

Graph-based geological modeling with faults using the geostatistical SPDE approach

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Stochastic partial differential equation (SPDE, Lindgren *et al.*, 2011) is a novel approach in geostatistics to generate a Gaussian random field. The solution of the SPDE is obtained on a mesh whose resolution is dependent on the spatial structure of the modeled Gaussian process. Then, solving the SPDE involves a numerical scheme, in our case Finite Elements, with a stencil that connects the locations of interest and can be seen as a graph. Then, the Gaussian distribution at any location in the domain can be approximated using the SPDE solution. Conditioning observations are integrated as constraints expressed as a linear combination of vertex distributions. Our work recasts the potential field method (Lajaunie *et al.*, 1997), an implicit geological modeling method, within the SPDE framework whose originality was to integrate both contact points and structural orientation measurements as modeling constraints.

As faults are major components of geological structural models. The relative displacement of geological layers on both sides of these discontinuity surfaces is challenging to model. Many methods have been proposed in the geological modeling literature. Concerning geostatistical approaches, the correlation between layers across the fault surfaces is neglected (*screen effect*, Marechal, 1984) or relies on discontinuous drifts to model this displacement (Calcagno *et al.*, 2008). We propose to correlate the domains on each side of a fault, extending the natural graph-based formulation that comes with the SPDE approach.

Under the assumption that fault surfaces are known, we create a mesh that conforms to the faults. Then, the mesh is split along fault surfaces, and a virtual mesh is connected to these inner boundaries. In a graph formalism, a sub-graph is added to reconnect duplicated vertices resulting from the splitting operations. Then, applying local anisotropies (Pereira, 2020) to this sub-graph allows correlating points according to the fault displacement.

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