Pacific Region Infrastructure Facility

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

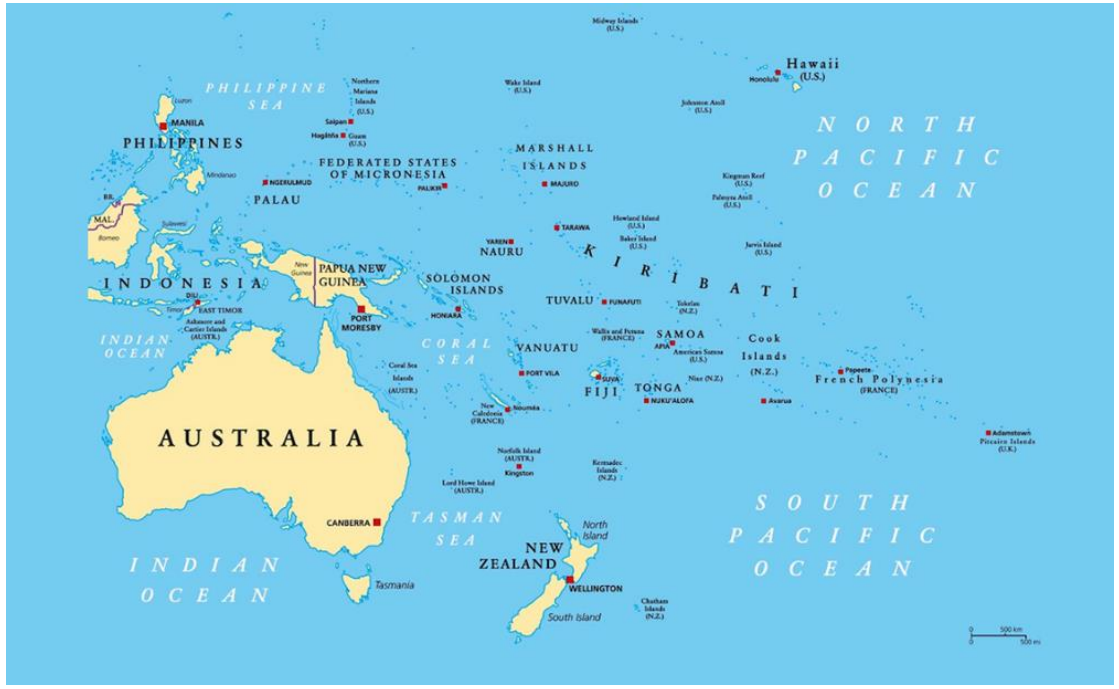
# Aggregates in the Pacific Islands: Alternative Supply Options

Dr Paul Rogers, UQ

11 September 2025

# The challenge of responsible aggregate sourcing in the Pacific

- ADB estimates that Pacific Island Countries need $30 billion in infrastructure investment by 2030
- Aggregate - Sand, gravel and crushed rock – are indispensable for concrete production, road base, road surfacing and land reclamation and climate adaptation works
- Sourcing affordable, quality aggregate of the right type has been a major challenge for infrastructure developers in recent years
- Challenges include:
  - Delays to infrastructure projects
  - High material and shipping costs
  - Port facilities
  - Lack of testing facilities to determine quality aggregate
  - Adverse impacts on infrastructure caused by poor quality
  - Significant environmental and social impacts from extraction



# The 2023-24 PRIF study - Aims and Objectives

## Aim

- Support identification of, and transition to, sustainable and resilient sources of quality, cost effective aggregates across PRIF member countries in the Pacific to meet growing demand from the infrastructure sector

Clearing a boat channel in the Betio Bariki causeway of sand, Kiribati

## Objectives

1. Develop a knowledge base of the aggregates sector focusing on the 14 PRIF member countries
2. Review experience of aggregates sourcing by infrastructure developers in the region
3. Identify fundamental issues, including challenges, associated with sourcing aggregates by infrastructure developers
4. Identify, document and assess alternative materials and their potential to be used in infrastructure projects
5. Assess options to improve the quality and adequacy of supply of aggregates
6. Develop recommendations and best practices to provide input for any future development of safeguards to improve the responsible sourcing of aggregates for key stakeholders

