A Strategy for Modeling Clay Deposits with RockWorks

3/5/24/JPR

The purpose of this study was to evaluate the clay resources within a lease polygon based on borehole data. The input data consisted of a digital terrain model, a lease polygon, borehole data, and a satellite image (Figure 1).

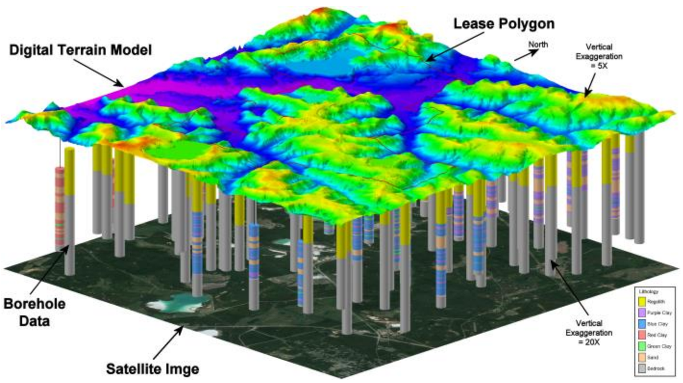

Figure 1. Input Data (DEM, Lease, Borehole Data & Airphoto)

Although the clay top and base are laterally contiguous across the lease area (Figure 2), different-colored sub-units within the clay are discontinuous and lens-like with abundant sandstone interbeds (Figure 3).

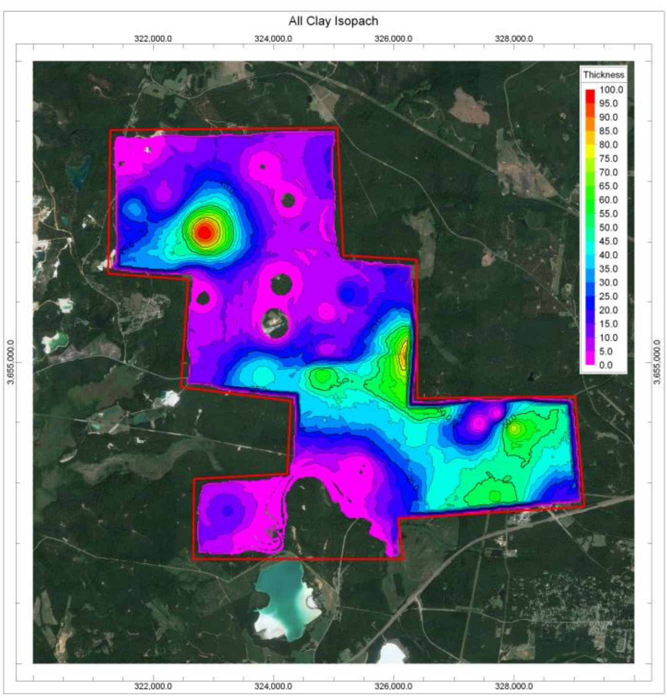

Figure 2. Total Clay Thickness Isopach

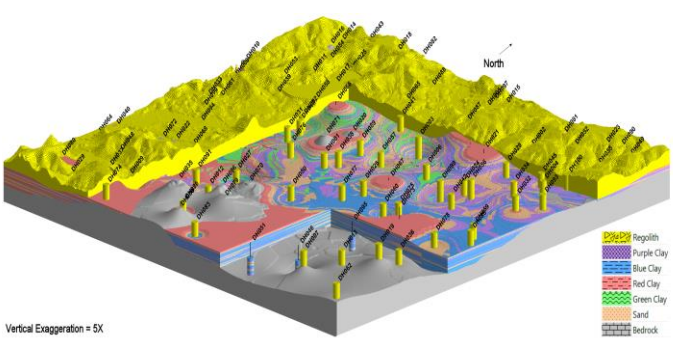

Figure 3. Geologic Model Cutaway View (Vertical Exaggeration = 5X)

Accordingly, isopachs were independently created for each clay type and subsequently used for volumetric (tonnage) computations (Figure 4).

