# Shape and distribution anisotropy of irregular arrangements of diverse bodies – a 3D computational model


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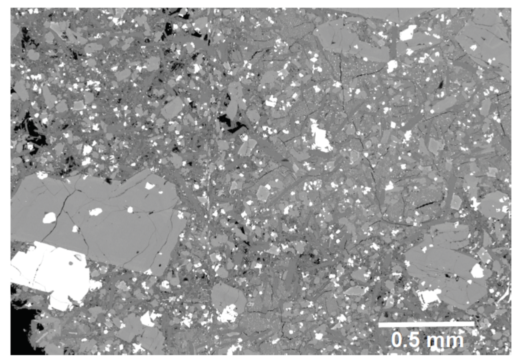
## Motivation

Magnetic anisotropy related to strongly magnetic bodies:
- Shape anisotropy due to self-demagnetization
- Distribution anisotropy due to magnetostatic interactions

Information on the rock's (de)formation history, mineral alignment and flow paths
- Magnetite grains in rocks
- Pore space impregnated with ferrofluid (magnetic pore fabric)

**Existing models** vs
- equal particle size and shape
- equal orientation
- regular spacing
- lines or planes
- infinite
- nearest-neighbour interactions

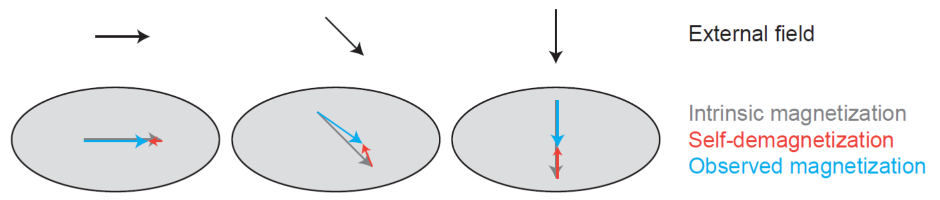
**Reality**



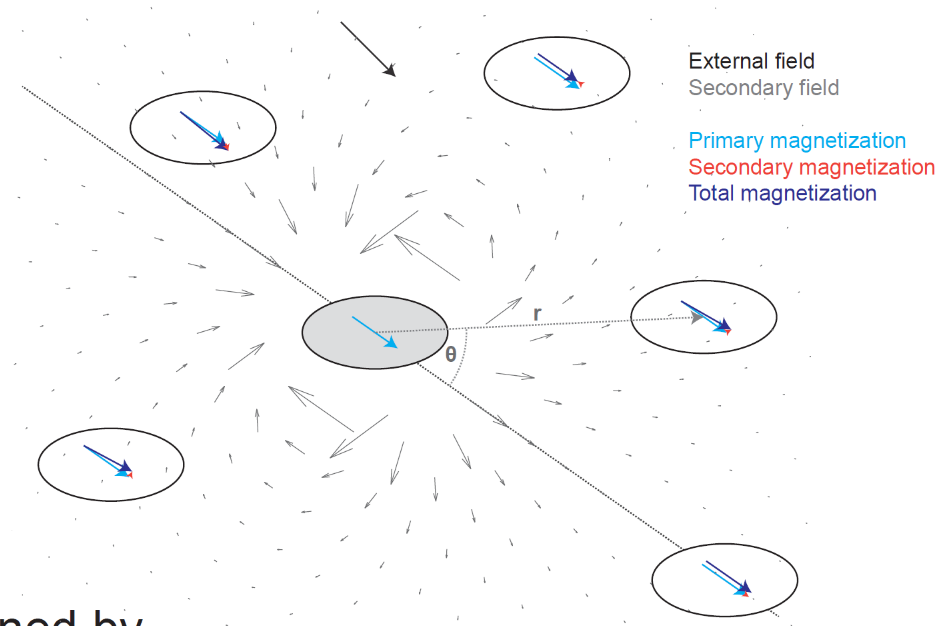

Need models for irregular arrangements of a finite number of particles with diverse sizes, shapes and orientations

## Theory

Shape anisotropy
- Particle shape
- Magnetization




Distribution anisotropy
- Inter-particle spacing
- Particle arrangement wrt secondary field
- Magnetic properties



