GEOSOFT

Oasis montaj Best Practice Guide

VOXI Earth Modelling - Building a Model for Forward Modelling

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Build a Model for Forward Modelling

Introduction

VOXI provides a Forward Modelling method for calculating the response of a given physical property voxel model (e.g. density, susceptibility) at specific points in a three dimensional space. The voxel model should be provided in Geosoft Voxel (Geosoft_voxel) format and the measurement location coordinates in a Geosoft database (GDB). Forward Modelling is a highly instructive process for the novice in particular, and at times, even for the expert. A solid understanding of the expected response from a given model is an essential prerequisite to a successful inversion.

In this document, we describe how to build a simple model - a "Half Graben" model (*Figure 1*) - based on a normal fault. It is first created as a lithologic model and through a thematic table, it is converted to a physical parameter model. The addition of a projected coordinate system will be necessary in order to calculate an accurate geophysical response over the model area using VOXI.

Overview

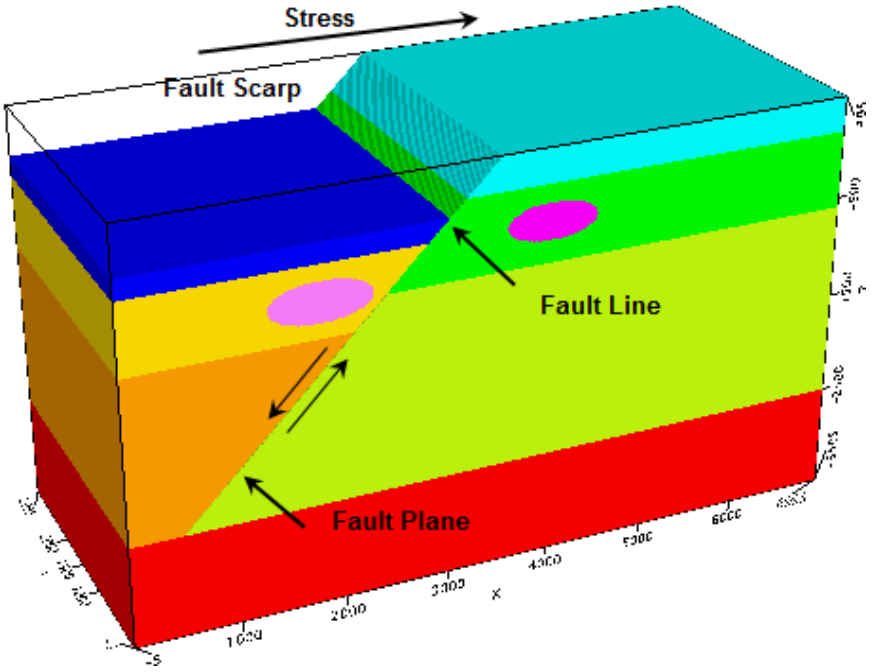


Fig. 1: A normal fault model built in Oasis Montaj, which will be used to demonstrate forward modelling in VOXI

The Half Graben model is created through the following steps:

1. Create a master voxel of the earth volume to be modelled and assign the same index to all voxel elements.
2. Add a fault to the model using Voxel Math and assign a unique index to the elements on each side.
3. Create the sediment layers to the right of the fault and assign a unique index to the elements of each layer.
4. Create the sediment layers to the left of the fault and assign a unique index to the elements of each layer.
5. Create the depression on the left using Voxel math and setting the uppermost layer to dummies.
6. Create the basement.
7. Add the 2 oblong cylindrical lenses.
8. Assign a coordinate system to the voxel model.
9. Convert the voxel model to actual properties using Lithology to Numeric conversion.