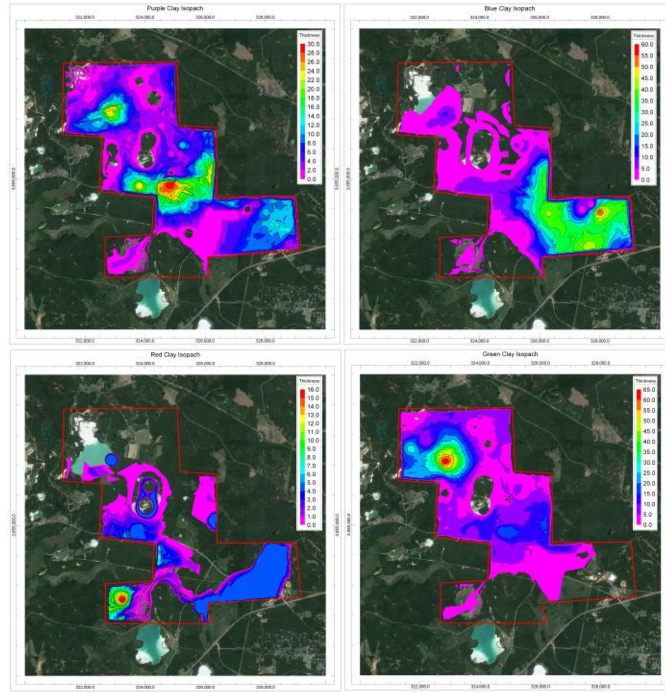

Figure 4. Clay Sub-Types Isopachs

The individual steps within the data processing were stored within a RockWorks Playlist (Figure 5. Multi-Seam Clay Evaluation Playlist) that can be used to evaluate other properties.

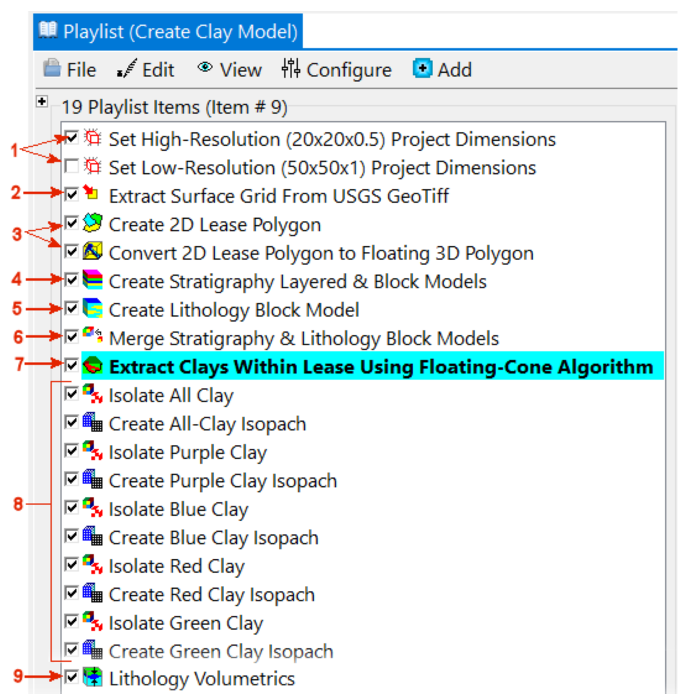

Figure 5. Multi-Seam Clay Evaluation Playlist

The numbered items within the Playlist (Figure 5) are described as follows;

1. **Project Dimensions**: The first two items within the Playlist are used to set the project dimensions. The two different sets of dimensions illustrate a useful trick: During the development of the Playlist, the low-resolution dimensions are used to quickly test the process. Once the process has been completed the low-resolution option is disabled and the high-resolution dimensions are used to re-process the data. The difference in processing time is significant. The low-resolution version takes a few minutes while the high-resolution version requires more than an hour.

