



SAND & CIRCULARITY

*Aiming at a symbiosis between the
Geosphere and the Anthroposphere*

Eric PIRARD

Luc COURARD, Julien HUBERT

Content

- **PEAK** Sand ?
- A **RENEWABLE** Resource ?
- A **CRITICAL** Raw Material ?
- A **CIRCULAR** Material ?

Peak Sand ?



[LOCATIONS](#)

[SERVICES](#)

[ABOUT US](#)

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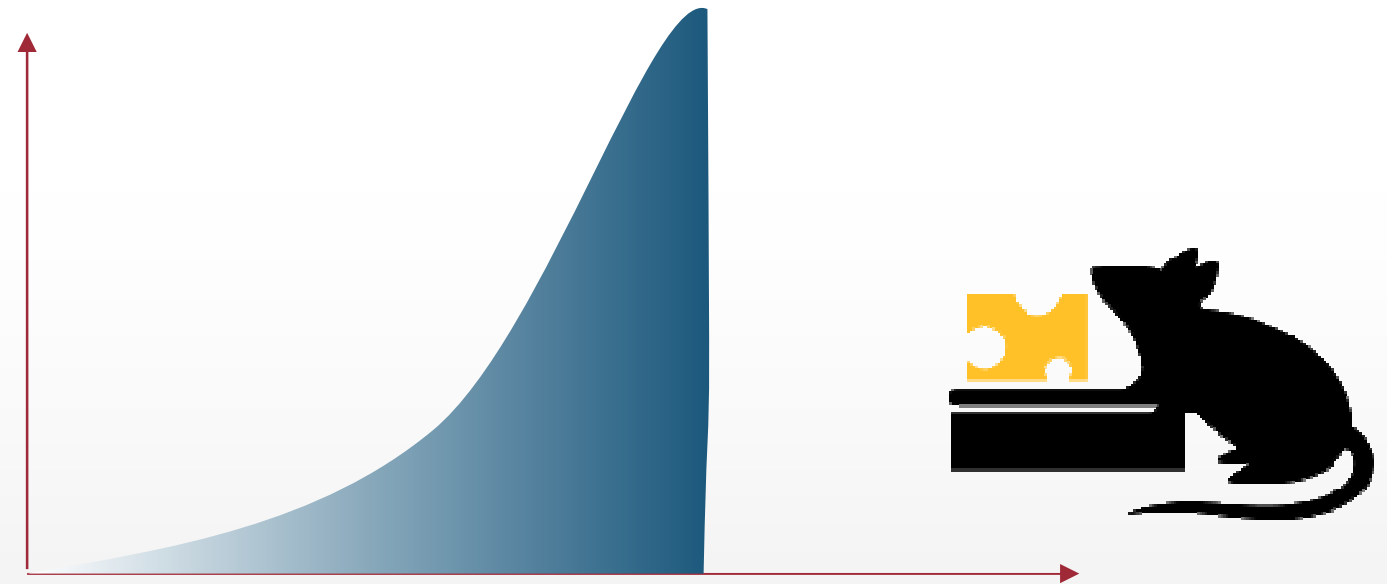
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Peak sand ?

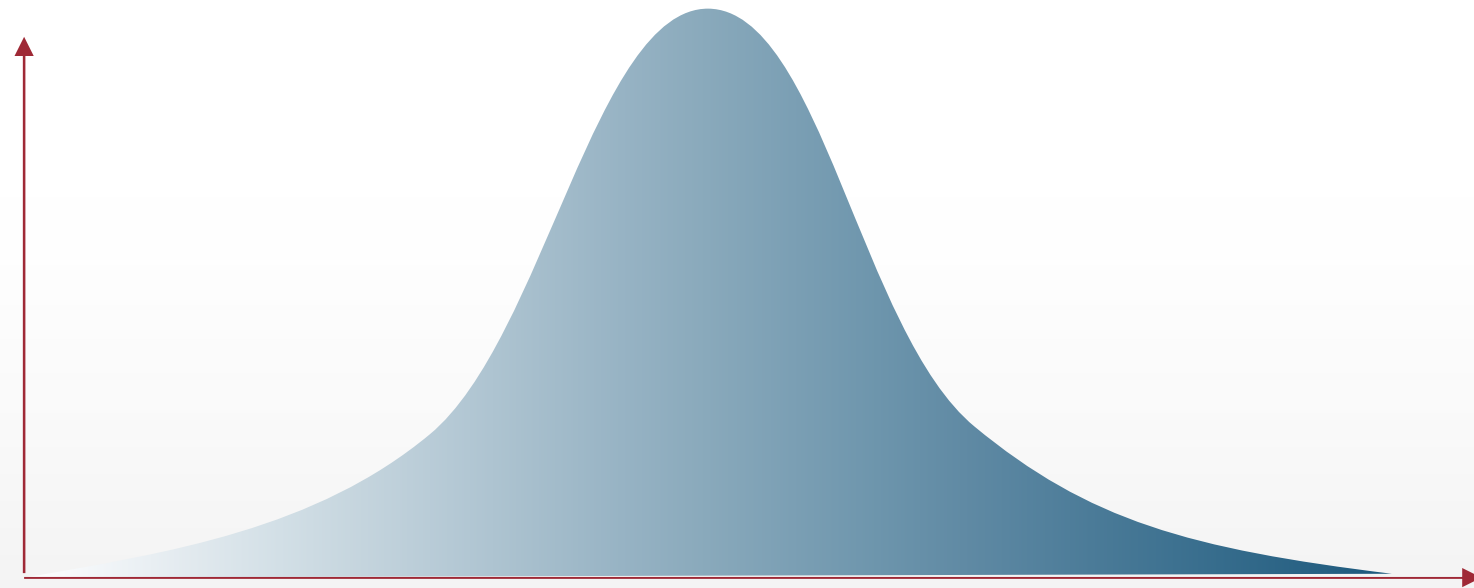
- Modelling the availability of a non-renewable resource
 - Depletion of a fixed stock
 - No awareness of the end of stock



! Abiotic Depletion Potential (ADP) in LifeCycle Analysis is based on this idea (Guinée & Heijungs, 1995)

Peak sand ?