Building the Half Graben Model

Create the master voxel

1. From the *3D* menu, select **Voxel Utilities | Create Master Voxel**.

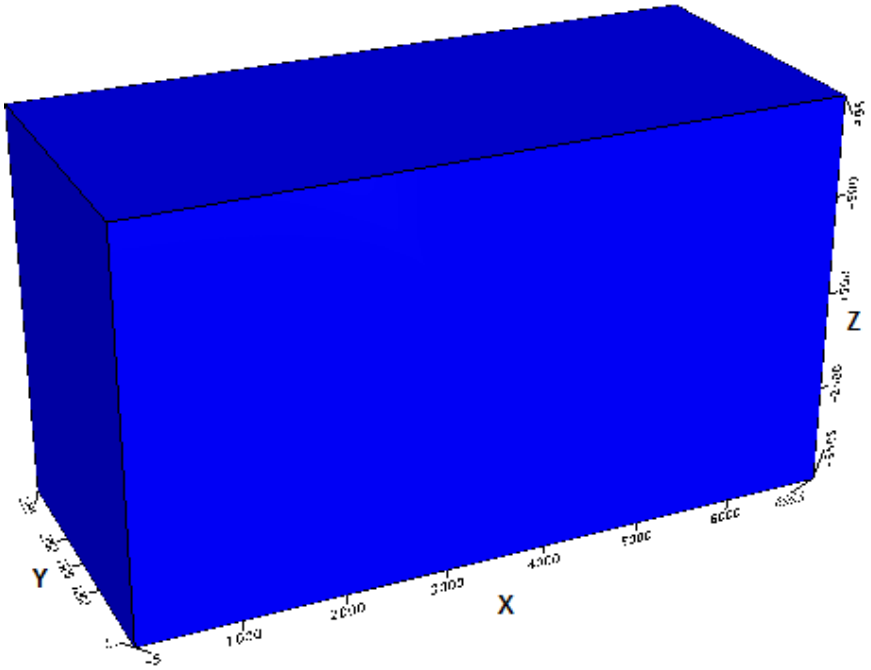
   The *Create Master Voxel* dialog is displayed.
2. Enter the following parameters:
   - New voxel name: HG0_Master
   - Number of cells in X: 140
   - Number of cells in Y: 60
   - Number of cells in Z:80
   - Constant voxel value: 0
3. Click **OK** to create the Master Voxel.

   The *Modify Voxel Properties* dialog box is displayed.
4. Enter the following parameters:
   - X voxel cell sizes: 50
   - Y voxel cell sizes: 50
   - Z voxel cell sizes: 50
   - Real origin X: 0
   - Real origin Y: 0
   - Real origin Z: -3500

     Leave the rest of the parameters in their default state.
5. Click **OK**.

   The *Voxel Properties* dialog box opens. Click **Exit** to close.

The Voxel Viewer opens to show the newly created voxel.



Add a Fault to the model using Voxel Math

1. From the *3D* menu, select **Voxel Utilities | Voxel Math**.

   The *Voxel Math Expression Builder* dialog is displayed.

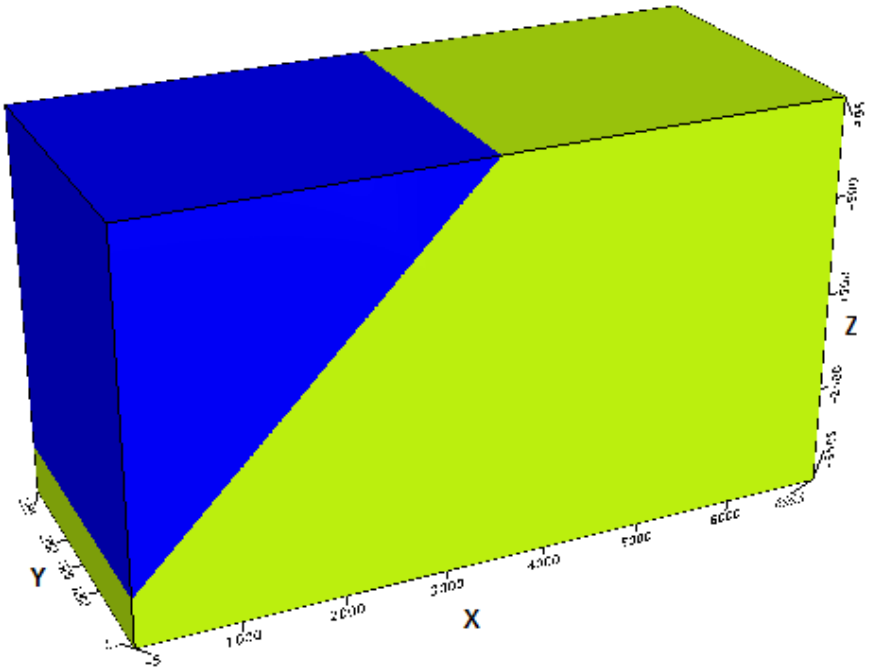
2. Assign an index of **1** to the right hand side of a fault by using the following math expression:

   ```
   V0=((Z-X)<=-3000)?1:VI
   ```

3. Assign the *Output Voxel (VO)* to be called **HG1_Fault** and assign the *Input Voxel (VI)* as **HG0_ Master**.

   Click **OK**.

