A geometrical texture model for geometallurgical separation prediction

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Modelling objectives

For geometallurgical simulations, we need to link ore properties to the separation outcomes that we can expect if processing that ore.

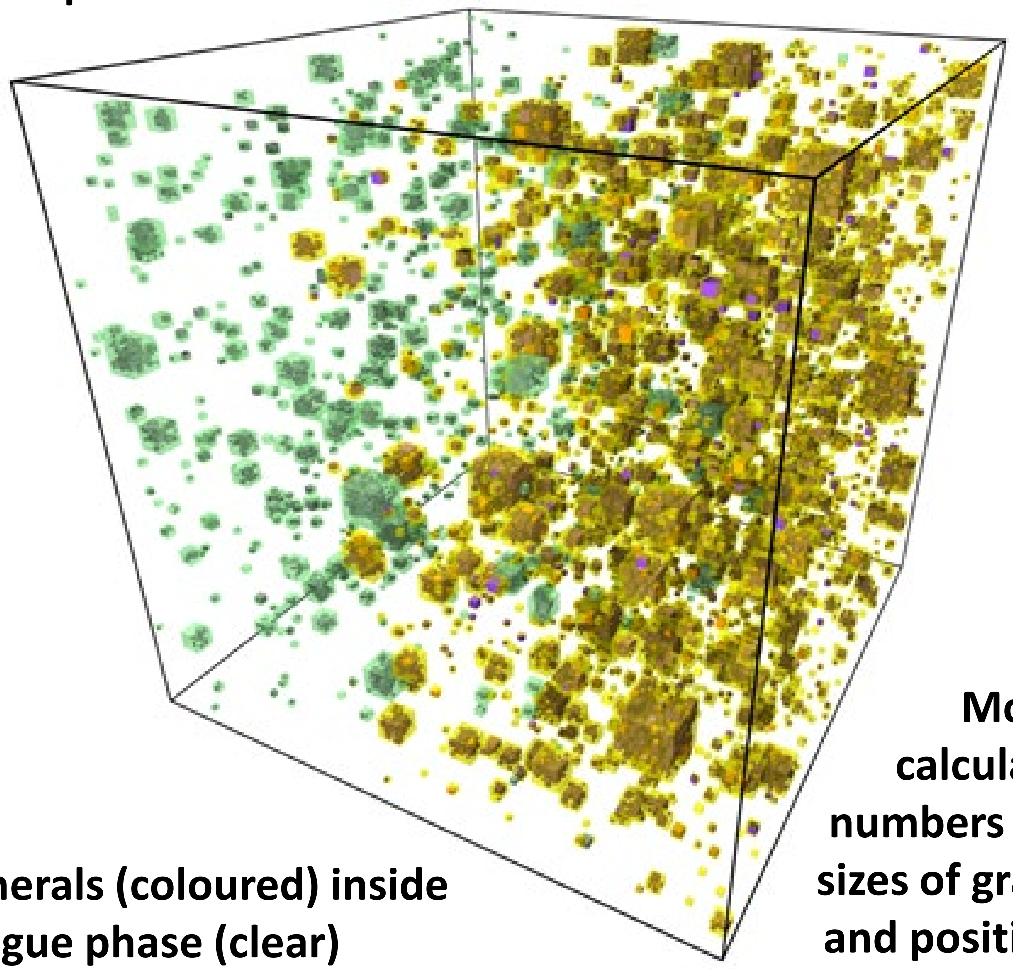
1. Mathematical 3D representation of intact ore texture
   - Representative of a larger parcel of ore
   - Should be sufficiently detailed (Several mineral phases, describe associations between minerals)
2. Predict the composition and properties of particles obtained by mathematically breaking the intact texture
   - Calculate theoretical liberation distributions
3. Be able to separate or sort these particles according to their properties
   - Calculate grade and recovery for a given grind size

Geometrical Texture Model: 3D Texture Construction

An artificial rock with a texture representative of a portion of the ore body

Model inputs (per mineral)

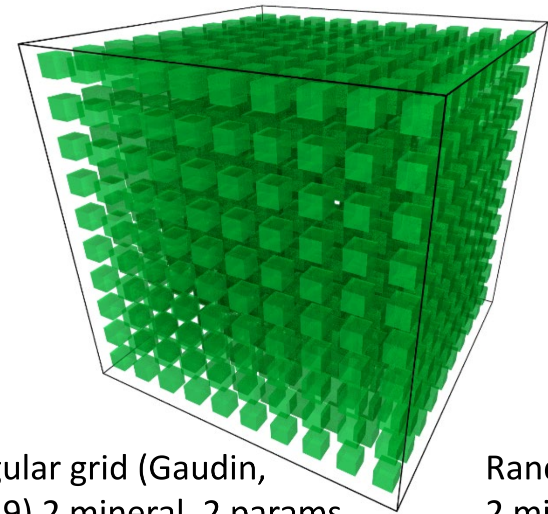
- Mineral grade
- Grain size distribution
- Proportion associated with other minerals
- Degree of clustering