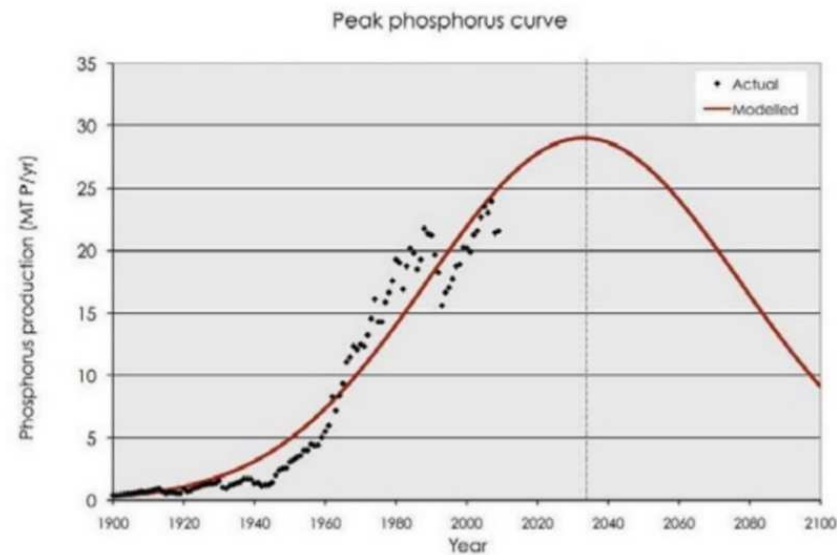
- Modelling the availability of a non-renewable resource
 - Depletion of a fixed stock
 - Awareness of **RARITY** : increases prices and limits availability



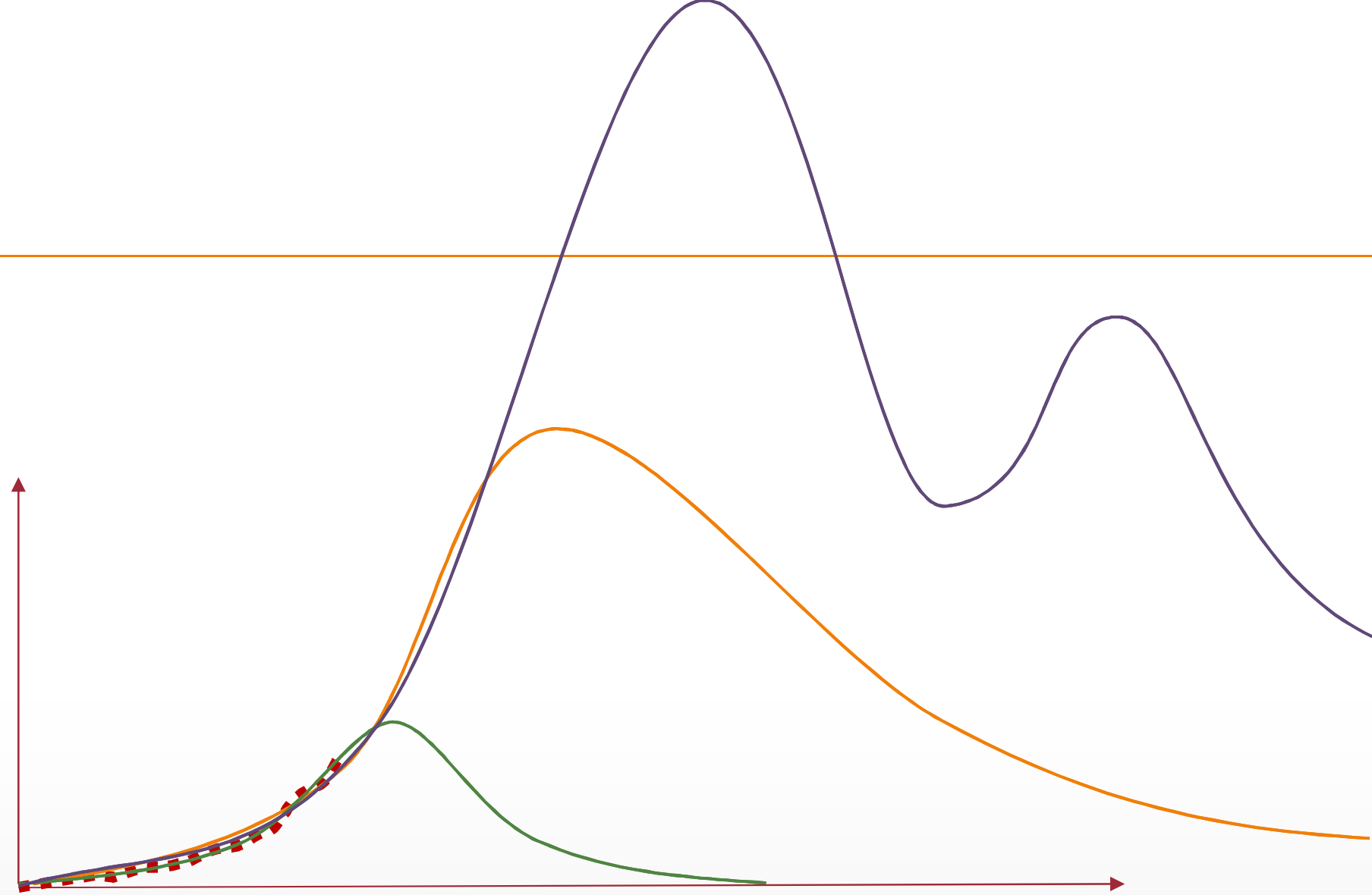
! Impact Assessment Based on Surplus Energy (SOP/RECIPE) is based on this idea (Vieira et al., 2016)