The Voxel Viewer displays the fault added to the model.



Add Right hand side Sediments

1. From the *3D* menu, select **Voxel Utilities | Voxel Math**.

   The *Voxel Math Expression Builder* dialog is displayed.

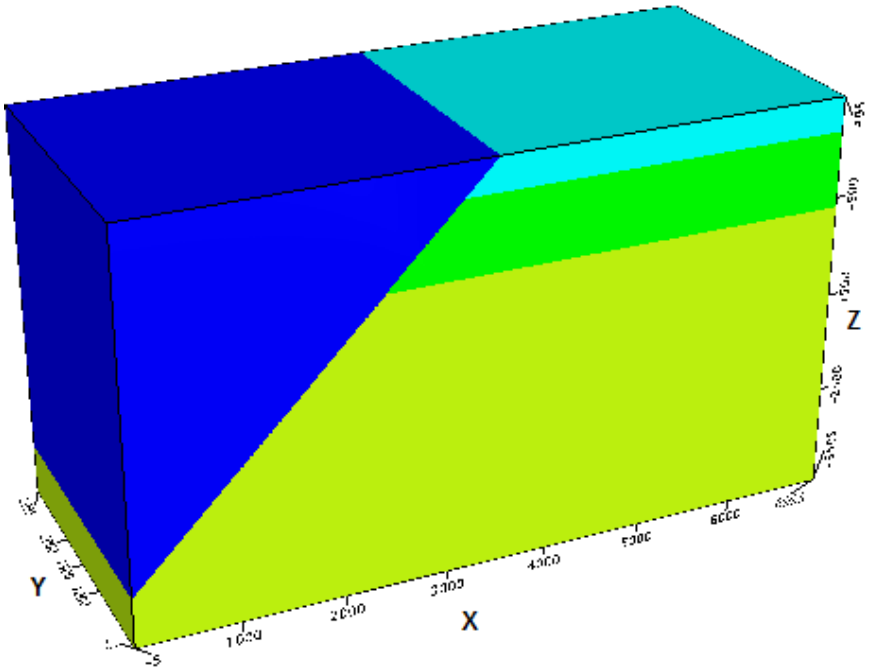
2. Create the sediment layers to the right of the fault by applying the following math expression:

   ```
   @V1=((Z-X)<=-3000&&Z>-600)?2:VI;
   VO=((Z-X)<=-3000&&Z>150)?3:@V1
   ```

3. Assign the *Output Voxel (VO)* to be called **HG2_RSediments** and assign the *Input Voxel (VI)* as **HG1_Fault**.

   Click **OK**.

The Voxel Viewer displays the right hand side sediments added to the model.



Add Left hand side Sediments

1. From the *3D* menu, select **Voxel Utilities | Voxel Math**.

   The *Voxel Math Expression Builder* dialog is displayed.