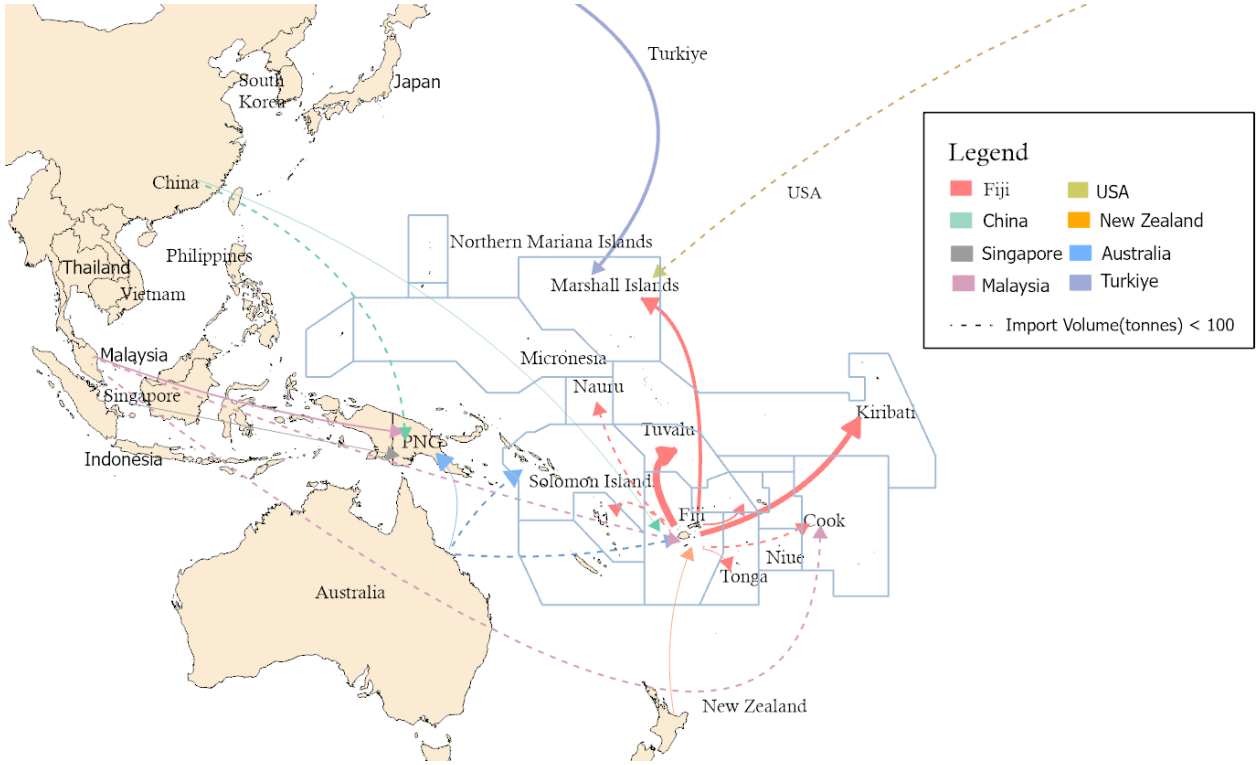
# Findings

## Regional Trade and Supply Chains

- Fiji is the main supplier of aggregates to other countries in the region (60-80% of the region's imports), with Kiribati, Tuvalu and the Marshall Islands being the biggest consumers of materials.
- Aggregate also imported from Australia, New Zealand, China, and even as far away as Tϋrkiye and Norway.

