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TEILTA REGOLITH PROJECT: BASEMENT MODELLING

Luisa Ruperto

CRC LEME OPEN FILE REPORT 157

June 2004

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Headquarters: CRC LEME c/o CSIRO Exploration and Mining, PO Box 1130, Bentley WA 6102, Australia

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L. Ruperto

Cooperative Research Centre for Landscape

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c/- Geoscience Australia

GPO Box 378

Canberra ACT 2601

Australia

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ABSTRACT

The basement modelling research initiative, which is part of the Teilita regolith project of CRC LEME Project 2.1, involved the development and construction of a 3D depth to basement model over the area covered by the Teilita 1:100,000 topographic map sheet. This arid landscape, located just to the north of the Broken Hill Domain, is dominated by Proterozoic bedrock overlain by various regolith units. The 3D model is able to provide a visual insight into the form and nature of the subsurface environment, in particular visualising the subsurface configuration of the Palaeoproterozoic Willyama basement under cover. The data used for this project, although forming a relatively small dataset, was collected from two major sources: (1) drillhole intersections as collated by New South Wales Department of Mineral Resources, and (2) ground observations of bedrock outcrops collated by Steve Hill from Adelaide University. Following a number of spatial adjustments required to fit the data to the topography, a variety of GIS products (such as contours maps, interpolated grids, point datasets) were generated and form the foundations of the 3D depth to basement model. The model allows for visualisation of the topographic surface combined with the interpreted location of the basement as it would appear in the actual environment in three dimensions. This allows the viewer to examine the model in a full 360° range of motion, including enabled zoom in/out features. The 3D model is able to identify areas where bedrock crops out at the topographic surface or where it is only very shallow below that surface, while also displaying significantly deeper bedrock distribution within the map sheet area.

INTRODUCTION

The area located to the north of the Broken Hill Domain at approximately 141°15'E 30°30'S to 141°45'E 31°0'S is referred to as the Teilta 1: 100, 000 map sheet. Formerly known as the Tindara area, this region situated in far western NSW is one of the principal sites for CRC LEME Project 2.1 Western NSW Regolith research initiative in 2003-04. The aim of this project was to produce an integrated regolith model of landscape evolution and geochemical dispersion, therefore promoting mineral exploration in this area. The generation of a 3D basement model would permit scientific inferences to be made based on the relationships that exist between the Willyama basement, overlying regolith and the chemicals that are transported between these units. The overlying regolith is deeply weathered and bears extensive transported cover over large areas of bedrock outcrop.

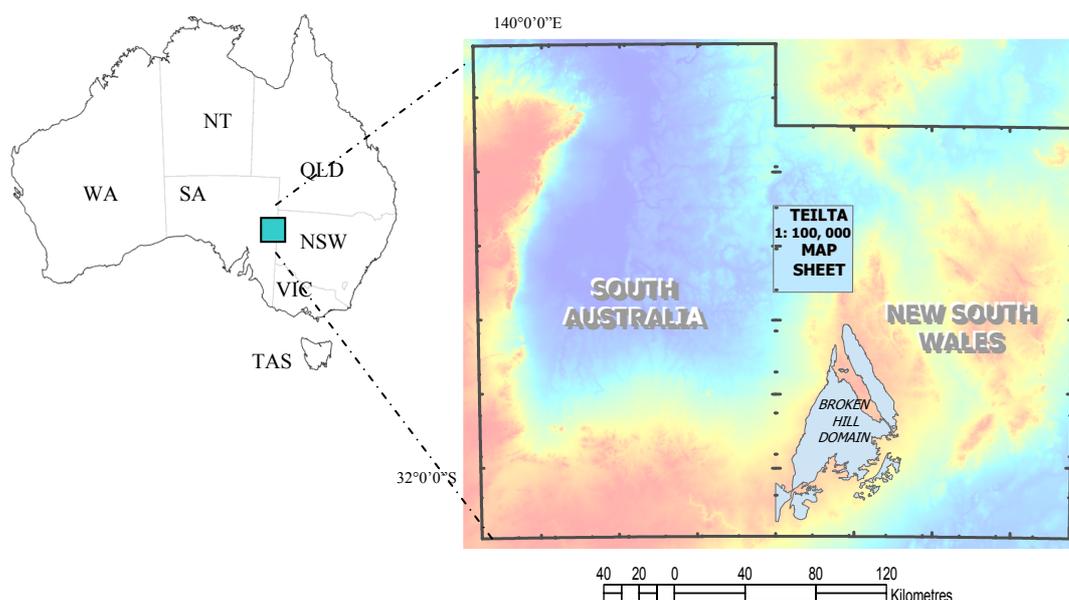


Figure 1 Located on the border between the NSW and South Australia, the Teilta 1: 100, 000 map sheet features as one of the most important study sites in the Western NSW Regolith Project in Project 2.1.

