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A Dual Representation for Multiscale Fracture Characterization and Modeling*

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Abstract

Numerical models of naturally fractured reservoirs are now commonly involved in the definition of field development strategies, allowing to optimize recovery, increase productivity or prevent early water breakthrough. Such models are expected to provide a quantitative insight into the impact of fractures on reservoir connectivity.

Static data such as seismic attributes and borehole image logs can be used to map major discontinuities. Along with structural attributes and facies distribution model, they also provide statistical information about the spatial distribution, orientation and organization of the fractures throughout the reservoir, allowing to build a detailed geological model of the fracture network. Although heterogeneity, anisotropy and relative variations of effective petrophysical properties can be deduced from these data, they do not allow to compute quantitatively the effective permeability of the fracture network. Conversely, dynamic data provide averaged values of fracture permeability but do not give detailed information about its anisotropy and heterogeneity.

The geological model should therefore be calibrated to dynamic data in order to have some predictive capability. The calibration process can be viewed as an inversion problem that consists in finding the values of uncertain parameters of the geological model (typically: fracture length, aperture, transmissivity, etc.) which minimize the mismatch between simulated and observed production data. That problem is usually solved iteratively, by selectively perturbating the model parameters. In this process, fracture model

generation, upscaling and flow simulation have to be repeated many times, and computational performance is often the limiting factor. Similar observations can be made about uncertainty and sensitivity workflows, which allow assessing the reliability of the models.

In this paper, we propose an original numerical representation of the fracture network that allows to produce or update quickly an accurate flow simulation model while preserving all the constraints and details contained in the geological model.