Barge carrying aggregate off Suva, Fiji (photo: Robert Smith, 2022)

Aggregate Regional Trade Pacific Island Countries (2020-2022)



# Findings

## Environmental and Social Issues

- River gravel extraction and coral mining presents serious environmental, social and reputational risks across the region.
- Atoll countries have been especially impacted by unsustainable sand and coral mining over several decades, however, there are bright spots such as ESAT in Kiribati and TCAP in Kiribati and Tuvalu and, potentially, RMI
- Beach sand mining continues even after prohibition, e.g., Tonga.
- Hard rock quarries offer the most responsible and sustainable source of quality aggregate for the region, though with some risks e.g., groundwater impacts in Tonga.

Top: Reef aggregate extraction, Marshall Islands. Bottom: River gravel extraction, Fiji. (photos: Robert Smith, Paul Rogers)

# Findings

## Aggregate costs

- Aggregate costs vary by country, type, quality, and amount of aggregate to be purchased, market conditions, and even the specific quarry it is from
- Quarries do not typically publicly disclose price lists, but an example one Fiji supplier indicated the following costs:

| Type | Price range (F$/m$^3$) | Price range ($/m3) |
|---|---|---|
| AP20-65 rock[430] | $65–70 | $29–31 |
| Sealing chip grades 2-7 | $140–170 | $63–76 |
| Limestone | $280–320 | $126–144 |
| Handpicked spalls (river rock) | $100 | $45 |
| Large hard rocks | Each $100 | $45 |
| Boulders – various sizes | $65 | $29 |

- Desktop review of coastal protection (2017) determined the following costs to acquire "local materials" for protection works per cubic meter:
  - Aggregate/underlayer was $57, sand (~$36), and armour rock ~$115.431
  - Costs included supply and placement on site.

# Findings

## Shipping costs

- Two main ways in which aggregate is shipped: 1) Chartered barges which carry bulk cargo, 2) Schedule ships carrying containers
- Shipping costs are high and can comprise up to 50% of total cost.
- Barge shipping examples:
  - Fiji to Tarawa (~2,100km): AU$135/m3 (US$88)
  - Fiji to Funafuti (~1,000km): AU$96/m3 (US$63)
- Scheduled shipping (container) example:
  - Aggregate transported 3,000 km and then unloaded locally and transported to site. Typical freight costs would be A$500/m3 (~US$385/m3) including taxes and import duties.

# Recommendations

## Good Practice Principles of Responsible Sourcing

- General principles – environmental and socio-economic
- Principles for river extraction
- Principles for sand mining and lagoon dredging (in atoll settings)
- Principles for hard and soft rock quarrying
- Specific guidance for government

Washing of crushed limestone aggregate, Efate, Vanuatu (photo: Paul Rogers, 2023)

## Future actions

- Refine and further develop principles
- Conduct regional workshops
- Develop implementation guidance

# Recommendations

## Explore alternative sources

- Several promising alternative sources of aggregate in the region, including:
  - Nauru's dolomite resources (and possibly those on Kiribati's Banaba Island)
  - Sustainably sourced lagoon sand (e.g., RMI)
  - "Ore-sand" from some of the region's existing and upcoming metallic mines, such as in Fiji, Solomon Islands, and PNG
  - Ferro nickel slag, or "Le Sland", a by-product of nickel refining in New Caledonia (a stockpile of 25 million tonnes is currently not being used and a further 2 million tonnes is added each year)

Top: Dolomite pinnacles, Nauru (photo: Peter Oliver, 2019). Bottom: Le Sland, New Caledonia (photo: SLN)

# Exploring potential sources of aggregates within the Pacific

## Project aims and objectives

- Explore potential sources of aggregates within the Pacific Islands region, focusing on ferro-nickel slag in New Caledonia, dolomite in Nauru and ore sands in Fiji.
- The study will take stock of technical characteristics, supply chains, socio-economic factors, potential uses, and institutional knowledge to validate the feasibility of sourcing alternative aggregates for use in Pacific infrastructure development and climate adaptation
- Led by the New Caledonia Nickel Research Centre, CNRTEC and Pacific Region Infrastructure Facility