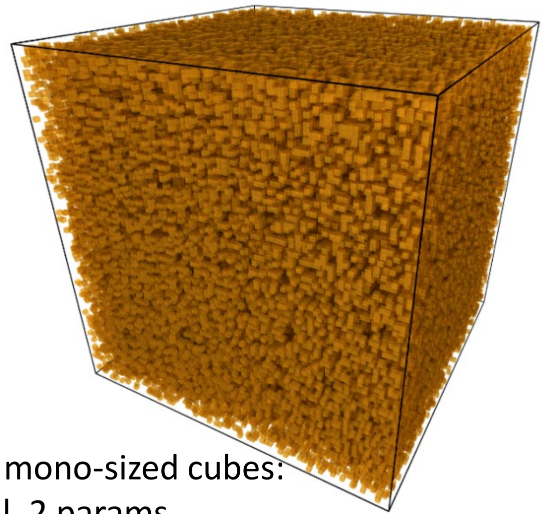
Minerals (coloured) inside gangue phase (clear)

Model calculates numbers and sizes of grains and positions

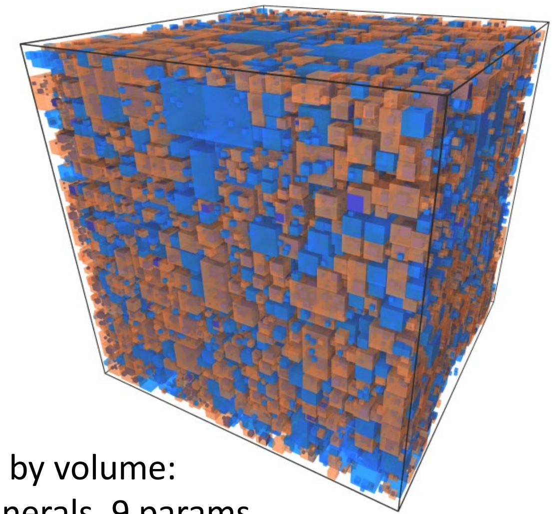
Examples of hypothetical simulated textures



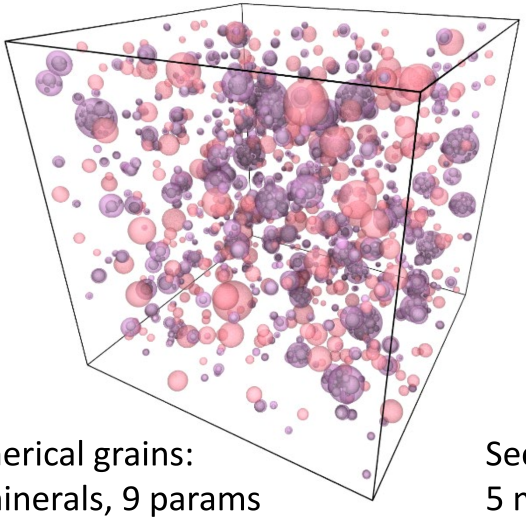
Regular grid (Gaudin, 1939) 2 mineral, 2 params



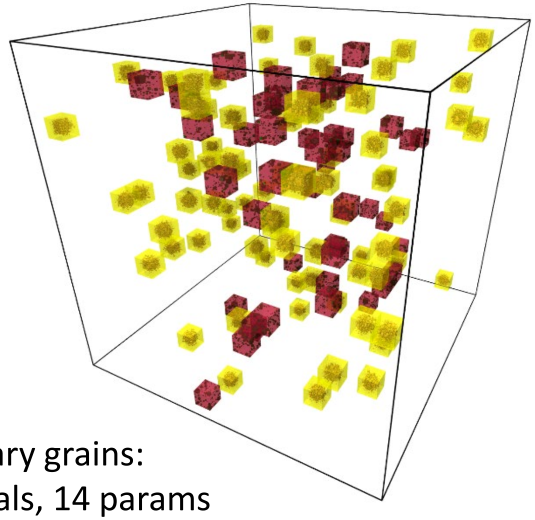
Random mono-sized cubes: 2 mineral, 2 params



