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Accounting for Different Anisotropy at Multiple Scales

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This short note is an extension of the previous paper 104 – "Kriging and SGS with Multigridding and LVA". The multigridding approach discussed in paper 104 was used to reduce the CPU requirements of kriging or simulating with locally varying anisotropy. In this note, the multigridding approach is used to account for different geological features at different scales. The larger scale features are modeled first on a coarse grid. The smaller features are modeled on the fine scale grid using the larger scale model as input. For deposits that display multiple layers of scale dependant anisotropy, the proposed methodology can be used to incorporate these features into kriging or sequential Gaussian simulation.

1. Introduction

The methodology for kriging or simulating with LVA is described in detail in Boisvert (2010). The methodology for kriging or simulating with LVA in a multigridding framework is described in the previous paper in this report. The discussion here is limited to deposits that display different features at different scales with the goal of incorporating multiple layers of LVA at different scales in numerical models.

The geological features of interest in this context are features that relate to the property distribution of a deposit. Often the property of interest (metal grade, porosity, etc) is preferentially distributed along some geological feature that causes the property to follow nonlinear directions of anisotropy. Capturing these LVA features in numerical models can have a large impact on the models. When geological features are different at different scales they are difficult to incorporate into numerical models. Often the 'most important' feature is selected and modeled while the other features are ignored. This may not be acceptable in some deposits. Large scale uncertainty (global resource calculations) can be highly impacted by large scale features such as trends, while small scale uncertainty (local resource calculations) are more influenced by small scale variations. Depending on the use of the model it may not be practical to determine *a priori* which features are more critical; ideally, multiple scales of anisotropy would be incorporated into modeling.

2. Methodology

The multigridding methodology is straightforward and presented in the previous paper in this report. The steps are:

1) Model the LVA field for the large scale features.
2) Krige/simulate a coarse scale model of the property of interest (say at a 10 unit resolution)
3) Model the LVA field for the small scale features.
4) Using the coarse scale model from step 2 as input data, krige/simulate at the fine scale (say at a 1 unit resolution)

The methodology is best highlighted by an example. Consider a role front uranium deposit where the large scale LVA causes the grades to be highly concentrated in a curvilinear front (Figure 1) due to the precipitation of dissolved uranium in a reducing environment (Guilbert and Park, 2007); the small scale features of interest are horizontal striations in the grade.

Step 1: Model the LVA field for the large scale features

The example for demonstration of the proposed methodology is a synthetic uranium role front deposit. The large scale anisotropy considers the curvilinear nature of the deposit due to the role front. A schematic of the geometry of the role front is given in Figure 2. The coarse scale LVA field is fit to the deposit by first considering two bounding surfaces (left and right on Figure 2). These surfaces are fit in the three cross sections where synthetic data exist (Figure 2). For each surface, a polynomial is fit to the pierce points available in the section. This polynomial is interpolated between cross sections to generate the overall coarse geometry. The orientation of the LVA field is assumed tangential to the two surfaces. Between the surfaces the orientation is linearly interpolated to generate the full LVA field orientation (Figure 2**,** section 200 is shown). The magnitude of anisotropy is assumed to be a constant 20:1.

Step 2: Simulate a coarse scale model of the property of interest

With the definition of the LVA field from Step 1, simulation is straightforward. The necessary inputs required are the number of landmark points (125) and a variogram range of 90m. The coarse grid is a 1m x 1m x 1m grid (240,000 blocks) that displays the desired curvilinear features (Figure 3).

Step 3: Model the LVA field for the small scale features

The micro features that will be incorporated into the synthetic example are small scale horizontal striations in the deposit. These features are assumed to be approximately 0.5-2m long. The LVA field is straightforward, a constant orientation (East-West) with a constant anisotropy ratio of 5:1. This LVA field could be more complex depending on the nature of the features desired.

Step 4: Using the coarse scale model from step 2 as input data, krige/simulate at the fine scale

The data from step 2 are used as input to a second simulation with the LVA field defined in Step 3. The necessary inputs required are the number of landmark points (125) and a variogram range of 20m. The fine grid is a 0.2m x 1m x 0.2m (6,000,000 blocks) grid that displays the desired horizontal striations (Figure 4). The 1m cell size was retained in the North-South direction as added resolution is only required in the East-West direction.