# Ferro-nickel slag, ‘Le Sland’, from New Caledonia

- A manufactured sand that is a by-product of nickel smelting (SLN & Koniambo)
- Used for over 80 years in New Caledonia and elsewhere in a wide range of applications:
  - Land reclamation - 20% of Noumea (1,000ha) is built on land reclaimed with Le Sland
  - Road base, sub-base, asphalt aggregate
  - An aggregate in concrete applications, including tetrapods for coastal protection (up to 50% sand replacement)
  - Geotextile bag fill for coastal protection (Vanuatu)
  - 100% sand replacement in bricks for housing (Tonga)
  - Sandblasting material
  - As a Supplementary Cementitious Material (SCM) to reduce use of expensive, carbon-intensive clinker to make concrete

Plans for extension of private quay, RMI

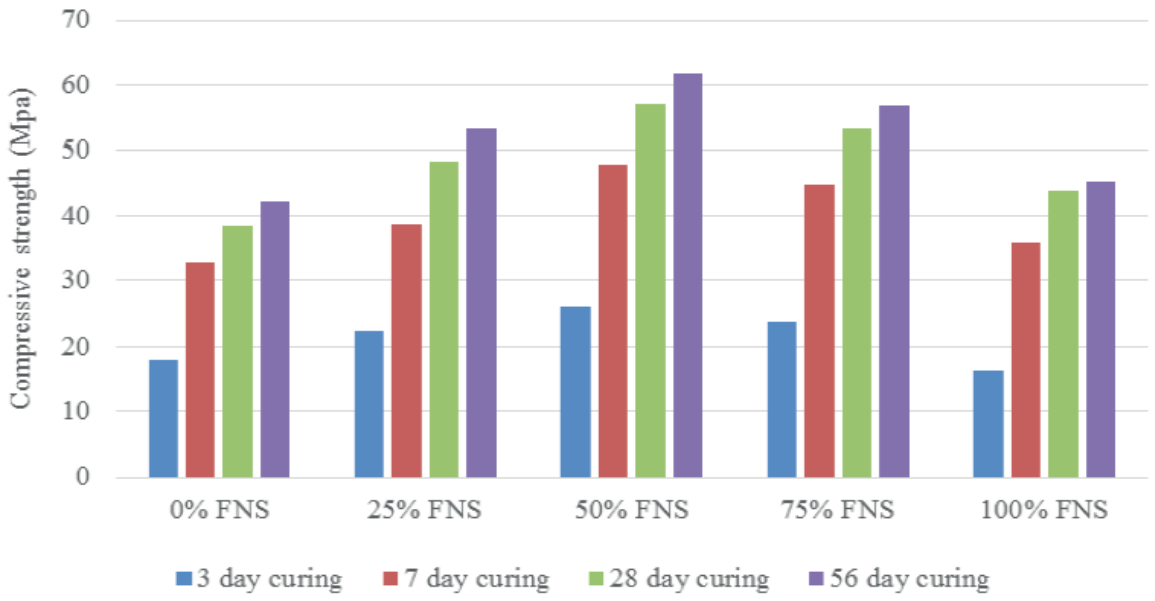
# Performance and cost - aggregate

- Similar compressive strength compared to natural aggregates
  - California Bearing Ratio (CBR) values of around 40
  - Durability – Los Angeles Coefficient: 12
- Very cost competitive with other aggregates:
  - Free-on-board price for putting Le Sland on a barge is ~US$10/ton
  - Shipping costs to Majuro ~US$35/ton

# Performance - concrete

- Compressive strength increases with sand content up to an optimal level of 50%
- Reportedly excellent workability (optimal around 50% content) and good finish
- Compliant with European and Australian Standards (e.g., AS 2758: Aggregates and rock for engineering purposes)
- Questions about risk of alkali-silica reaction in concrete but recent tests of New Caledonian FNS show no/low reactivity.

