The Hidden Parameter

The Roman scholar Claudius Ptolemaeus, known as Ptolemy (90 to 170 CE) invented the latitude and longitude cartographic convention. His atlas featured maps of the Roman Empire. Subsequently, he mapped the whole planet on a grid system placing north on the top as it is today. His work was translated to Latin in early fifteen through sixteen century (Rosenberg, n.d). Since then scientists have been improving and enhancing the concept; such as Gerhard Mercator's parallels and meridians straight lines projections, followed by Lambert's greatest contribution of conic projections system (Greenhood, 1964). Today, we have a plethora of projection systems and gridding methods. The projection systems facilitate the collection of surveys and the position of datasets in the appropriate geographic frames, and the gridding facilitates subsequent processing, such as filtering and contouring.

The purpose of gridding is to produce a regularly spaced array of Z values, or a set of equidistant grid nodes from randomly or deliberately spaced datasets (Gridding, n.d). Even though the oil and gas industry has provided a superfluity of algorithms to grid dissimilar surveys and diverse datasets, it is our responsibility to retain and preserve the integrity of the datasets.

As a reminder, here is a quick overview of the mostly used and popular gridding algorithms methods (Gridding Methods, n.d):

- **Inverse Distance to a Power**: this gridding method is fast, but it generates undesired "bulls-eyes".
- **Kriging**: this is a geostatistical gridding method that has been proven useful and popular especially when dealing with irregularly spaced datasets. Kriging discerns hidden trends in the dataset and extrapolates grid values beyond the dataset' Z range. For large datasets it is very slow computation.
- **Minimum Curvature:** this method generates the smoothest possible surface while attempting to honor the datasets as closely as possible.
- **Natural Neighbor:** this method does not extrapolate Z grid values beyond the range of dataset, rather it honors heavy populated areas.
- **Polynomial Regression:** this method is fast with large datasets. It reveals large-scale trends and patterns are shown, but local details in the data are lost.
- **Modified Shepard's Method** is similar to Inverse Distance to a Power but does not tend to generate "bull's eye" patterns, especially when a smoothing factor is used.
- **Local Polynomial** is independent of the dataset's volume. It is applicable to data sets that are locally smooth (i.e. relatively smooth surfaces within the search neighborhoods).

A meaningful and successful interpretation is always based on honoring the data and keeping its integrity intact. Therefore, to a scientist or yet an interpreter, it is essential and crucial to correctly position and grid datasets. The first fundamental steps to achieve that goal are: a) to choose the appropriate algorithm method in conjunction with its suitable gridding parameters, b) to consider a hidden parameter; the geology of the area.

The intention here is not to evaluate the products of the various gridding algorithms, nor to compare their mathematical systems. The evaluation has been explored and scrutinized by (Kamcili, 2001). He elucidated the assessments of these gridding methods through vivid slides devoid of gridding parameters discussion.

The assumption of parameters is critical, according to Netteleton, all mathematical systems involve assumptions at certain stages in their reduction and practical use (Nettelton, 1976). Therefore, our goal is predominantly to illustrate:

How an unreasonable assumption of grid spacing, using Minimum Curvature method of Briggs (1974), leads to erroneous and undesirable results. A larger grid mesh creates wide regional trends, and generates broad gravity anomalies, and a shorter one curtails gradients, and introduces “bull-eyes” in the processed dataset.

How a hidden parameter, geology of the area, can condense and minimize a defective choice of the grid spacing parameter. Indeed, careful use of geologic constraints will keep the integrity of the data intact and will avoid the obliteration of known and major structural and geological features.

Example Area:

The area is approximately 50x49 square miles in northwest Mississippi. It comprises seven counties: Hinds, Humphrey, Issaquena, Sharkey, Warren, Washington and Yazoo (Figure 1a). Sharkey Platform and Tinsley field are common to the area. Approximately 453 randomly spaced gravity stations were downloaded from PACES from University of Texas at El Paso.