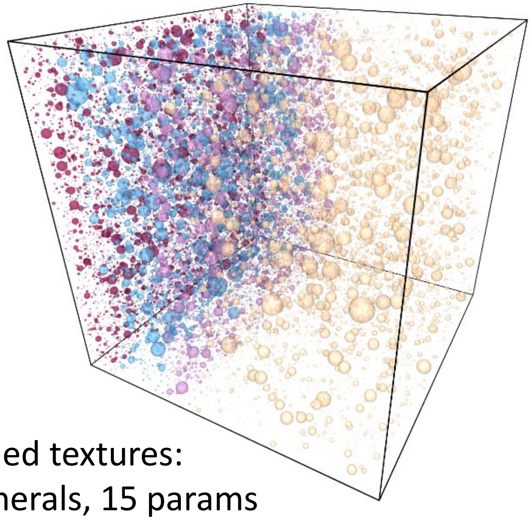
62% by volume: 4 minerals, 9 params



Spherical grains: 4 minerals, 9 params



Secondary grains: 5 minerals, 14 params

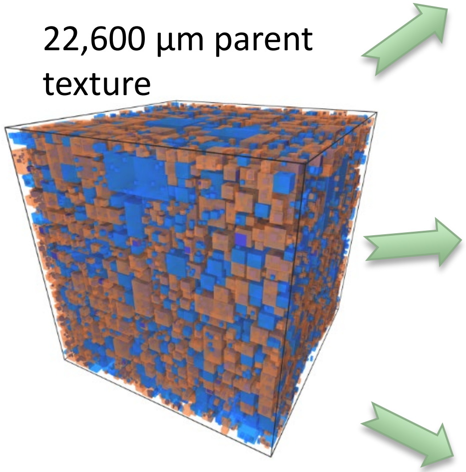


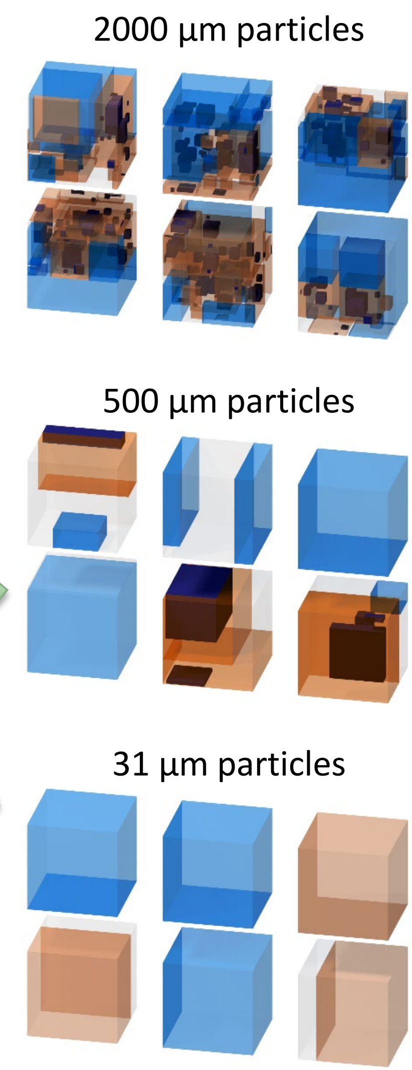
Banded textures: 5 minerals, 15 params

Particle production & particle properties

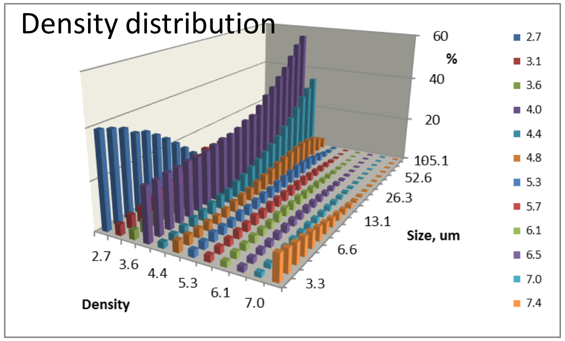
- ‘Break’ the texture to create particles (random sampling)
  - 60 size fractions 9.5 mm to 0.3 µm
  - 10^6 particles in 10-60 seconds