2. **Ground Surface Model**: In this example, the ground surface model was extracted from a USGS GeoTiff. Other grid creation methods include the import of drone-based elevation data and interpolating a surface based on the borehole collar elevations.

3. **Lease Polygon**: In this example, the lease polygon vertices were digitized from an existing map. Other polygon import options include the import of DXF and Shapefiles. After creating the 2D polygon, it was "draped" over the ground surface model to create a 3D polygon (Figure 6. 3D Lease Polygon).

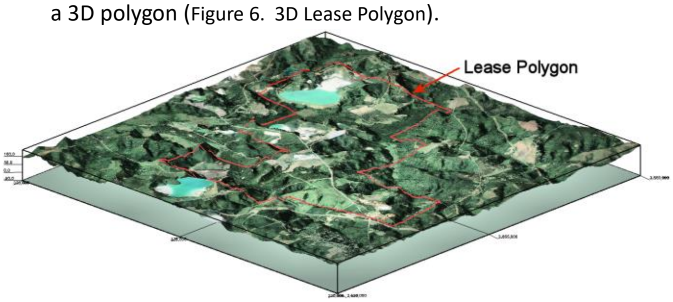

Figure 6. 3D Lease Polygon

4. **Modeling Stratigraphy**: During this step, two types of models were created. (1) A layered stratigraphic model composed of grids that represents the stratigraphic contacts was interpolated by using a Kriging algorithm. These grids were used within the next step to constrain the lithologic modeling. (2) A block model was then created in which the nodes between each stratigraphic contact were assigned g-values based on a table (Figure 7) that defines the g-values associated with the different stratigraphic units.

Data Type	Name	G-Value
Stratigraphy	Regolith (Overburden)	1
	Clay	2
	Bedrock (Limestone)	3
Lithology	Purple Clay	2.1
	Blue Clay	2.2
	Red Clay	2.3
	Green Clay	2.4
	Sand (Interburden)	2.5

Figure 7. Table Defining G-Values Assigned to Lithology & Stratigraphy Voxels Within Block Models

5. **Modeling Lithology**: Next, the lithology, as constrained by the base of the Overburden and the top of the stratigraphic Bedrock unit, was interpolated using an algorithm that metaphorically "bleeds" lithologies away from the boreholes. The lithology model also uses the g-values defined within the same table (Figure 7) that was used for the stratigraphy modeling.

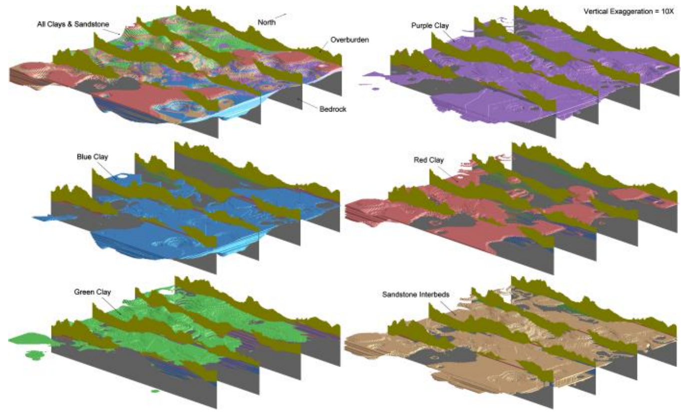

Figure 8. Selected Units Within Geologic Model Plotted as Fence Panels & Isosurfaces

6. **Merging Stratigraphy & Lithology Models**: A "Geology" model was created by replacing all of the Clay voxels (g=2) within the Stratigraphy block model with the g-values from the Lithology block model (Figure 8).

7. **Extraction**: All of the voxels with g-values between 2.05 and 2.45 (i.e., the different types of clays) were then extracted from the lease polygon region within the Geology model. This was accomplished by using a floating cone algorithm that was configured to use a 20-degree slope angle for the pit perimeter (Figure 9).