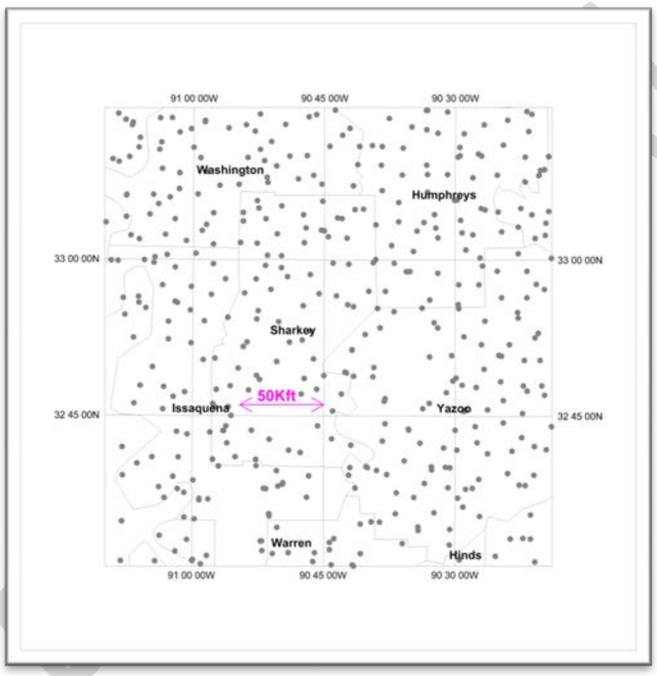

Figure 1a
Northwest Mississippi area with station locations posted

By visual inspection of the randomly spaced gravity stations distribution, one might presuppose that a grid spacing of 50 Kft is adequate for use with Minimum Curvature gridding method. Again, we reiterate that this grid mesh has been erroneously chosen to demonstrate that this unreasonable choice leads to undesirable results. So, figure 1b is an erroneous Bouguer gravity anomaly map at a reduction density of (2.67 g/cc). It appears as if there exist two wide compartments; a northern maximum gravity anomaly indicating a denser block or structure, and two minimum gravity anomalies indicating low density blocks to the southeast. The blocks are broken by a dominant southwest northeast gradient. A skillful interpreter acquainted with the geology of the area - the hidden parameter, may raise questions about the map, and wonder about the absence of the significant known geological features in the area. Others may pay scant attention to the map and move on.

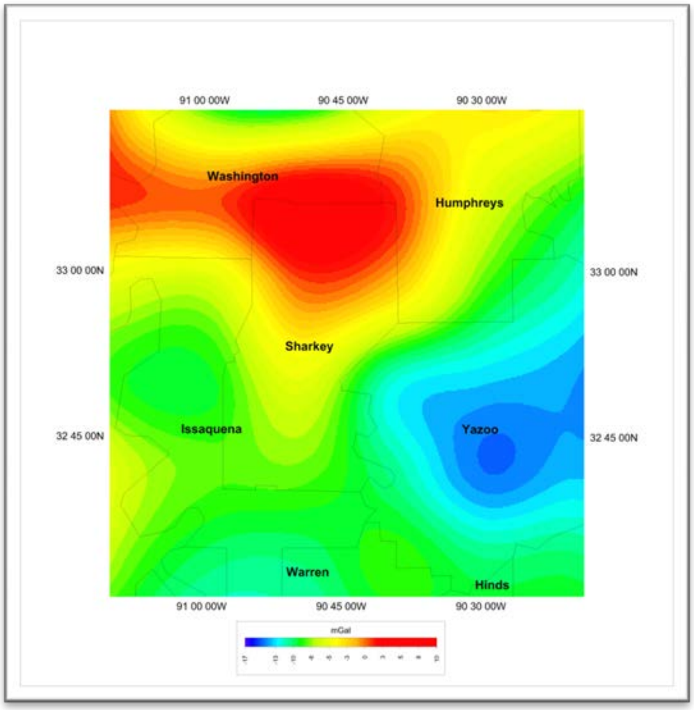

Figure 1b
Bouguer Gravity Anomaly (Erroneous) Map generated by using the broad 50 kft grid mesh.

Figure 1c is also a Bouguer gravity map generated from the same processed dataset using Minimum Curvature gridding method. It differs from the map on figure 1b by virtue of our *hidden parameter* i.e. geology of the area. The geological constraints have facilitated a reasonable selection of grid spacing – 5Kft grid cell. A first look at the map indicates that the southwest northeast trend is still dominant. But supplementary local features have appeared, such as the two maxima in Sharkey County, accompanied with regional minima in Yazoo County. At this stage the interpreter may have enough ammunition to proceed with enhancement maps to decipher the dataset for better interpretation.