PHYSIOGRAPHIC SETTING

The climate of the Teilta area is typically dry and arid (Hill and Roach 2003). With scarce, highly variable rainfall, the vegetation supported in this climate generally comprises of chenopod shrublands, forbs, grasses, saltbush, bluebush and, mulga (Hill and Roach 2003, Lawrie and Stanley 1980). The climate of the Teilta area is predominantly dry with hot summers and mild winters. The mean annual rainfall is about 220-230 mm, but rainfall events are erratic both in intensity and location; mean annual minimum and maximum temperatures are 15 and 24 °C, respectively (Bureau of Meteorology, 2004).

GEOLOGY

The solid geology of the area is predominantly Proterozoic in age, varying from Mid to Mid-Late Proterozoic. This broad Proterozoic coverage extends over approximately 80 percent of the 1: 100, 000 map sheet. The north-east quadrant is of early to mid Cambrian while a small Silurian outcrop is situated between Teilta Homestead and Mt. Westwood. The flat undulating Cainozoic red-brown clayey loam and lateritic soil plains which display east-west

trending dune deposits, consist of red-brown clayey sands with interdunal claypans, in the north and west of the sheet (Cameron 1993). In the far south-eastern corner of the sheet the geological extent consists of Upper Proterozoic Yancowinna beds of conglomerate, sandstone with numerous erratic pebbles and boulders (Cameron 1993).

REGOLITH LANDFORM UNITS

The predominant regolith-landform units (RLU) and associated descriptions within the Teilta sheet as obtained from the Cobham Lake 1:250, 000 map sheet (Lawrie and Stanley 1980) may be categorised into Ranges; Tablelands; Rolling Downs and Lowlands; Alluvial Plains; Sandplains and Dunefields; and Playas and Basins. The following is summarised from Lawrie and Stanley (1980).

The south-east corner of the map sheet exhibits the Farraway and Teamsters regolith units which belong to the Ranges RL. This portion of the sheet bears the highest relief to 250 masl where the Farraway regolith unit (characterised by steep quartzite and sandstone ridges and footslopes covered by locally calcareous reddish, loamy sand lithosols) is flanked to its west by the lower relief of the Teamsters regolith unit. With similar bluebush, saltbush vegetation, this regolith unit's rocky limestone ridges and footslopes exhibit contour bands alternating between bare stony well-developed red sandy loam with massive calcareous soil with saltbush and herbs.

Pulgamurtie is the name of the regolith unit belonging to the Tablelands RL. Located in a small somewhat linear feature at the centre bottom of the 100K map sheet, this regolith unit of brown lithosols and deep red desert loam supports mulga, perennial shrubs and abundant forbs and grasses.

From the Rolling Downs and Lowlands RL the Nuntherungie and Katalpa regolith units flank the east- southeast areas of the Teilta sheet around the Westwood –Mt Westwood regions. Both units display undulating plains of low relief that are distinguished by alternating contours of red-clay bands, a lack of stones, a presence of dense saltbush/ bluebush with the stony red desert loams, grasses and forbs of the Nuntherungie. The Katalpa regolith unit on the other hand, has the most distribution between these two units with its stony surfaces covered with red desert loams and sparse vegetation. Katalpa also exhibits bands of stone-free red clays located in Gilgai depressions while any drainage tracts comprise of deep loamy alluvium.

Within the Alluvial Plains RLU, the Caloola, Fowlers and Conservation regolith units are scattered throughout the south-eastern quarter of the sheet. The extensive Gilgai terminal floodplains with saline grey/brown cracking clays of Caloola bear similar characteristics to Conservation with its crusty brown cracking clays in the drainage zones. Conservation is also characterised by its scalded alluvial plains covered in red-brown sandy and loamy soils with a loose sand cover and mainly grasses for vegetation coverage. Fowlers' narrow floodplains of moderately scalded back plains reveal brown sandy loam soils with crusty brown clays. The Allandy member of the Alluvial Plains RLU is widely dispersed as small pockets of scalded alluvial flats throughout the 100K sheet. This unit bears loamy soils and brown clays with clayey-sandy dunes with dense mulga. Langawirra's slightly undulating calcareous plains with longitudinal alkaline clayey sand dunes and scattered grey clay pans are located in the southwest quarter of the sheet just south of Avenal.