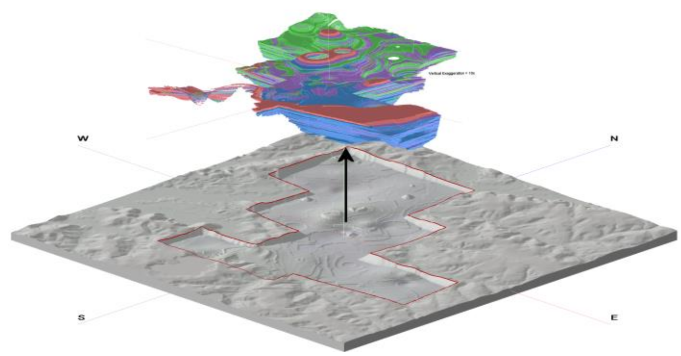

Figure 9. Excavation Pit & Extracted Ore – Note: Vertical scale of ore body has been exaggerated 10x.

8. Clay Isopachs: Next, the different clay types were extracted from the extracted ore model and converted to isopach thickness maps (Figure 3 & Figure 4).

9. Finally, the volumetrics for each lithotype of the geology model within the lease polygon were computed on a level-by-level basis (Figure 10) to assist with mine planning.

Max.Elev.	Min.Elev.	Item	Blue Clay	Green Clay	Purple Clay	Red Clay	Undefined	Total
140	130	Volume (Cubic Meters)	0	0	0	0	1,008,016,000	0
130	120	Volume (Cubic Meters)	0	0	0	0	1,008,016,000	0
120	110	Volume (Cubic Meters)	0	0	0	0	1,008,016,000	0
110	100	Volume (Cubic Meters)	0	0	0	0	1,008,016,000	0
100	90	Volume (Cubic Meters)	0	0	0	0	1,008,016,000	0
90	80	Volume (Cubic Meters)	994,800	0	1,222,600	17,142,600	988,656,000	19,360,000
80	70	Volume (Cubic Meters)	41,692,700	4,831,900	8,637,800	737,200	952,116,400	55,899,600
70	60	Volume (Cubic Meters)	37,734,400	13,846,900	28,543,900	2,087,200	925,803,600	82,212,400
60	50	Volume (Cubic Meters)	34,911,700	34,634,600	27,990,200	3,390,600	907,088,900	100,927,100
50	40	Volume (Cubic Meters)	34,854,000	41,636,100	26,420,600	8,461,500	896,643,800	111,372,200
40	30	Volume (Cubic Meters)	36,664,500	39,981,000	22,844,900	1,338,500	907,187,100	100,828,900
30	20	Volume (Cubic Meters)	20,711,600	22,066,800	14,643,400	916,200	949,678,000	58,338,000
20	10	Volume (Cubic Meters)	12,786,800	10,641,400	10,740,200	0	973,847,600	34,168,400
10	0	Volume (Cubic Meters)	8,793,700	6,663,500	4,713,200	335,800	987,509,800	20,506,200
0	-10	Volume (Cubic Meters)	1,909,200	3,577,000	2,043,400	0	1,000,486,400	7,529,600
-10	-20	Volume (Cubic Meters)	488,600	936,800	763,200	200	1,005,827,200	2,188,800
-20	-30	Volume (Cubic Meters)	326,200	620,000	218,200	0	1,006,851,600	1,164,400
-30	-40	Volume (Cubic Meters)	47,600	173,800	78,800	0	1,007,715,800	300,200
-40	-50	Volume (Cubic Meters)	0	0	0	0	1,008,016,000	0
Totals:		Volume (Cubic Meters)	231,915,800	179,609,800	148,860,400	34,409,800	18,557,508,200	19,152,304,000

Figure 10. Level-by-Level Ore Volumetrics Report