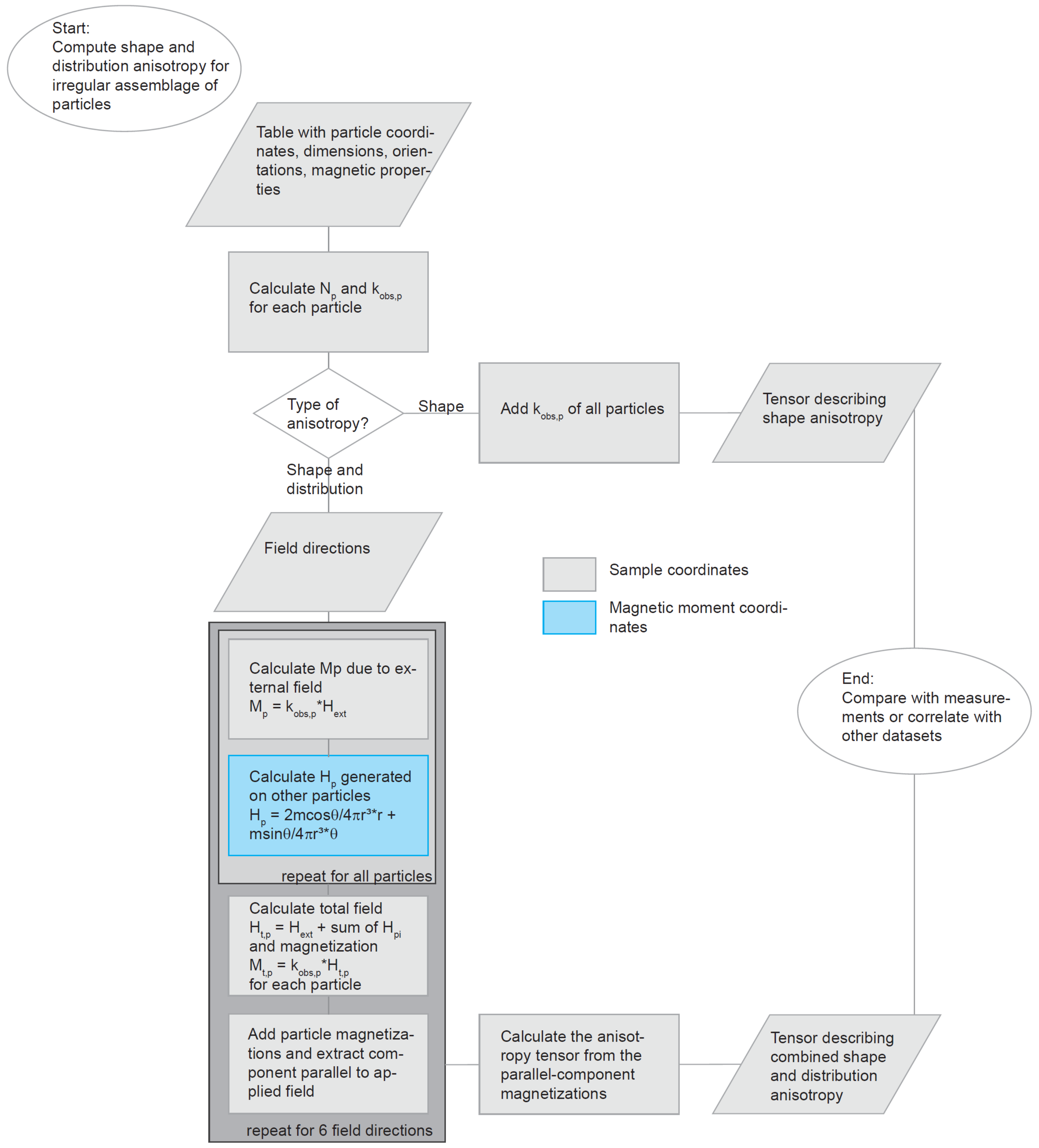

Relative importance defined by
- Particle shapes and orientation
- Inter-particle spacing
- Particle arrangement
- Magnetic properties

## Model

Assumptions:
- Ellipsoidal or cylindrical particles
- Known and homogeneous intrinsic susceptibility
- Non-magnetic matrix

Input parameters:
- Coordinates for each particle center
- Particle dimensions (major, intermediate and minor axes)
- Orientation vectors of the principal axes, defined by 2 angles

These parameters are read in from a table format, and can be derived e.g. from
- Known parameters of man-made samples
- X-ray computed tomography data
- Imaging in the optical or electron microscope, subject to some assumptions due to lack of information in third dimension