Peak Anything

- When is the peak ?
 - No easy answer



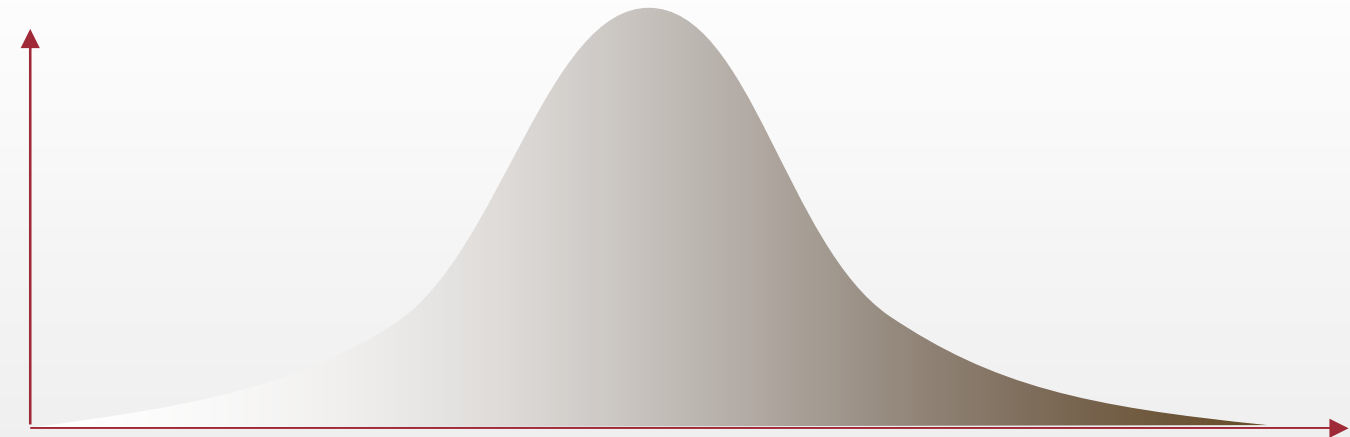
Peak Phosphorus (Cordell D., 2010)



- Four fallacies of peak theories (Wellmer and Scholz (2017))
 1. Assuming a fuel-tank model for a deposit or a group of deposits
 2. Assuming that every peak has its cause in geological availability
 3. Assuming one can forecast a peak based on an idealistic logistic or Gaussian-type curve
 4. Assuming one can reconstruct a Hubbert curve from known reserves and resources

Peak Natural Sand

- EXPLORATION : Do we know all remaining resources ?
 - Superficial material
 - No costly and deep exploration needed
- TECHNOLOGY : Do we expect technological breakthroughs to unlock resources ?
 - Deeper dredging
 - Mineral processing
- SUPPLY RISK Are we dependent on imports
 - Limited transportation
 - 25 km doubles the price!