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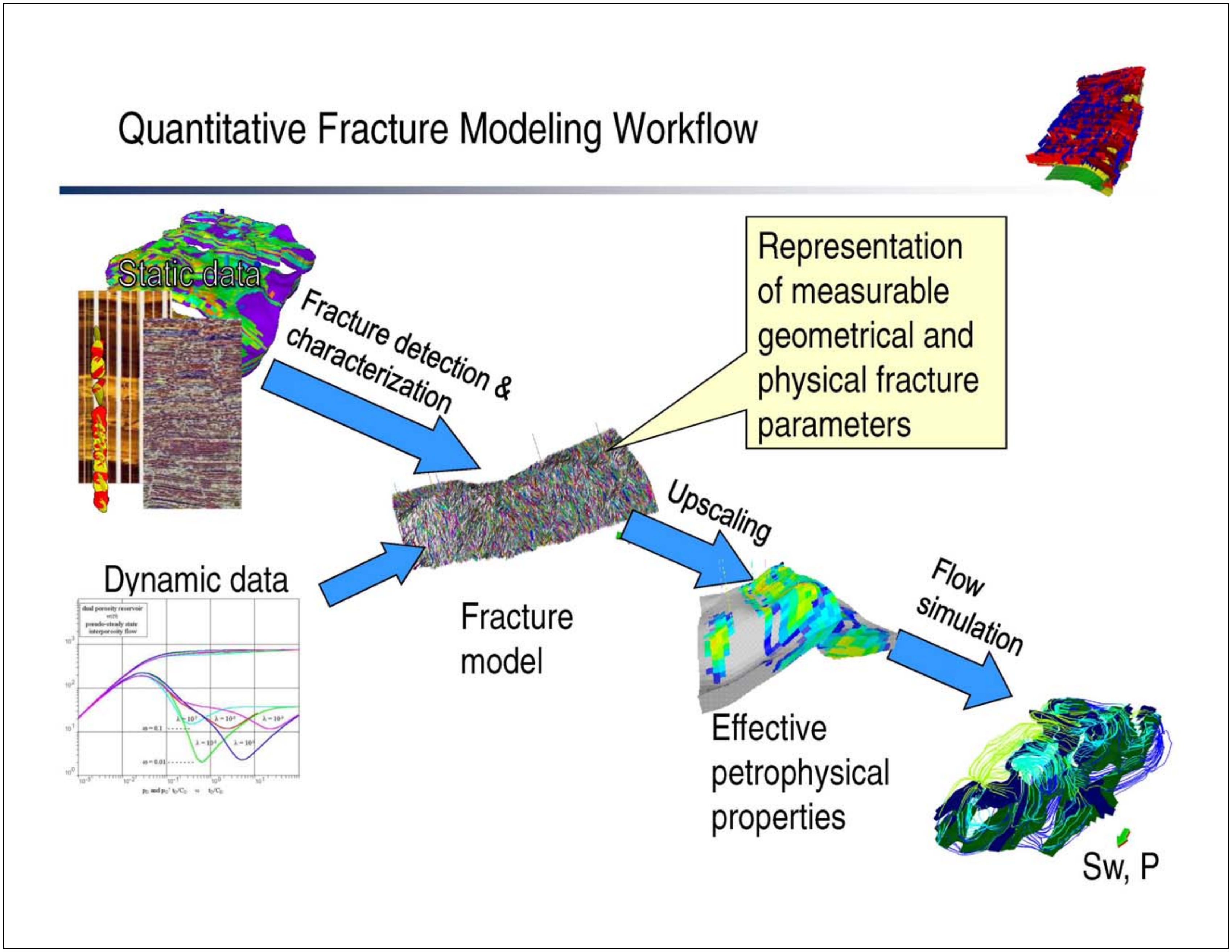
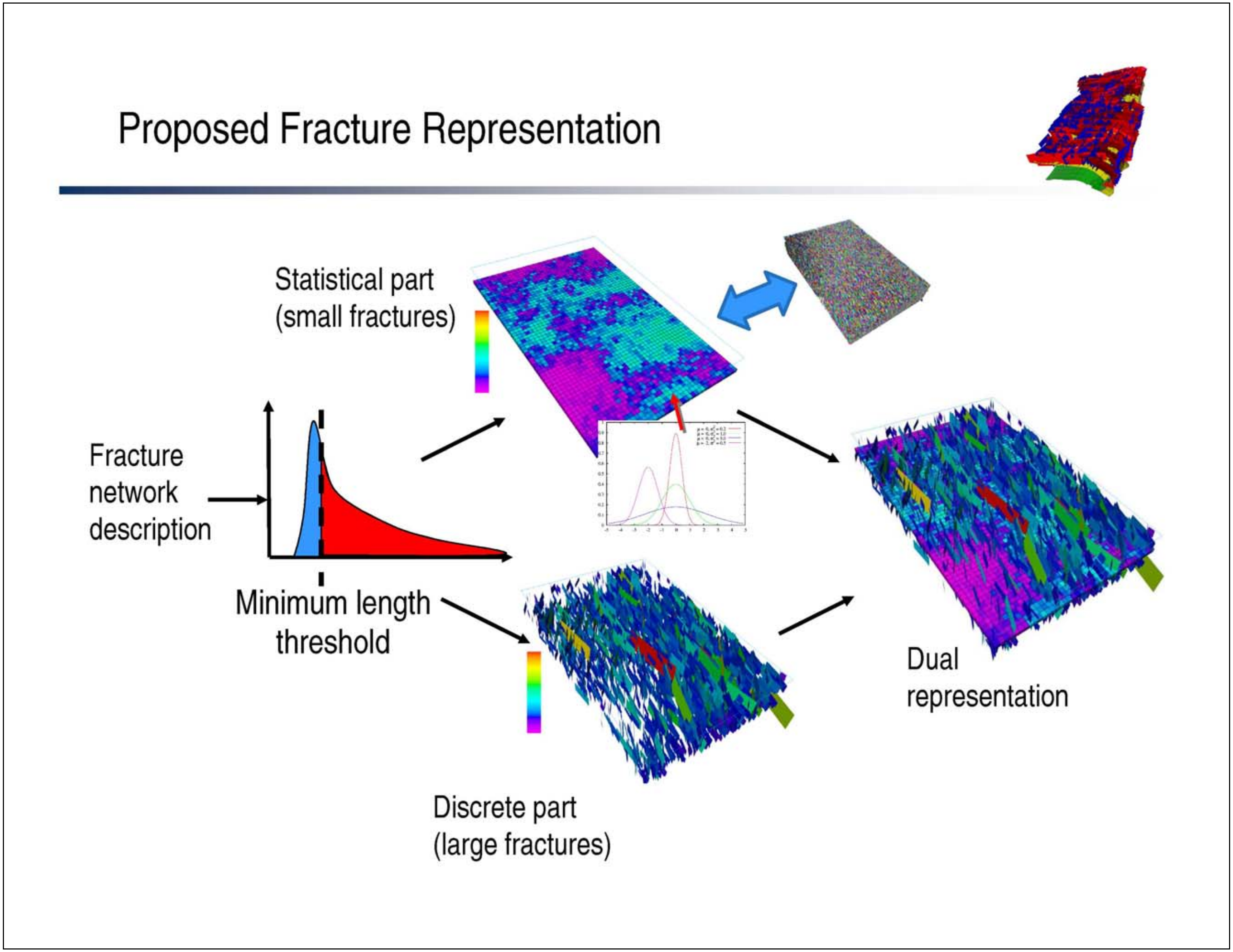
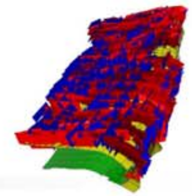


