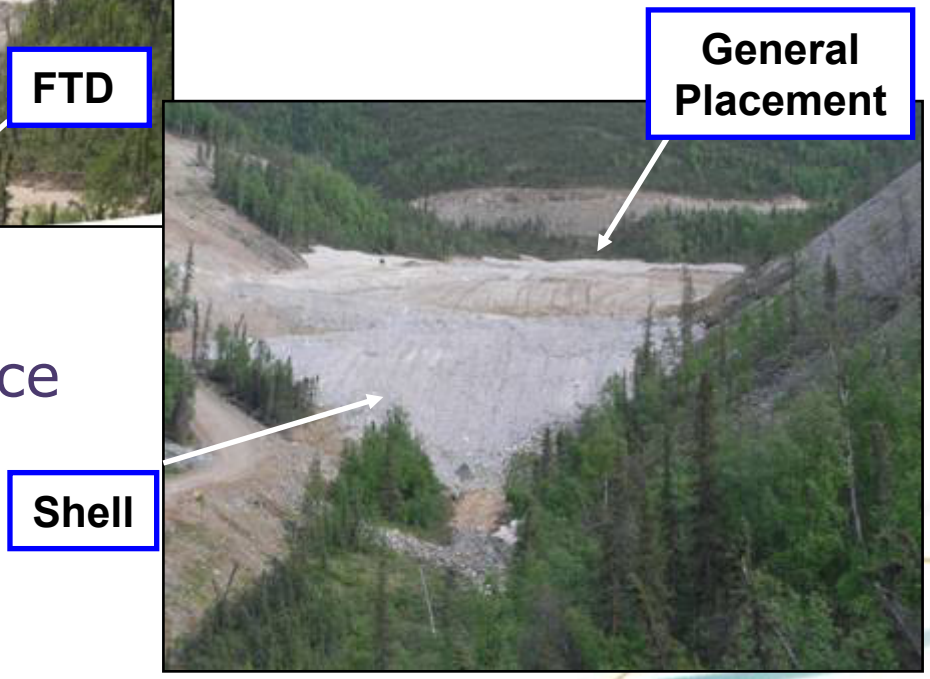
Worldwide Extent – Dry Stacks

- Approximately 55 metal/industrial mineral operations
  - Current range from <100 tpd to about 24,000 tpd
  - Gold, uranium, coal, phosphogypsum, copper, lead/zinc, silver etc.
- Proposed on dozens more – wide variety of mine types
- Fairly broad geographical usage
  - Canada, United States, Chile, Mexico, South Africa, Tanzania, Zambia, Zaire, Australia
- Approximately 12 sand and gravel operations

Dry Stack Physical Attributes

- Viewed by knowledgeable regulators (and correctly so) as both less invasive and less difficult to decommission
  - Not a “dam” impounding fluids
  - Does not conjure up “massive” failure scenarios
  - Lesser footprint
  - Limited, if any, seepage
  - Reclamation advantages
  - Much less water lost
  - Reclaim wash water solution
  - “Optics”
  - ARD dealt with by means other than “flooding”

Pogo Mine, Alaska



Tailings Dry Stack
Nearly two years into service
(June 2007)

Greens Creek Mine, Alaska

Climatic Extremes
Raglan, northern Quebec, and La Coipa, Chile

Raglan – pressure filtered to w_{opt}

La Coipa – vacuum filtered to 2% over w_{opt}

World's Largest Tailings Stack
La Coipa Mine, Chile

- Nominally 20,000 tpd since 1990

Another “Dewatered” Technology - Co-Disposal

- Elkview Coal Mine, British Columbia

Dewatered tailings and coarse coal refuse deposited together

Co-Disposal

Result looks more like a conventional waste dump than a tailings impoundment

Fine (tailings) refuse mixed with coarse (CCR) refuse to create co-disposed “mixed” coal refuse

Dewatered Tailings and ARD

- Dewatered tailings can certainly provide a more “responsible” option for many operations in terms of water management
- Dewatered tailings *can* have oxidation potential enhanced
- This oxidation is balanced against much lower seepage rates (particularly for filtered tailings)
- Thickened tailings
  - Mechanical consolidation intervention prior to the impoundment
  - Still involves a pond to manage
- Paste tailings
  - A common U/G backfill alternative
  - Surface = “thicker” thickened tailings
  - Still has surface oxidation issues
- Filtered tailings
  - No pond
  - Greatest amount of dewatering intervention
  - Needs to have sound geochemical modeling
  - Can traffic and reclaim immediately upon placement

Thank you.