3. Conclusions

The features discussed in this paper (role front with horizontal striations) are not important and they may be geologically or statistically relevant depending on the deposit of interest and the goals of the modeling procedure; the idea is to present a nested methodology where LVA at multiple scales can be incorporated into modeling. With a simple multigridding procedure, two scales of features were modeled.

Future work in this area is to consider what size the coarse/fine grids should be. In this example the large scale features were on the order of 10's of meters; however, a smaller grid is required to resolve these features. Likely, the most appropriate coarse grid would be selected on a trial-and-error basis as the largest grid size possible for which the coarse features can still be adequately characterized (note this grid often contains few cells and rerunning the modeling algorhim for different grid sizes would not be difficult). The fine scale grid is more straightforward and is usually dictated by the goals of the modeling process in combination with the size of the small scale features.

References

Boisvert J, 2010. Geostatistics with Locally Varying Anisotropy. PhD Thesis. University of Alberta. 175 p.
Guilbert J and Park C, 2007. The Geology of Ore Deposits. Waveland Press Inc., Illinois. 985p.

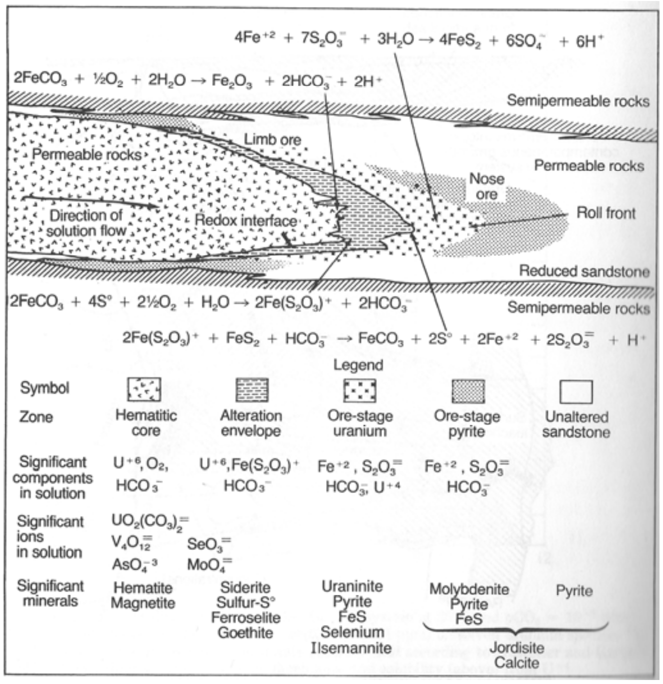

Figure 1: Uranium role front deposit (Guilbert and Park, 2007).