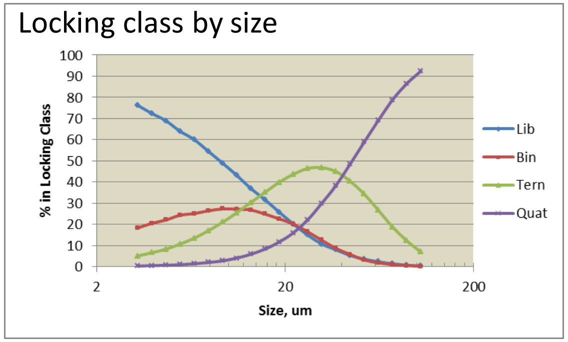
- For each particle, calculate
  - Density
  - Volumetric composition
  - Surface composition
  - 2D section composition
  - Perimeter composition
  - Locking class (Liberated, binary, ternary …)
  - Grain count

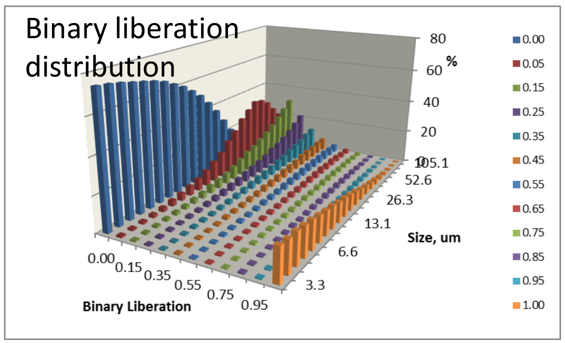


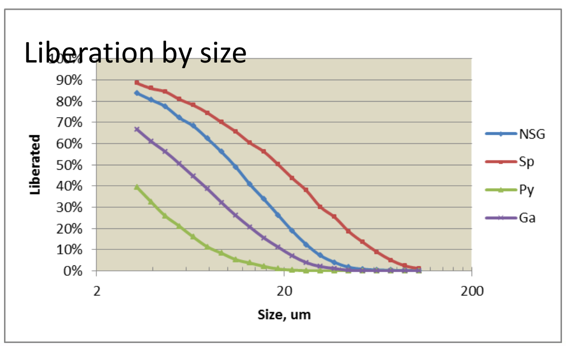


Particle property reports – Similar format to MLA/QemScan









Particle class distributions

Size 74.33 um

Mineral	Lib	Bin-NSG	Bin-Sp	Bin-Py	Bin-Ga	Tern	Quat+	Total
NSG	0.15	-	0.09	0.11	0.00	10.87	34.87	46.09
Sphalerite	1.21	0.76	-	0.00	0.00	0.71	20.95	23.63
Pyrite	0.00	0.00	0.00	-	0.00	3.12	9.87	12.99
Galena	0.00	0.00	0.00	0.00	-	4.10	13.19	17.29

Size 37.16 um

Mineral	Lib	Bin-NSG	Bin-Sp	Bin-Py	Bin-Ga	Tern	Quat+	Total
NSG	1.86	-	1.97	2.05	0.14	24.91	15.60	46.53
Sphalerite	5.94	3.48	-	0.00	0.01	2.38	11.40	23.21
Pyrite	0.00	0.27	0.00	-	0.19	7.71	4.83	13.00
Galena	0.21	0.06	0.00	0.52	-	9.97	6.51	17.27

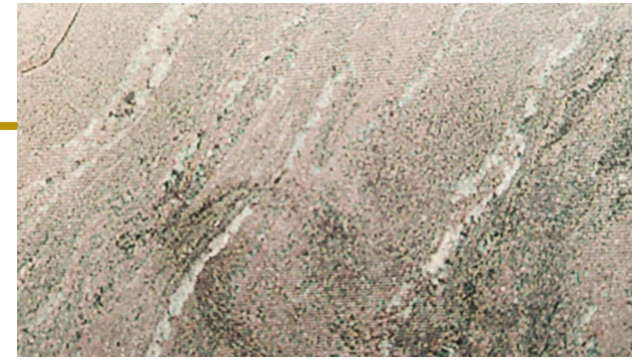
Size 18.58 um

Mineral	Lib	Bin-NSG	Bin-Sp	Bin-Py	Bin-Ga	Tern	Quat+	Total
NSG	12.46	-	4.35	6.08	0.97	19.70	3.97	47.53
Sphalerite	11.27	5.14	-	0.02	0.02	2.17	3.77	22.40
Pyrite	0.12	1.58	0.01	-	1.37	8.08	1.72	12.87
Galena	1.94	0.60	0.03	2.47	-	9.96	2.20	17.20