Quantitative fracture modeling workflow.



Proposed fracture representation.

Implicit Fracture Model (Persistent Statistical Model)



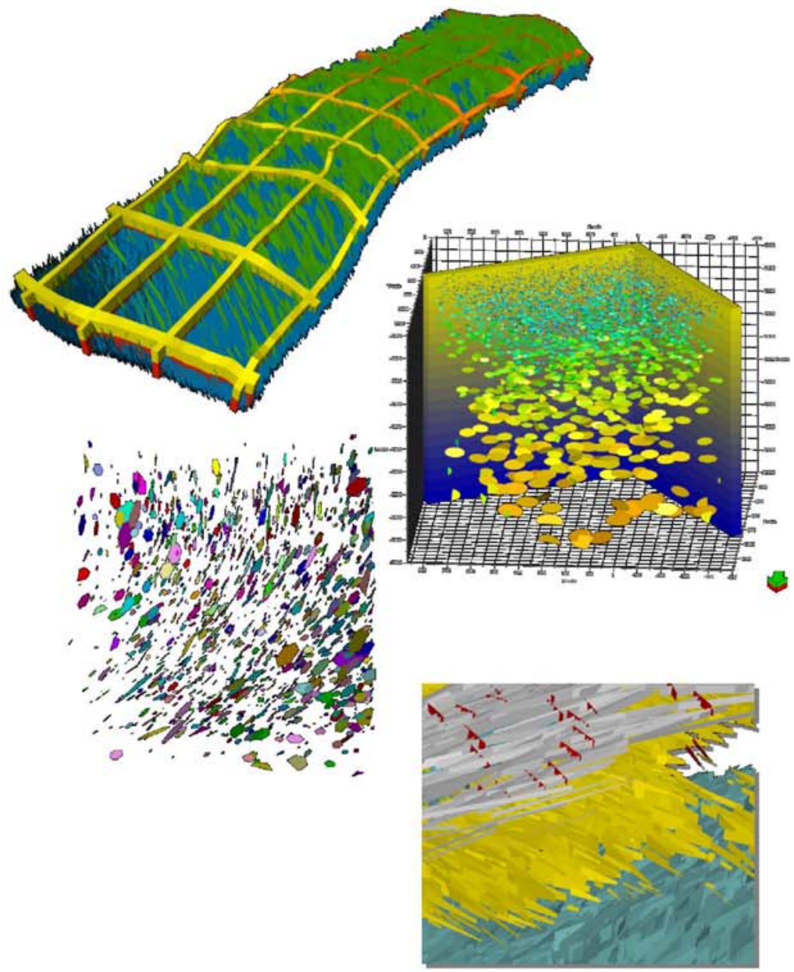
Parameters (for each fracture set)