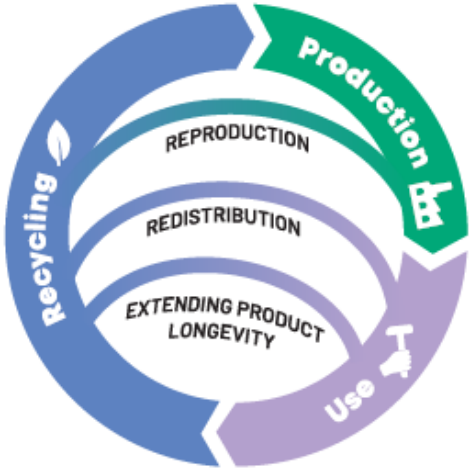
FNS content and compressive strength




# Environmental benefits

- Circular economy benefits
- Ready-supply of aggregate with proven properties for climate change adaptation works (land reclamation, coastal protection etc.)
- Stable, non-leaching / toxic material – used as land-fill for Noumea City for decades with no negative environmental impacts
- Hardens when in contact with salt water, so good for geotextile bags for coastal protection
- Use as an SCM means reduced clinker use and hence, carbon emissions reduction for cement production

*Circular Economy/ Cradle-to-cradle Model*

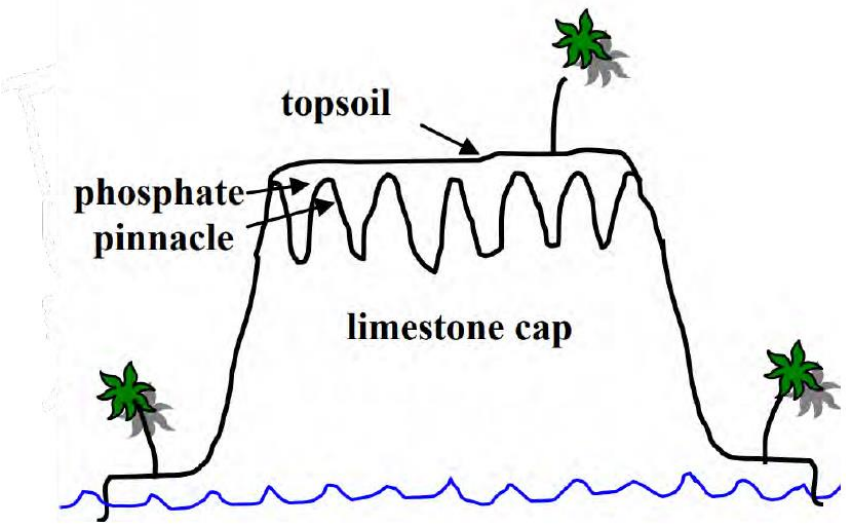



# Logistics

- Dedicated owned berth at plant in Noumea
- Ship loader (max capacity 600t/h)
- Long term contracts with shipping companies in area available
- SLN has experienced logistics team
- But how to get material into small and outer islands?

# Dolomite from Nauru

- Dolomite is an anhydrous carbonate mineral (calcium magnesium carbonate) that can be crushed to produce strong, high-quality aggregate suitable for concrete, road construction and other applications
- A source of much in-demand ‘big rock’ for seawalls and coastal protection.
- A waste product resulting from decades of phosphate mining - extraction would have the benefits of creating a valuable product and rehabilitating disturbed land, which is scattered with dolomite pinnacles




# Nauru's dolomite

- The dolomite pinnacle fields left after phosphate mining ended cover an area of 1,600 ha or ~68% of Nauru's land area
- Primary pinnacles – above ground, secondary pinnacles are below the level reached by phosphate mining down to the fused base.
- Resource estimates: primary pinnacles ~5,525,000 $m^3$; secondary ~25,000,000 $m^3$
- Assumption is that deeper dolomite is denser and of superior quality