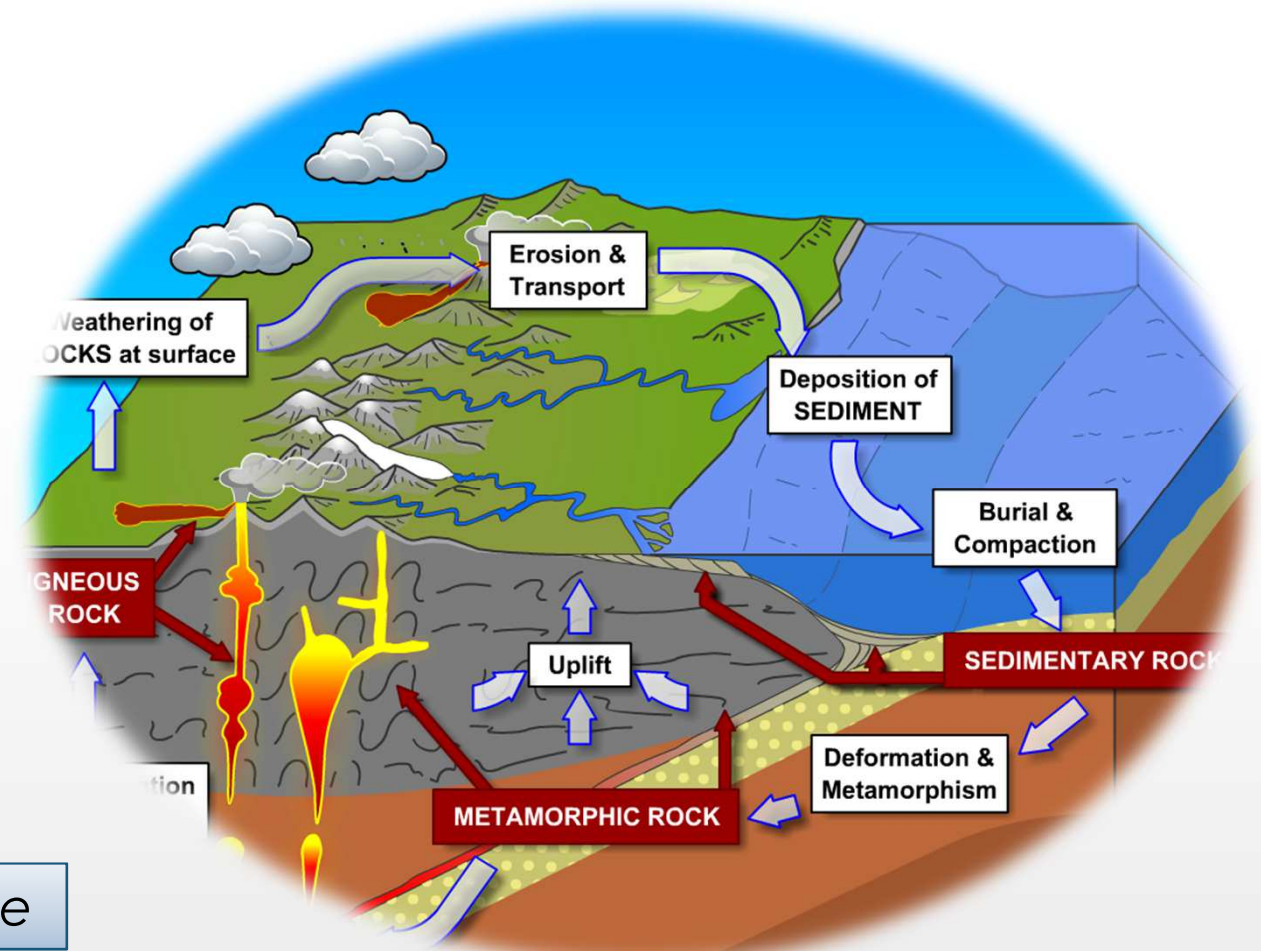


Natural sand is peaking (regionally),
except if it is renewable...

Sand : A Renewable Resource?

A Renewable Resource?

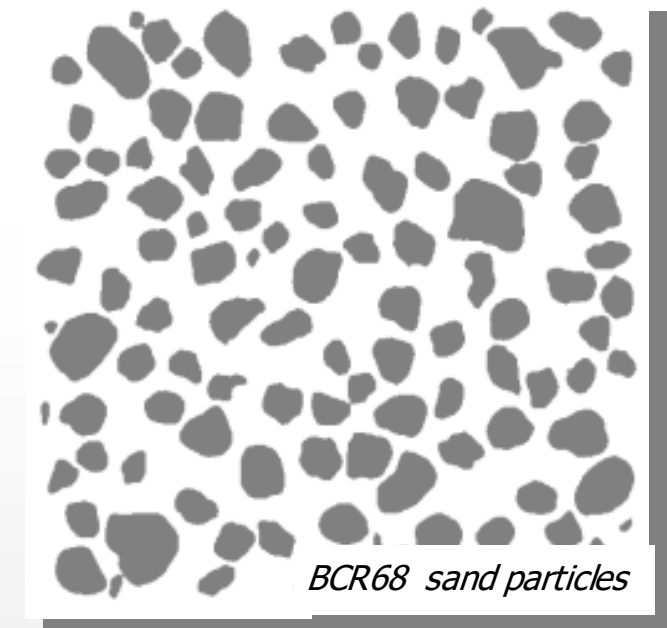
- Natural cycles are highly variable in speed and duration
 - **Surface Cycling**
 - Ex. water, carbon,...
 - ✓ Atmosphere/Hydrosphere (hours ⇔ years)
 - **Near-surface Cycling**
 - Ex. phosphorus, fossil carbon,...
 - ✓ Hydro/Bio/Geosphere (years ⇔ kyrs)
 - **Deep Cycling**
 - Ex. copper, chromium, tungsten, deep carbon
 - ✓ Geosphere (kyrs ⇔ Myrs)



There is no such thing as a sand cycle

A Renewable Resource?

- What is sand for a GEOLOGIST?
 - Sand is a granular material resulting from erosion/transportation processes. It is typically composed of finely divided particles in the range **63 μm to 2mm**.
 - NATURAL SAND (SN)
 - Accumulation rate much slower than extraction rate
 - Natural Erosion **12 Gt/yr**
 - Human Extraction **100 Gt/yr** (25% for construction)
 - Not-renewable from a human perspective