- Fracture density
  → **P32,** P31 or P30

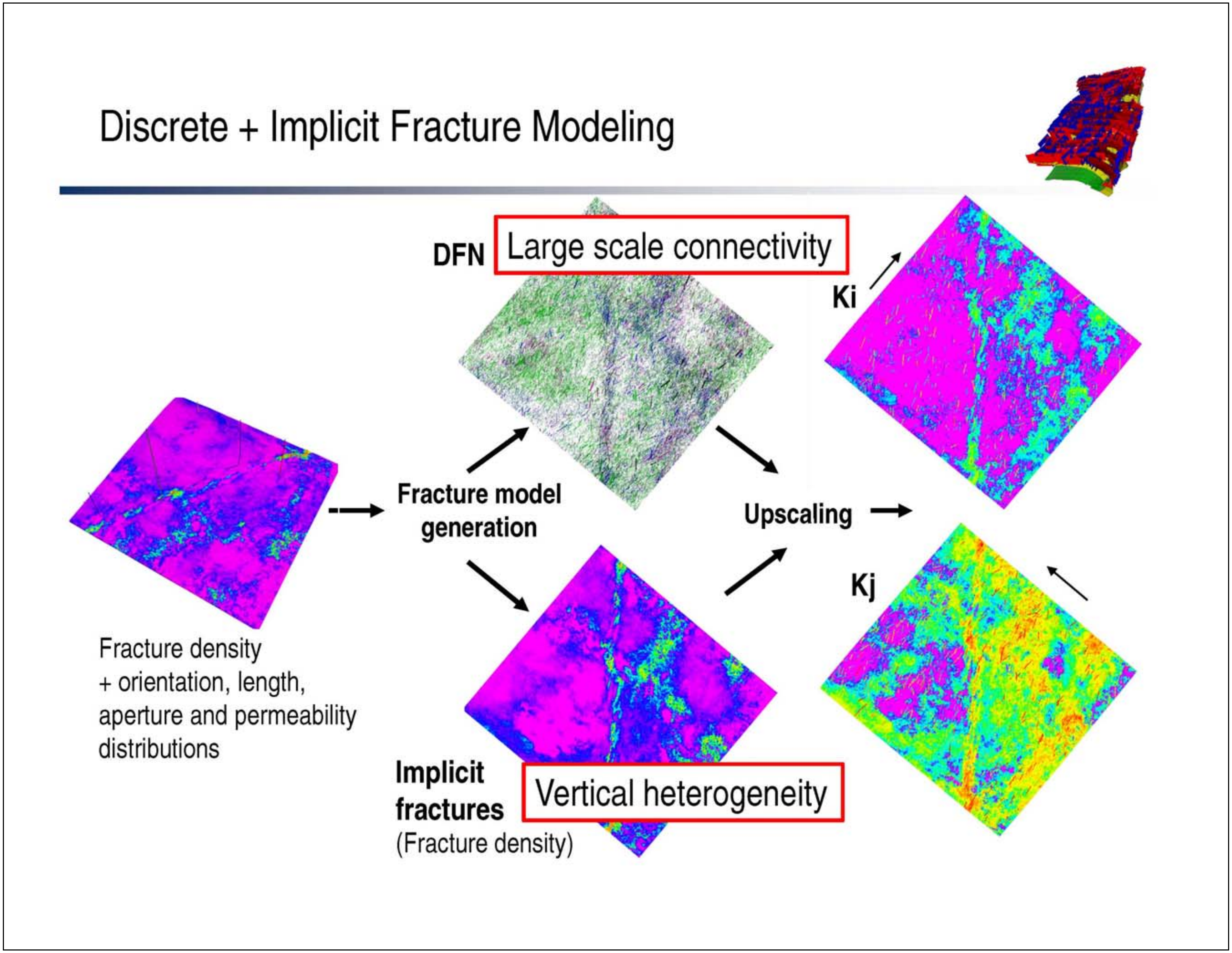
- Geometry
  → Fracture length and elongation ratio