Photo credit: Peter Ollivier 2019

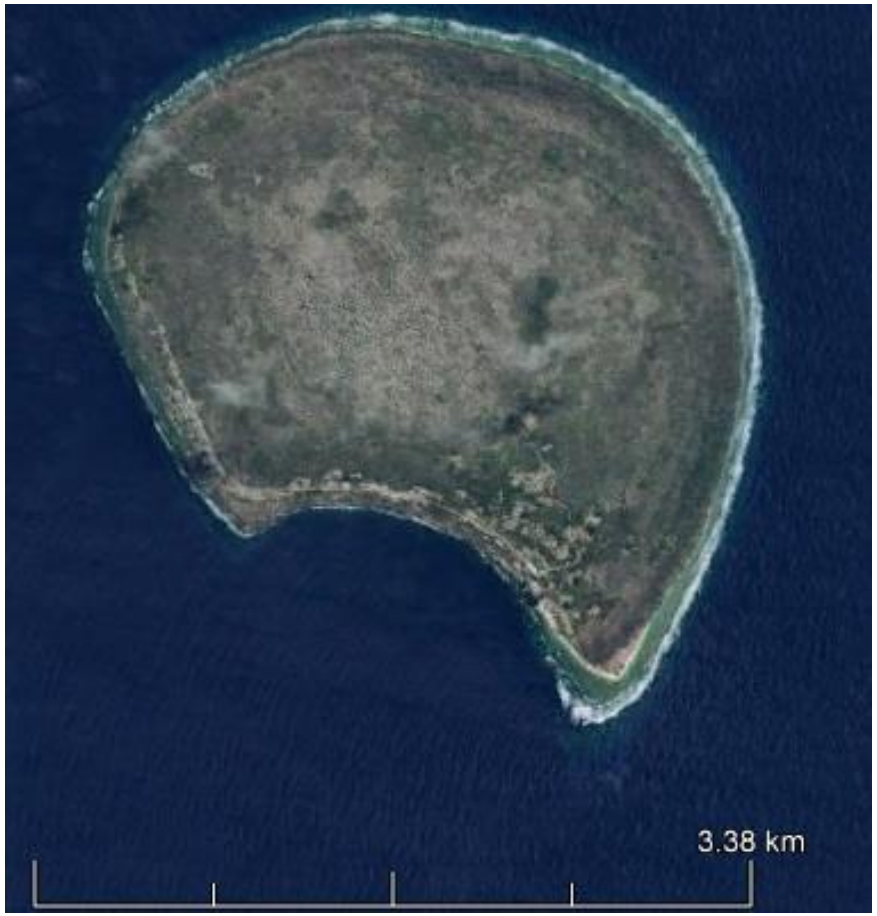
# Nauru's dolomite - advantages

- A well managed quarry industry could make Nauru self-sufficient in aggregates and a key exporter to neighbouring countries
- Currently one active quarry in Nauru operated by the NRC
- Advantages:
  - High demand for big rock, quality aggregate, particularly in atoll countries
  - Geographically well placed
  - Recent port redevelopment
  - Experience shipping dolomite to other countries (e.g., PII in RMI)
  - Government commitment - aligned with Nauru National Sustainable Development Strategy (NSDS) 2019–2030

# Nauru's dolomite - challenges

- Ensuring costs are competitive with other suppliers (e.g., Fiji)
- Access to affordable, regular shipping
- Ensuring roads, access points and quarry management are at a high standard (e.g., good practice benching practices)
- Skills shortages (e.g., blasting engineers)
- Availability and maintenance of plant and equipment
- Access to land?