Sand is not renewable at current extraction rates

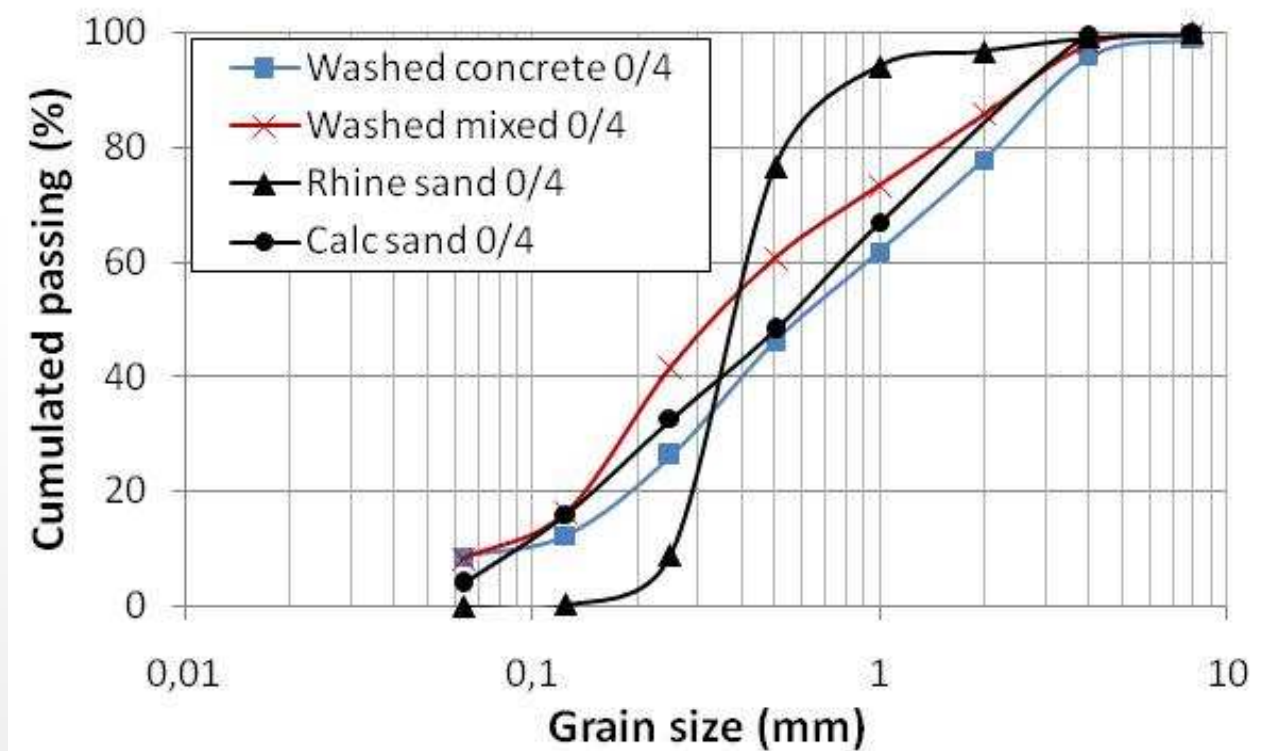
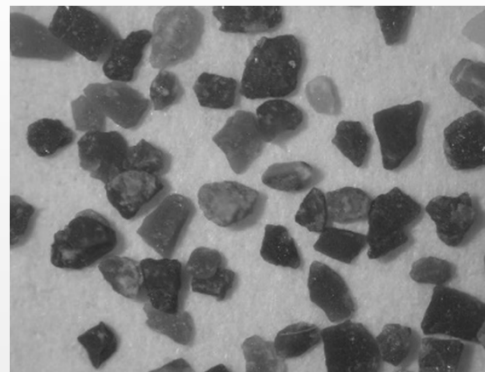
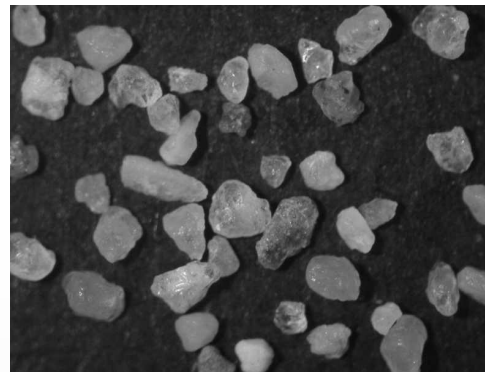
A Renewable Resource?

- What is sand?
 - **ENGINEERING** : Sand is any particulate material with a size distribution below 4 mm.
 - It is a « functional material » : **fine aggregate** (NBN EN 1620)

- Very low value < **10€/ton**
- Limited transportation (**30 km**)

- NATURAL SAND (SN)