Just to the north of Mt Westwood is Rodges, one of four regolith units in the Sandplains and Dunefields RLU within the 1: 100, 000 map sheet. These sandplains bear low sandy rises with sandy calcareous red earths exhibiting brown crusty clays on alluvial pans covered with calcareous subsoils on scalded pan margins. The predominant regolith coverage of the entire sheet is Gumpopla. These parallel clayey dunes comprise of narrow scalded alluvial flats, all

covered with extensive arid zone vegetation. Marrapina, generally located in the south-west quarter south of Avenel (and a minor unit on the north-west corner) displays locally aligned small yellowish-red leached sand dunes with dense vegetation.

The Fort Grey regolith unit of the Playas and Basins RLU are typified as small bare lakes with massive, cracking self-mulching brown clay soils located as small pockets in the northern margins.

3D MODEL AIM

The production of a three-dimensional depth to basement model of the Teilta Block is a result of a prescribed need to visualise the spatial extent of fresh bedrock pertaining to the Proterozoic Willyama Supergroup. The overall aim of this model is to gain a unique and graphic perspective of Teilta's subsurface environment which will aid in the exploration of subsurface interactions, forms and processes that are otherwise assumed. Through an integration of this model and various other geo-spatial datasets this model will enable an interactive approach in identifying regolith and geochemical relationships.

The Palaeoproterozoic Willyama Supergroup (Stevens and Burton 1998, Willis et al. 1983) is recognised in this study as the 'basement' or depth where fresh bedrock first occurs within the stratigraphic sequence. Many of these appearances occur as outcrops particularly in the south eastern corner of the block. This particular group of outcrop observations was one of three Excel files of point data used to form a basement dataset from which the 3D depth to basement model was based upon.

THE DATA

The principal component for this project is the input data. Totalling 103 data points, the complete basement dataset utilises points originating from three different sources all bearing a description of depth to basement values. Primarily DMR's drillhole information (files: *dtbproj ww.xls* and *d2bproj nonbhb drilling 30jul03.xls*) were used as foundation datasets which were added upon by 54 outcrop observations made by Steve Hill (*Teilta Bedrock Shill.xls*). The combination of datasets were edited so as to remove any redundant information that would not perform a significant role in the generation of the 3D model. It was also required that Digital Imaging of Geological Systems(DIGS) reports (from NSW DMR) be interpreted to confirm some of the data points within the main dataset.

The depth to basement values were taken at a vertical reading of 90 degrees to the land's surface. However, as these values were recorded in metres below surface, calculations were performed on the final dataset in a measure to realign the drilled depths to the land surface. This was performed by conducting a data join based on spatial location to all depth to basement values where each pixel within the digital elevation model (depicting the topographic surface) has an *actual* height value above mean sea level. These topographic pixel heights are referred to as Grid Code. The calculation performed on the original depth to basement values were transformed to a new height through the equation below. This allows each drillhole's depth to basement value to be recalculated based upon the height of the topographic surface at that particular spatial location.

$$\text{New Height} = 1 * \text{Grid Code} - \text{Depth to Basement}$$

In Figure 1.2 the drillhole identified as Depth to Basement is shown to be adjusted, following the application of the new height equation originating at the topographic surface aptly named New Height.

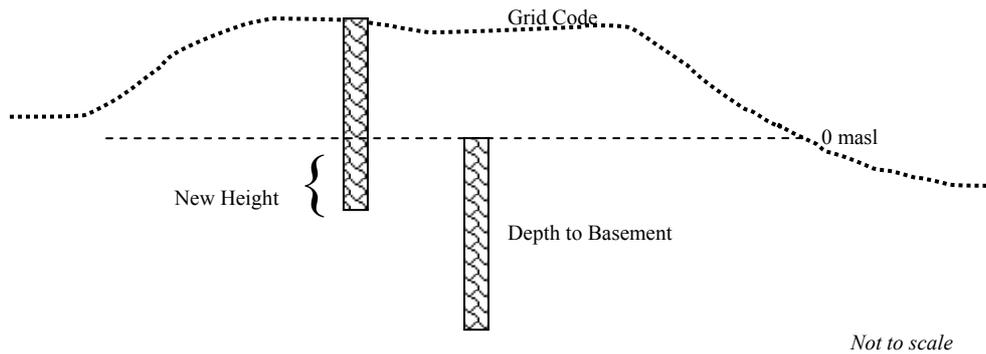


Figure 1.2. The sketch shown above portrays the various components of the New Height equation which realigns the depth to basement values to the DEM surface layer. The depth to basement value is measured from the actual ground surface. However, this true ground surface does not bear a uniform elevation that is topographically based at 0masl. The New Height value describes the remaining difference from Grid Code – Depth to Basement. It is this height that is recognised as the adjusted height of the depth to basement value below the topographic surface.