- Orientation
  → Absolute or relative to structural dip

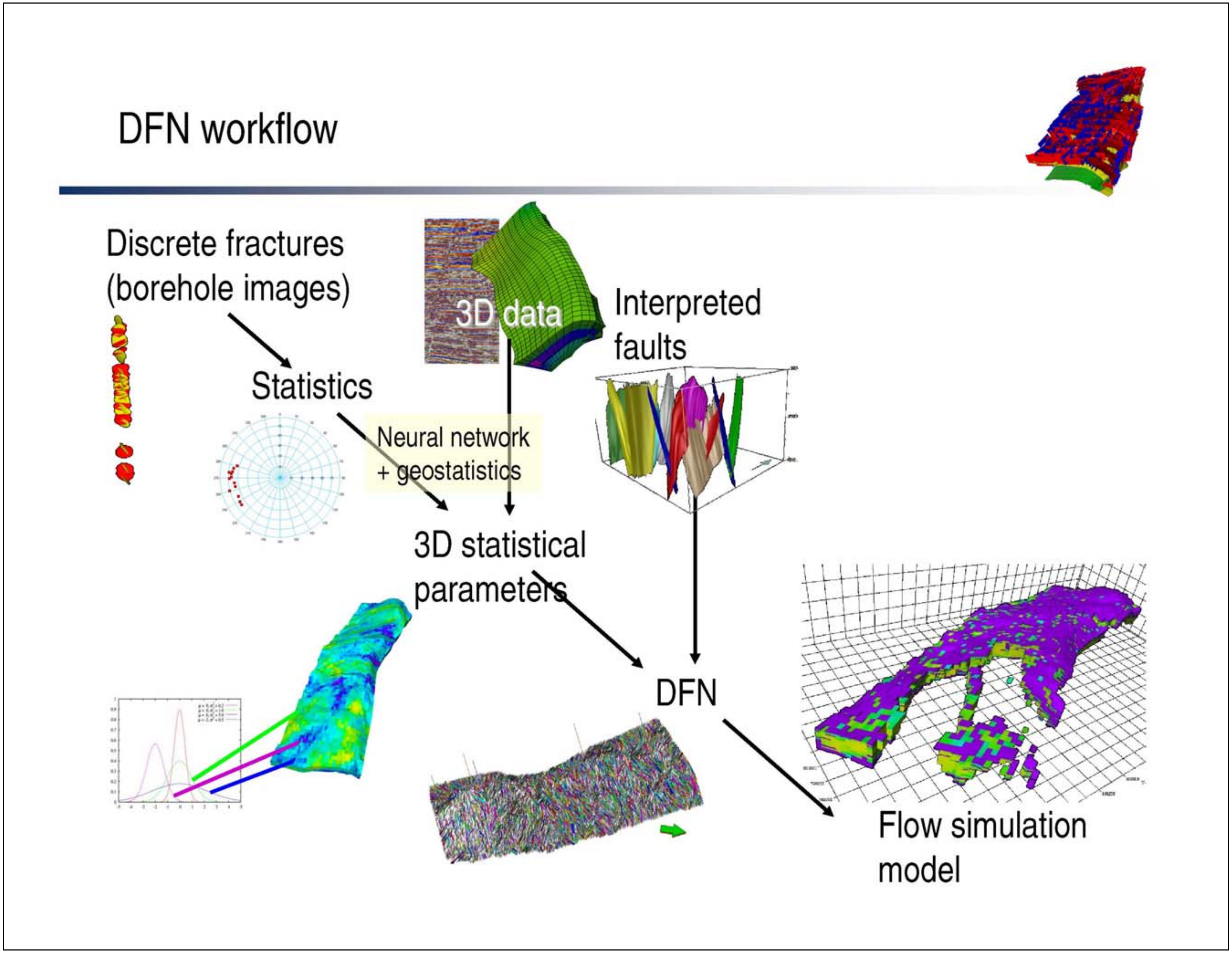
- Attributes
  → Aperture, permeability



Implicit fracture model (persistent statistical model).



Discrete + implicit fracture modeling.



DFN workflow.