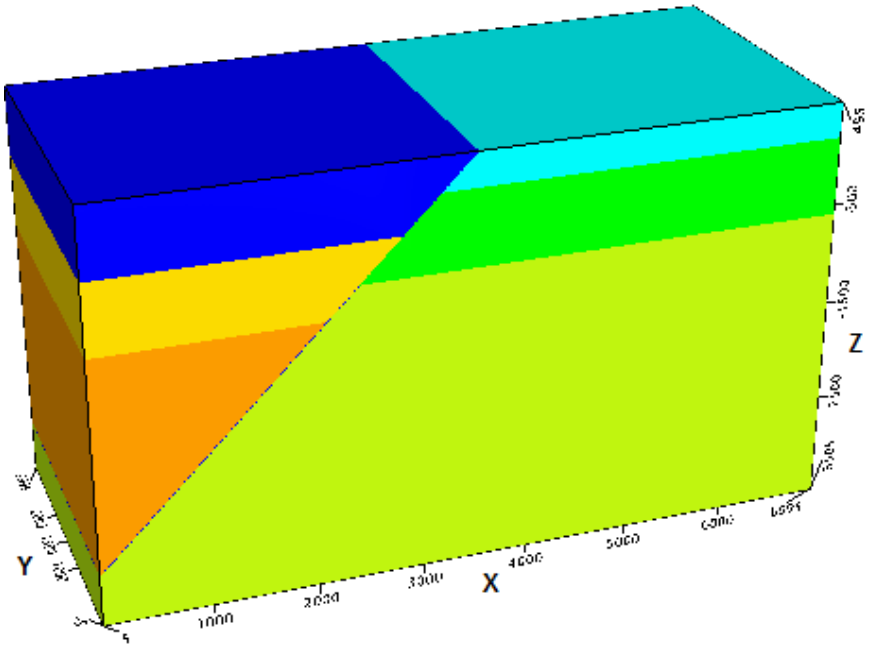
2. Create the sediment layers to the left of the fault by applying the following math expression:

   ```
   @V1=((Z-X)>-3000)?4:VI;
   @V2=((Z-X)>=-3000 && Z>-900)?5:@V1;
   VO=((Z-X)>=-3000 && Z>-200)?6:@V2
   ```

3. Assign the *Output Voxel (VO)* to be called **HG3_LSediments** and assign the *Input Voxel (VI)* as **HG2_RSediments**.

   Click **OK**.

The Voxel Viewer displays the left hand side sediments added to the model.



Add the depression

1. From the *3D* menu, select **Voxel Utilities | Voxel Math**.

   The *Voxel Math Expression Builder* dialog is displayed.

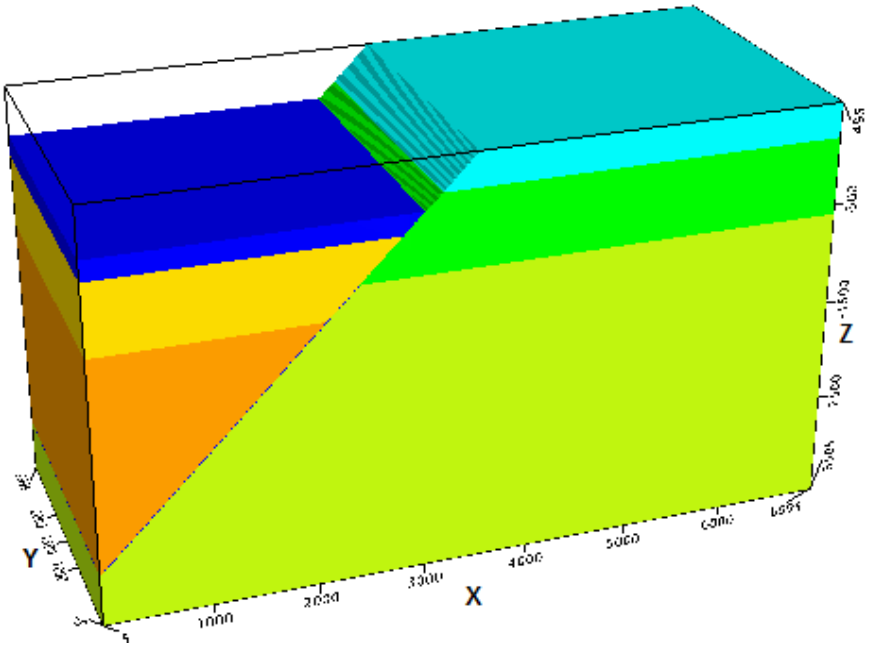
2. Create the depression on the left and set the uppermost layer to dummies by applying the following math expression:

   ```
   VO=((Z-X)>=-3000 && Z>0)?DUMMY:VI
   ```

3. Assign the *Output Voxel (VO)* to be called **HG4_Depression** and assign the *Input Voxel (VI)* as **HG3_LSediments**.

   Click **OK**.