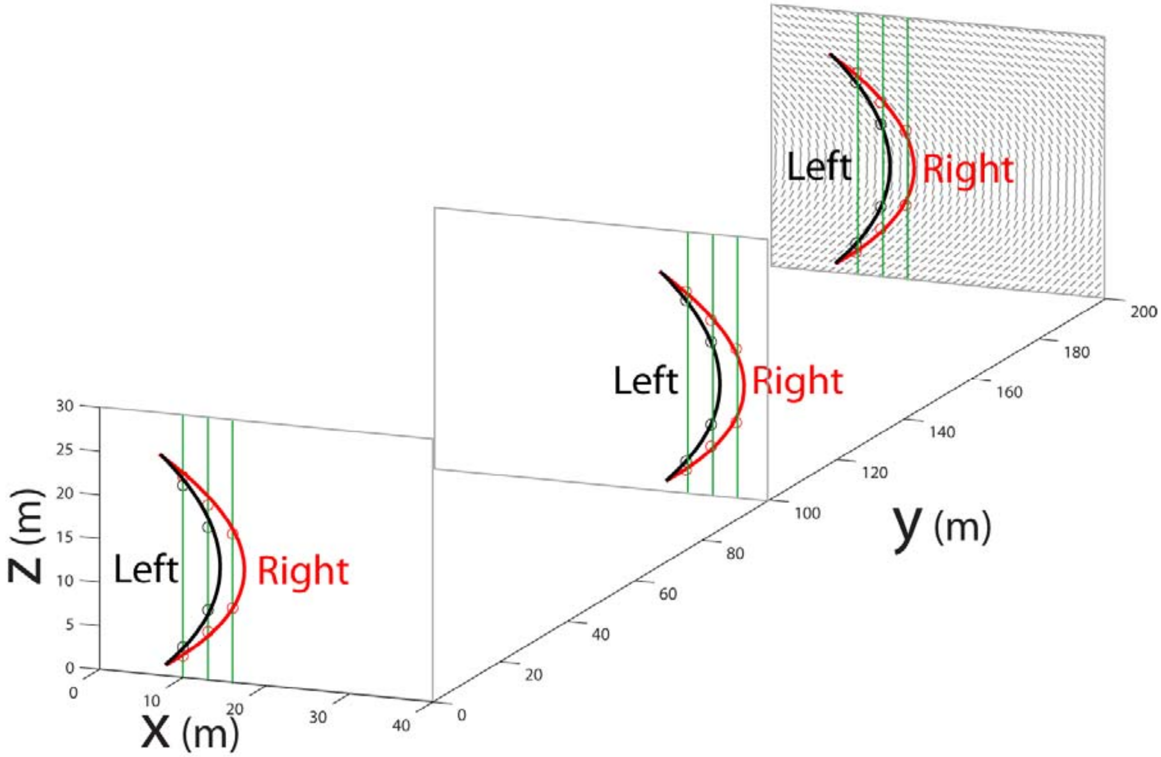

Figure 2: Schematic of the synthetic uranium role front deposit as well as the drill holes used. A total of 9 drill holes intersect the formation (circles) defining three sections upon which the surfaces (right and left) are generated. The LVA orientation is shown on the 200m cross section and is typical of each section.

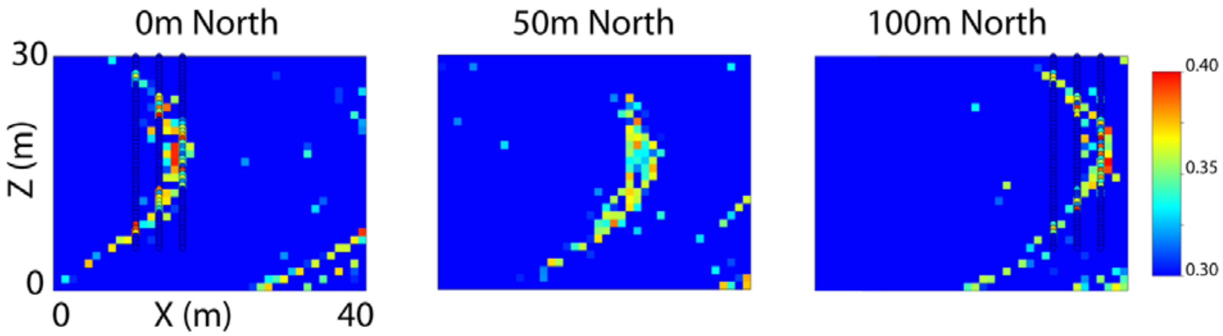

Figure 3: Coarse simulation with uranium grades.

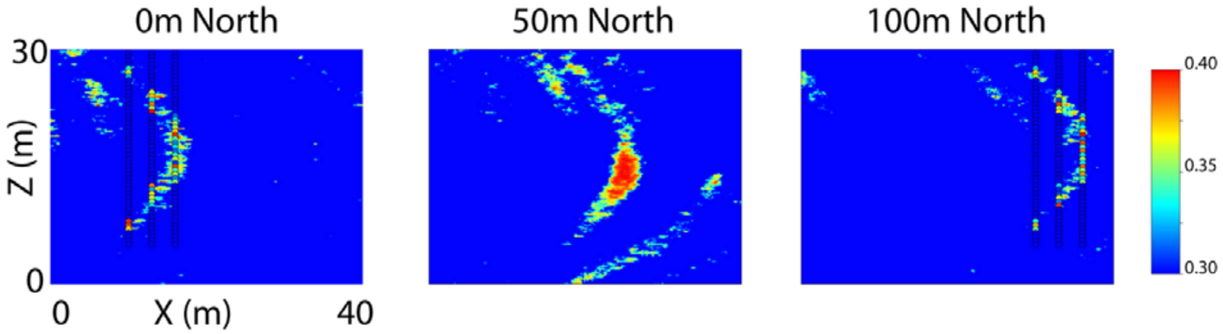

Figure 4: Fine simulation with uranium grades.