Size 6.57 um

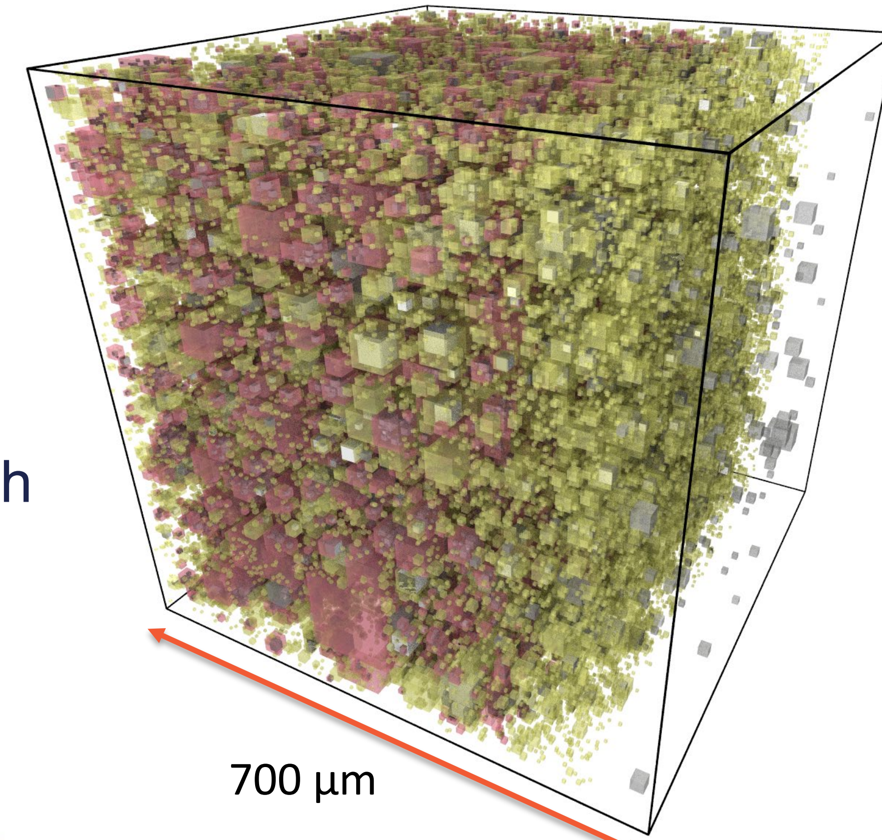
Mineral	Lib	Bin-NSG	Bin-Sp	Bin-Py	Bin-Ga	Tern	Quat+	Total
NSG	33.20	-	2.98	5.85	1.20	5.11	0.24	48.58
Sphalerite	17.46	3.29	-	0.06	0.02	0.98	0.50	22.32
Pyrite	1.97	3.22	0.04	-	3.29	3.62	0.29	12.42
Galena	7.45	1.07	0.02	4.06	-	3.73	0.35	16.68

Texture fitting / reconstruction



Bojevski (2004) MSc Thesis

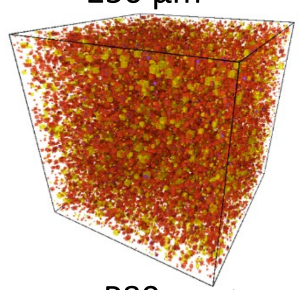
- Demonstrated for a fine-grained “banded sphalerite” ore
  – Pyrite (yellow), Sphalerite (pink), Galena (grey) & NSG
- 25 fitted parameters
- 3D reconstruction from 2D QemScan data @ 4 particle size fractions
- Predicts pyrite-rich and NSG-rich regions – corresponds with banding observed in actual texture



Particle separations

- Simulated particles can be separated one at a time based on their properties
- Recovery models for
  - Gravity separation
  - Flotation
  - Sorting
- Predict overall grade and recovery
- Can also solve for optimum grind size for required recovery objective

P80 = 250 µm



P80 = 250 µm

Simulated gravity-sep

Using particle density

	Grade		Recovery
	Sink	Float	
NSG	17.6	98.5	0.7
Pyrite	34.5	0.2	86.3
Chalco	44.9	0.8	70.3
Bornite	2.6	0.0	83.7

Simulated flotation

Using particle surface composition

	Grade		Recovery
	Conc	Tails	
NSG	14.9	97.2	0.4
Pyrite	10.6	1.2	25.6
Chalco	69.5	0.7	74.4
Bornite	4.1	0.0	80.3

Conclusions

Applications in Geometallurgy

- Understand how texture variability across ore-body is likely to influence mineral recoverability
- Optimize grind-size for each ore type and identify most suitable recovery technologies
- Simulate and optimise pre-concentration / sorter circuit performance and evaluate cost/benefit

Future work

- Improve texture fitting procedures
- Extend technique to modelling re-breakage
- Extend technique to modelling non-random breakage (preferential liberation)