The Voxel Viewer displays the depression added to the model.



Add the basement

1. From the *3D* menu, select **Voxel Utilities | Voxel Math**.

   The *Voxel Math Expression Builder* dialog is displayed.

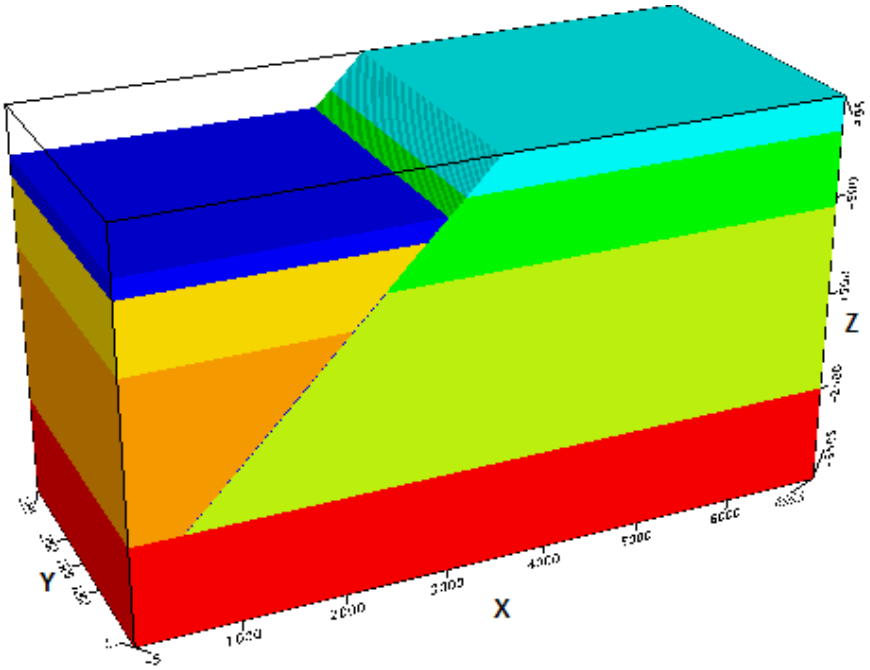
2. Create the basement by applying the following math expression:

   ```
   VO=(Z<-2500)?7:VI
   ```

3. Assign the *Output Voxel (VO)* to be called **HG5_Basement** and assign the *Input Voxel (VI)* as **HG4_Depression**.

   Click **OK**.

The Voxel Viewer displays the basement added to the model.



Add the lenses

1. From the *3D* menu, select **Voxel Utilities | Voxel Math**.

   The *Voxel Math Expression Builder* dialog is displayed.

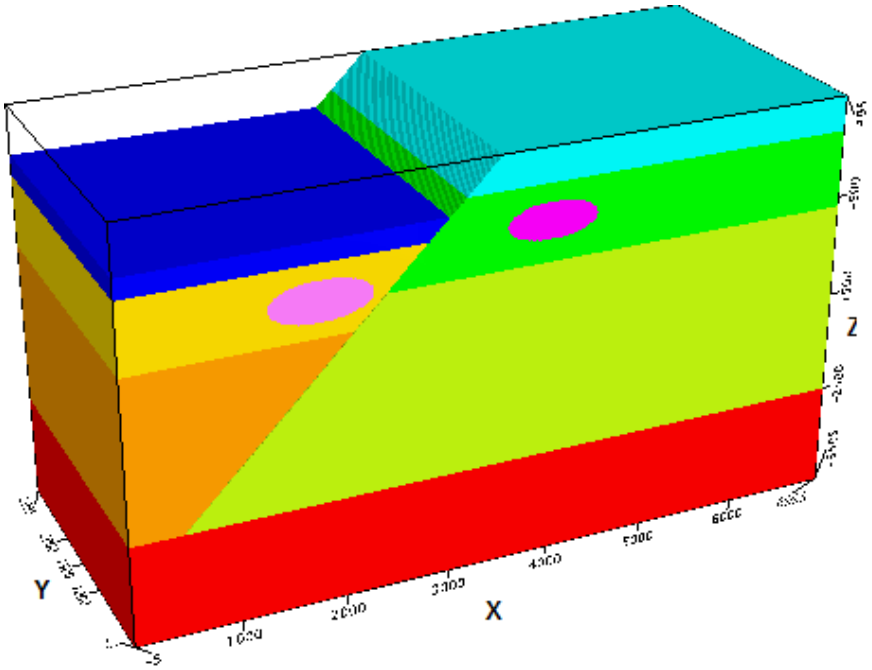
2. Add the 2 oblong cylindrical lenses by applying the following math expression:

   ```
   @V1=(((X-1800)*(X-1800)/6+((z+550)*(Z+550)))<40000)?8:VI;
   VO=(((X-4000)*(X-4000)/6+((z+200)*(Z+200)))<32400)?9:@V1
   ```

3. Assign the *Output Voxel (VO)* to be called **HG6_Lenses** and assign the *Input Voxel (VI)* as **HG5_Basement**.

   Click **OK**.

The Voxel Viewer displays the lenses added to the model.



Add a projection of the model

1. Add the projection to the *HG6_Lenses* voxel model. From the *3D* menu, select **Voxel Properties**. The *Voxel Properties* dialog is displayed.
2. Browse to select the *HG6_Lenses.geosoft_voxel* file and click **Next**. In the following *Voxel Properties* dialog that appears, click **Modify**. The *Modify Voxel Properties* dialog is displayed.
3. Modify the following parameters to the values below:
   - Real origin X: 500000
   - Real origin Y: 1000000
   - Real origin Z: -3500
4. Click **CoordSys**.

   The *Coordinate System* dialog is displayed.
5. For the *Coordinate system* field, select the **Projected (x,y)** radio button. Modify the following parameters from the respective drop down lists to the values below:
   - Datum: NAD83
   - Local datum transform: [NAD83] (4m) North America
   - Projection Method: UTM zone 17N
6. Click **OK**. The projection has been added to the model.
7. Click **OK** and then **Exit**.

Convert the index voxel model to a lithology model

1. Create a Theme table with the following fields and save as a CSV (Comma delimited) file:

CODE	LABEL	DESCRIPTION	Index	Avg Density	Res Density	SUSCEPTIBILITY	Lithology	COLOR
U0	M	Master	0	1	1	0.0001	0	C255M255Y000
U1	LLS	Lower Left Sediment	1	2.682	0.682	0.0006	1	C060M006Y240
U2	MLS	Mid Left Sediment	2	2.671	0.671	0.0005	2	C255M000Y255
U3	ULS	Upper Left Sediment	3	2.661	0.661	0.0004	3	C255M000Y000
U4	LRS	Lower Right Sediment	4	2.68	0.68	0.0007	4	C000M096Y255
U5	MRS	Mid Right Sediment	5	2.67	0.67	0.0006	5	C000M032Y255
U6	URS	Upper Right Sediment	6	2.66	0.66	0.0005	6	C255M255Y000
U7	BR	Bed-Rock	7	2.75	0.75	0.002	7	C000M255Y255
U8	L1	Lenze	8	2.88	0.88	0.002	8	C000M128Y000
U9	L2	lenze	9	2.89	0.89	0.003	9	C000M255Y000

2. Convert the Indices to lithology with the Numeric to Lithology Voxel utility. From the *3D* menu, select **Voxel Conversions | Numeric to Lithology Voxel**.

   The *Numeric to Lithology Voxel* dialog is displayed.

   Use the following parameters:

- Input numeric voxel: HG6_Lenses
- Output lithology voxel: Index2Lithology
- Lithology table: Themetable.csv
- Input property: LITHOLOGY

Convert the lithology model to a property voxel

1. Apply the property conversion with the Lithology to Numeric utility. From the *3D* menu, select **Voxel Conversions | Lithology to Numeric Voxel**.

   The *Lithology to Numeric Voxel* dialog is displayed.

   Use the following parameters:

   - Input lithology voxel: Index2Lithology
   - Output numeric voxel: Half_Graben
   - Lithology table: Themetable.csv
   - Input property: AVG DENSITY

You have now successfully build the Density Half Graben model and are ready to submit it to a Forward Model calculation in VOXI.

The equations built in this document can be concatenated in a single expression file and processed by one call to Voxel Math.