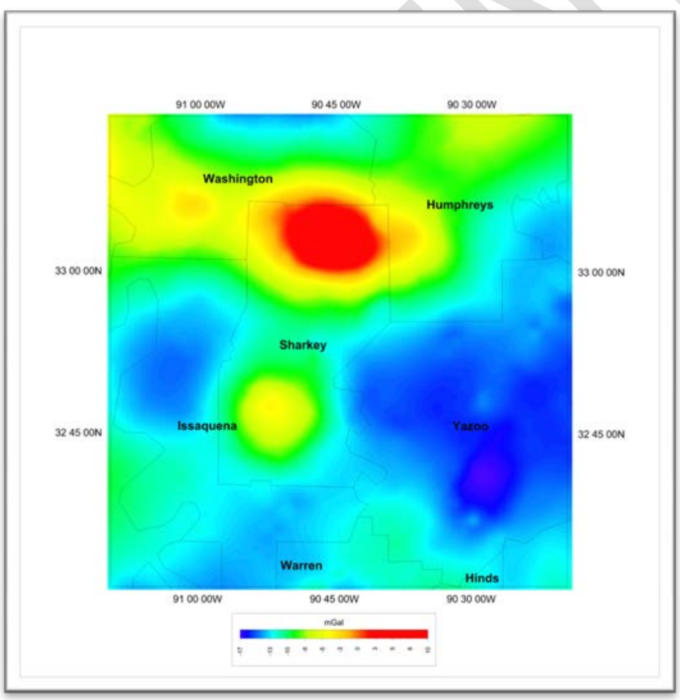

Figure 1c
Bouguer Gravity Anomaly Map generated by using 5 Kft grid mesh which takes advantage of the closer gravity stations.

The Hidden Parameter: Geology of the Area

The mapped Bouguer gravity field shown in figure 1d is similar to that in figure 1c with the addition of a geologic overlay. The superimposed overlay appends structural attributes to the major gravity highs and lows. Cary and Midnight are known structures that correlate with the gravity highs. Tinsley field is situated on gravity minima. Sharkey Platform uplift is trending north-south over Sharkey County.

Sharkey Platform is interpreted as a major uplift which occurred during late Upper Cretaceous (Taylor) time and continued into late Tertiary (Miocene) time. The region was lifted above sea-level, and the older beds were removed by erosion. The regional upwarping was coupled with intrusive and extrusive activities (Thomas, 1950).

The Cary, considered to have been an original magnetometer lead, and Midnight structures are located in Sharkey County. They are Upper Cretaceous volcanic vents, both have undergone post-Cretaceous uplift. Their gravity effects reflect denser basement structures (Thomas, 1950).

The Tinsley structure has been interpreted as due to deep-seated salt uplifts corresponding to minima gravity effects (Thomas, 1950). The Tinley field has a cumulative production of 224.5 million barrels of oil and 15.0 billion feet of gas (Maurice, et al). A definitive gravity anomaly would be observed with additional infill gravity surveys in Yazoo County. Tinsley structure has several fault blocks which might be further defined by using those infill gravity surveys.

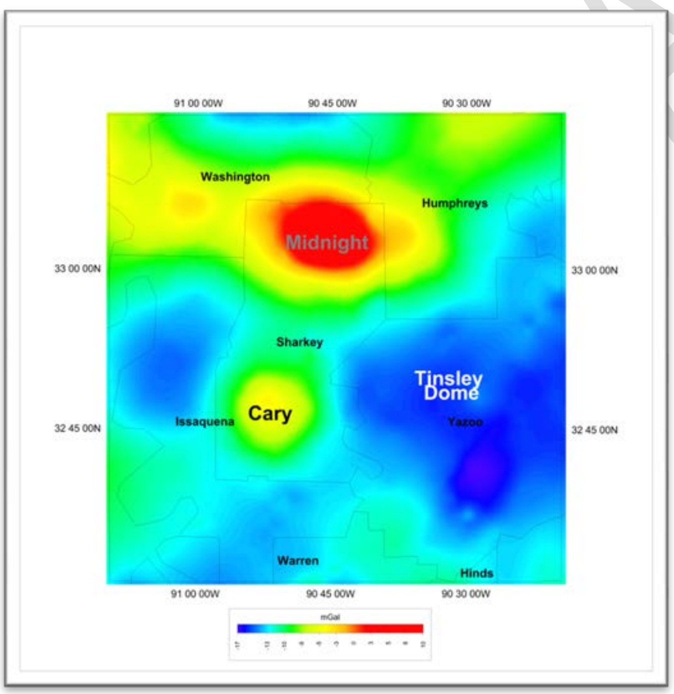

Figure 1d
Bouguer Gravity Anomaly Map with a Geologic overlay

Take Aways

Scientists have been using Ptolemy's cartographic convention to position and grid their datasets for decades. Today, we have an overabundance of projection systems and gridding logarithms. These mathematical systems involve assumptions of parameters at a certain stage. A poor choice of grid spacing will unquestionably conceal or bury vital information inherent in our datasets. The grid spacing, as obvious as it is, must be carefully chosen to honor the datasets and to keep their integrities intact.

Hengl stated that the selection of a suitable grid resolution is based on the inherent properties of the input data, processing power, positional accuracy, inspection density, spatial correlation and complexity of terrain (Hengl, 2006). I submit that the geology of the area is also a key element in obtaining a suitable grid resolution. Therefore, to grid a dataset, one needs to keep the geology at the forefront with the grid spacing selection to negate catastrophic blunders, such as the obliteration of major known geologic features.

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