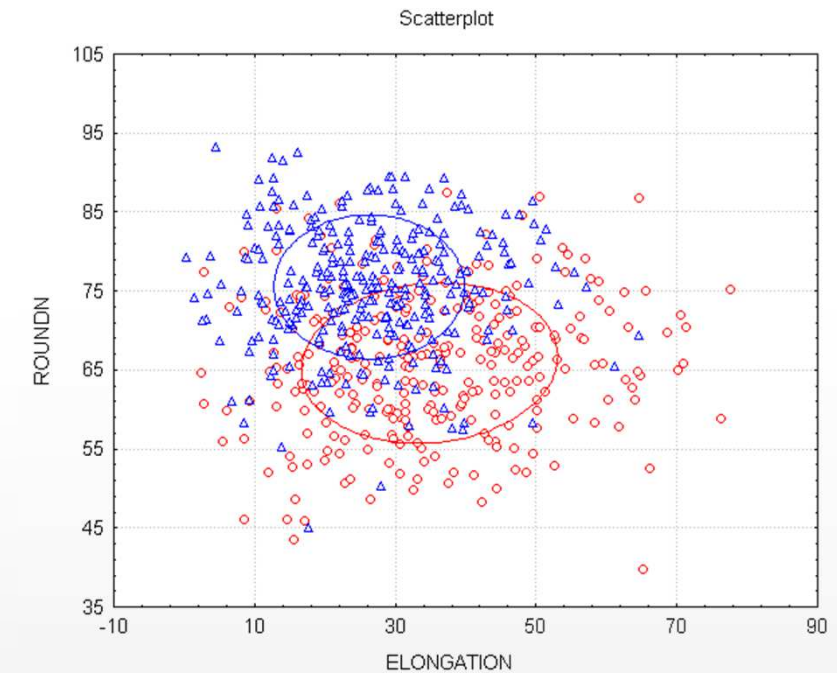
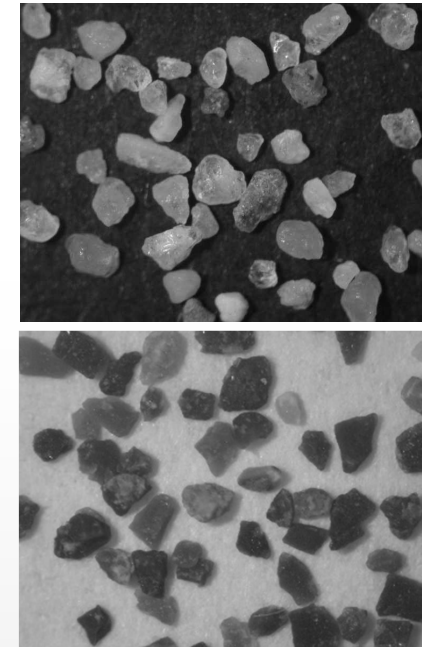
- CRUSHED SAND (SC)



By-passing the natural cycle

A Renewable Resource?

- Crushed Sand
 - Can substitute SN provided functionality is preserved
 - Particle Size Distribution
 - Particle Shape
 - ✓ Flakiness, Bluntness, Specific Surface, ...
 - Mineralogy
 - ✓ Carbonates, Silicates,...
 - Contaminants
 - ✓ Chloride, Sulphide, Organics,...
 - Double as much embodied energy (climate change)
 - Less impact on biodiversity and resource depletion



Sand – A Critical Raw Material ?

Sand and Criticality

- <https://rmis.jrc.ec.europa.eu/>

Choose a raw material

Choose a raw material

Aggregates

Aluminium

Antimony

Arsenic

Baryte

Bauxite

Bentonite

Beryllium

Bismuth

Borates

Cadmium

Cerium

Chromium

Cobalt

Coking coal

Copper

Diatomite

Dysprosium

Erbium

RMIS - Raw Materials Profiles - **Aggregates**

Raw Materials Dashboard

Primary Exporters

Primary Importers

EU Sourcing (primary)

IR (primary) 1%

EOL-RIR 10%

Uses Construction

2,621 Mt of aggregates produced in 2018 in the EU

Germany Top EU producer of aggregates in 2018

NO Critical Raw Material in 2020?

RMIS © 2020 European Commission

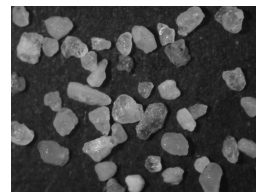
Limited information available
Aggregates (only 15% in sand range ?)

Sand - A Circular Material ?