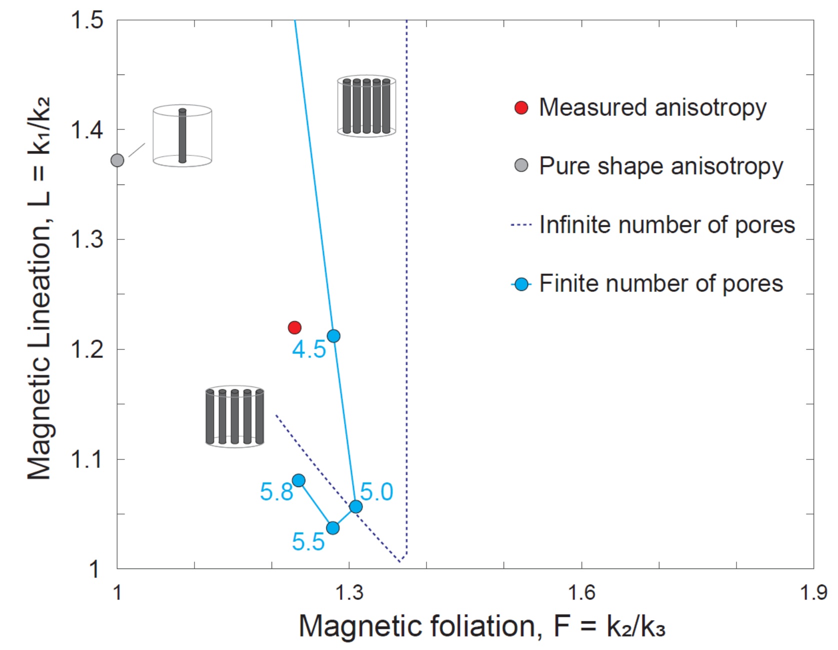

## Examples

Synthetic samples, **cylindrical cavities filled with ferrofluid**

Known
- Cavity dimension
- Number of cavities
- Bedding-type fabric
- Ferrofluid susceptibility

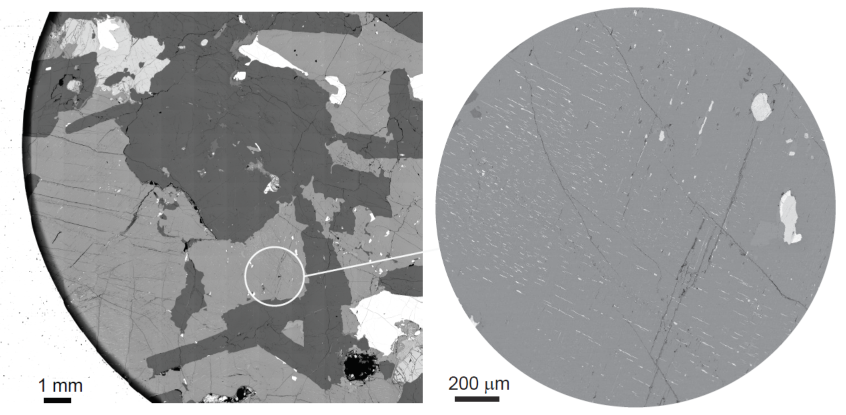
Not known
- Spacing

Previous work
- Measurements Jones et al., 2006
- Infinite model Biedermann, 2019




New finite model matches the data better than the infinite model, and predicts 4.5 mm distance between cavity centers

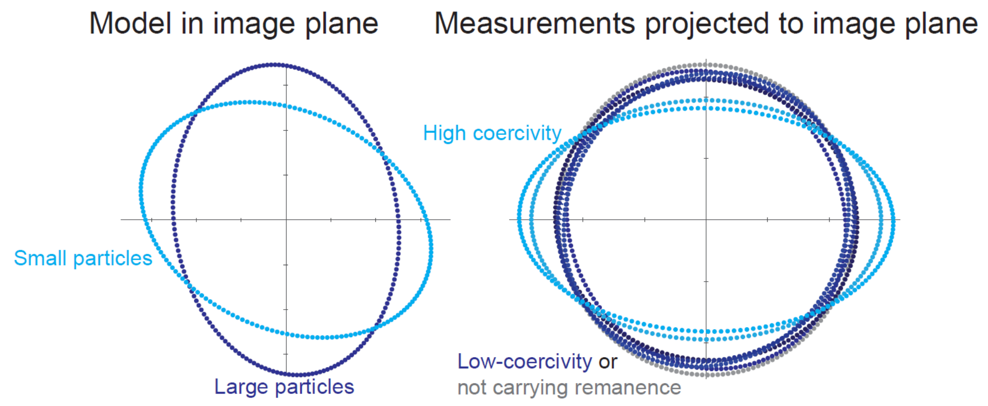
### Magnetite particles in oxide gabbro




Known:
- Backscattered electron image -> particles in 2D
- Susceptibility

Assumption: long axis is symmetry axis

Previous work
- Measurements Biedermann et al., 2020




Model reflects observed differences between fabrics of large vs small grains


**References:**
Biedermann, A.R., 2019. Magnetic pore fabrics: the role of shape and distribution anisotropy in defining the magnetic anisotropy of ferrofluid-impregnated samples, Geochemistry, Geophysics, Geosystems; Biedermann, A.R., Jackson, M., Bilardello, D. & Feinberg, J.M., 2020. Anisotropy of full and partial anhysteretic remanence across different rock types: 2. Coercivity-dependence of remanence anisotropy, Tectonics; Jones, S., Benson, P. & Meredith, P., 2006. Pore fabric anisotropy: testing the equivalent pore concept using magnetic measurements on synthetic voids of known geometry, Geophysical Journal International.


## Conclusions

Can predict shape and distribution anisotropy in realistic particle assemblages

Advanced understanding of interplay between shape and distribution anisotropy in natural samples

More robust and reliable interpretations