# Banaba's dolomite – a long-term option?

# Ore-sands – a circular economy solution to the global sand crisis

- Ore-sand is a manufactured sand produced as a by-product of metal ore mining
- **Not tailings repurposing – is a product of the ore not the waste!**
- Originated from a partnership between Vale Minerals, UQ and University of Geneva:
- Catastrophic tailings dam collapses in Brazil and the "global sand crisis"
- Vale now commercially sells ore-sand in Brazil
- UQ partnerships with other minerals companies to develop ore-sand, including Newmont in Australia, Anglo-American in Chile, with scoping work being undertaken with Rio Tinto and Arcelor Mittal

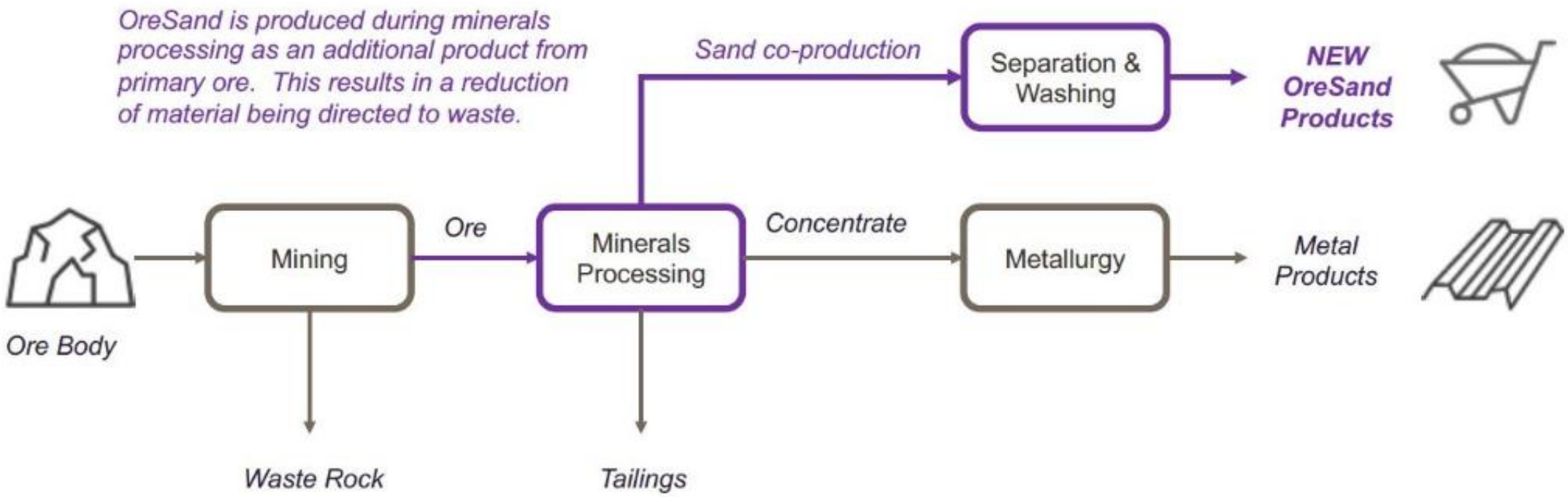
Ore-sand stockpile – Vale's Brucutu Mine

# Ore-sands – the limits of natural sand extraction

- Every year, the mining industry produces over 13 billion tonnes of tailings waste and additional tens of billion tonnes of waste rock
- ~3,400 active tailing storage facilities in the world (>8,000 in total)
- Potential to dramatically reduce mine waste / tailings by up to 50% and reduce demand on natural sand
- Natural sand extraction is unsustainable: 14 million sized Olympic sized pools used each year with massive environmental impacts


Vale ore-sand

# Ore Sand – the process



# Ore sands in Fiji

- Initial investigations being undertaken as part of the Blue Concrete Initiative in Fiji
- Potential to provide another source of sand for the infrastructure sector while taking pressure off Fiji's rivers, some of which are under acute environmental stress.
- Discussions to explore the feasibility of producing ore-sand in Fiji currently underway with two gold mining companies


- Motivation - desire to reduce tailings due to pressure on tailings storage facilities
- Potential in other metals mines in the region, including in PNG and the Solomon Islands

# Thank you


- Dr Paul Rogers
- Senior Research Fellow
- p.rogers@uq.edu.au
- +61 413 722 365