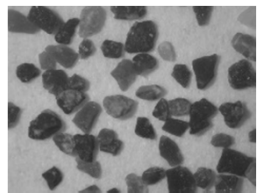
Sand and Circularity

- The four challenges of a more circular economy

5 tons aggregates / cap.year



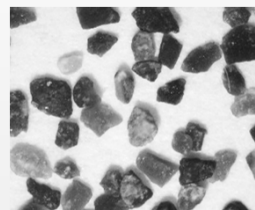
SN
41%



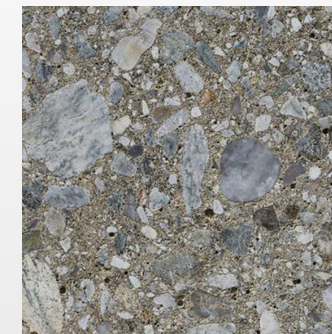
SC
47%



**CONCRETE
DESIGN**



SR
10%

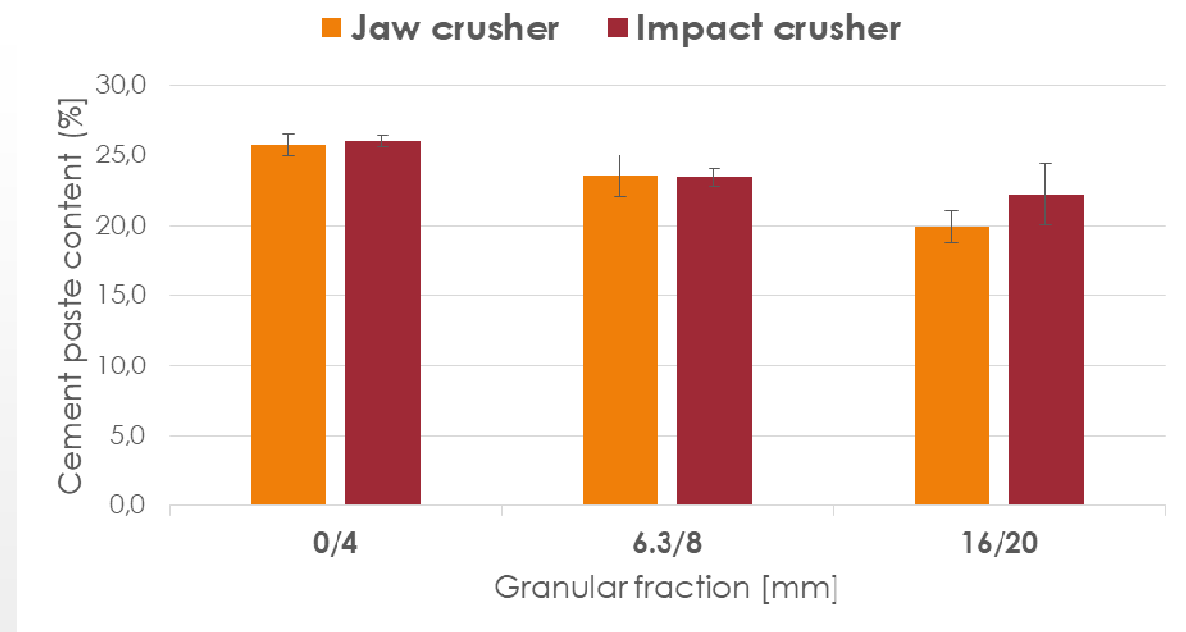
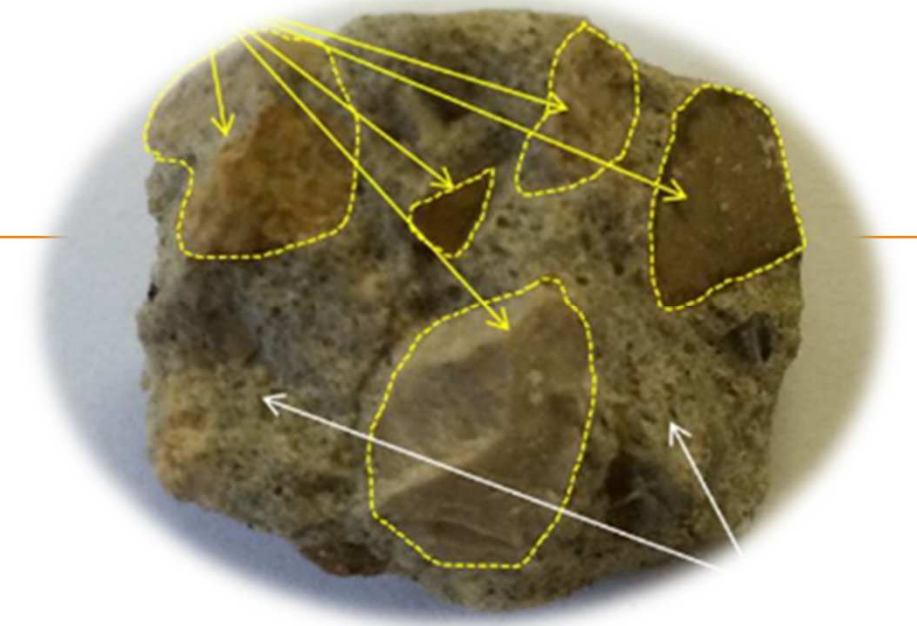


DURABILITY



Sand and Circularity

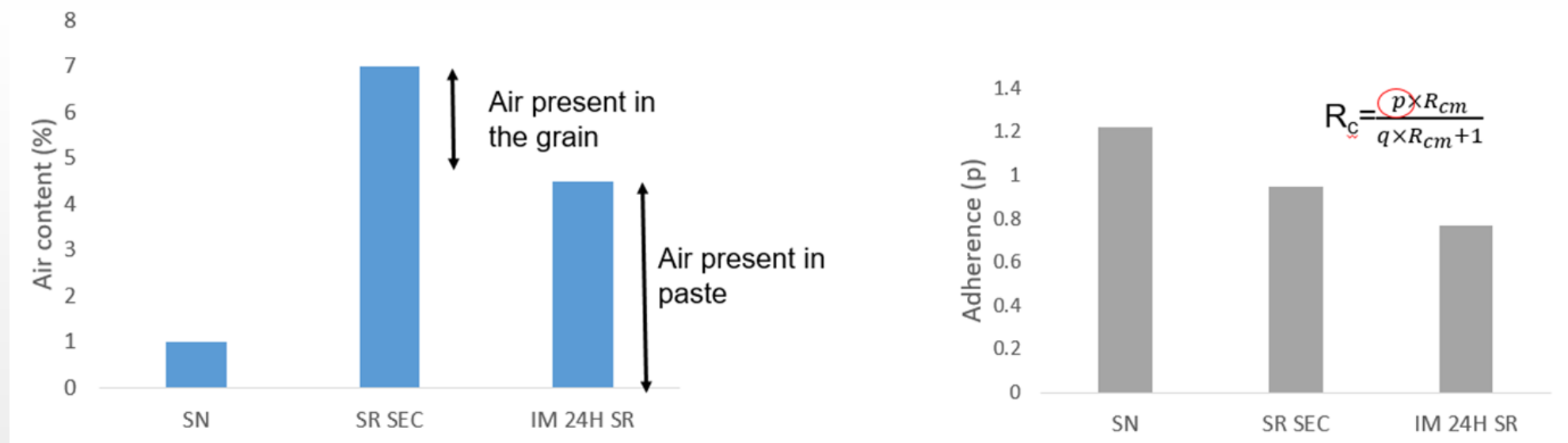
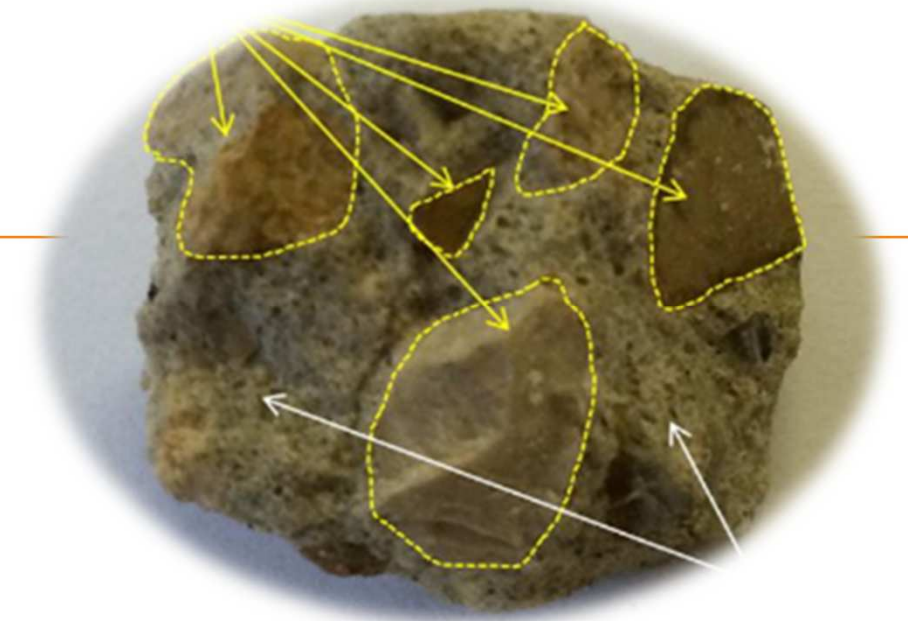
- Recycled Sand
 - Fine Recycled Concrete Aggregate (RCA)
 - Not accepted as substitute to SN
 - Lack of trust inducing downcycling
 - Uncompetitive prices
 - End-of-waste legislation
 - Variable composition with size
 - More cement in finest fraction
 - Washing to remove $< 63 \mu\text{m}$ (10% by mass)
 - Less appropriate for concrete
 - Lower density
 - Higher sulphate content
 - Higher water absorption



Sand and Circularity

- Recycled Sand in mortars

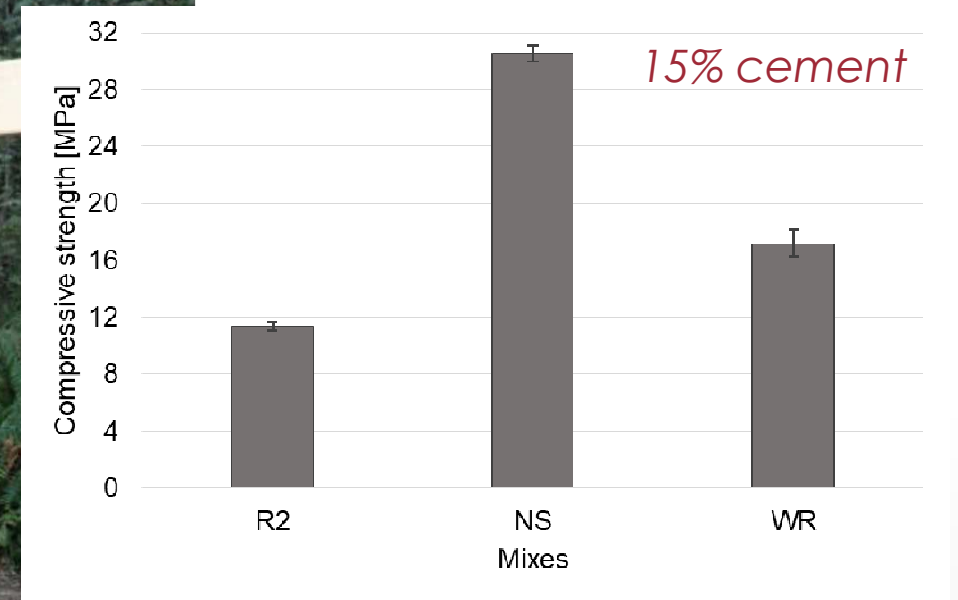
- Higher air content in the cement paste for the mortar made with the recycled sand.
- Better adhesion between the natural sand and the cement paste
- Using recycled sand in dry state gives better mechanical strength than when saturated



Use of grinded hardened cement pastes as mineral addition in mortars. M.K. Bouarroudj, S. Remond, D. Bulteel, F. Michel, Z. Zhao, L. Courard. *Journal of Building Engineering* 2020, 101863. (<https://doi.org/10.1016/j.jobbe.2020.101863>) (<http://hdl.handle.net/2268/251565>).

Sand and Circularity

- Rammed concrete



Recycled sand (R2)

Natural sand (NS)

Washed Recycled sand (WR)

Conclusion

Conclusions

- Natural sand is peaking and irreplaceable
 - Unsustainable extraction rates
- Engineering sand can be produced to substitute natural sand
 - Unlike clay minerals!
- Aggregates can be locally critical
 - Long supply distance
 - Poor energy mix
- Lifecycle Analysis needs more data
 - Resource depletion requires a different approach than for metals
- Circularity requires more trust
 - More research on sand quality vs. concrete
- Concrete should be made to last
 - Oldest buildings are not yet turning 100 years!

Thank You