This newly adjusted dataset was displayed in ESRI’s ArcMap extension to achieve a visual display of the point data’s spatial extent within the Teilta area. This area was interrogated so as to ensure the correct(ed) height was displayed when the identity tool was used as a method of query. Due to the uneven spatial distribution of these points, spatial interpolation was performed to generate a surface that would provide an interpolated depth to basement cell value for the entire raster coverage where there were no actual drillhole locations.

INTERPOLATION

Interpolation provides a statistical coverage of the specified areal extent. It creates weighted averages (with varying cell parameters) of the pixels within the current spatial theme generating a surface which is statistically interpreted and consistent.

Two of the most popular interpolation methods, Inverse Distance Weighted (IDW) and Ordinary Kriging were employed in generating interpolated surfaces of Teilta’s basement extent. These methods of interpolation were applied to the dataset (using the New Height data field as a constant) experimenting with a variety of cell parameters each providing a unique raster output surface. A general rule which became apparent is that by reducing the number of points in the variable search radius and consequently by reducing the output cell size, the resulting raster bears greater definition and leads to less generalisation of cells where actual data is scarce. This in effect is limited to the amount of data points available in a dataset and may produce an output surface that lacks surficial detail. Figure 1.3 is a contour map of the interpolated basement layer and was based on the depths and distribution of points displayed in Figure 1.4.

Inverse Distance Weighted interpolations displayed highly generalised raster surfaces which were comparable to the Kriged surfaces. Figures 1.5a and 1.5b are examples of such a comparison. In these figures, it is evident that the variation between the interpolations methods is significant and provides distinct cell interpretations. This is an important factor to consider and is often good practise to generate a variety of cell parameter combinations particularly when the spatial distribution of point data is irregular.

The output rasters that the variable interpolations generated were converted from the default floating point rasters to integer rasters. This was so that the surface layers could be imported into a 3D viewing environment, ArcScene.

ARCSCENE

As an extension of ArcGIS, ArcScene offers the viewer a mode of visualisation which allows for a three dimensional aspect of the rendered surfaces generated using ArcMap. Within a scene of thirty times vertical exaggeration setting, a DEM of Teilta's topographic surface was imported along with the drillhole dataset and multiple integer raster combinations of depth to basement values. The base heights for each theme were set to display the surface with a z dimension (see Figures 1.6a, 1.6b). The subsurface themes were set to a z-unit conversion of -1 while the DEM had a positive z value as it depicts the areal topographic land surface.

Figure 1.6a is a south-western aspect of the Teilta sheet which shows newly calculated drillhole depths to the basement extruded as lines displaying the point data as vertical drillholes originating at the topographic surface down to the basement Willyama stratigraphic unit. The drillholes shown in the graphic (Figures 1.6a,b) depict the drilled depths intersecting the Willyama basement rock. Seen in the appended raw data, numerous holes do extend through this basement layer.

This model was visualised in 3D however it is actually displayed in 2.5D. However for the purposes of this project, ArcScene allows for multiple surfaces to be simultaneously examined from a full 360° aspect. Such flexibility enables the viewer to explore the topographic variation exhibited within the stratigraphic surfaces. Following an addition of regolith and basement geology maps, subsequent interrelationships between depths of regolith units and saprock/saprolite may also be examined.

The Teilta basement model can be viewed as a pre-recorded video file ([arcscene_3dimage2.avi](#)) using a standard media player. Should the user wish to manipulate and interactively view the model within a 3D visualisation environment, the .wrl files contained in the '[teilta_vrml](#)' folder on the CD included with this report can be viewed in a browser after downloading the free VRML viewer plug-in Blaxxun Contact (<http://www.blaxxun.com/en/products/contact/index.html>). The plug-in offers a variety of tools (accessed by right-clicking in the active view) that enable the user to interactively examine the modelled basement surface from multiple aspects. (An internet connection is required to view these images in 3D.) The [readme.txt](#) file located in the 'teilta_vrml' folder contains further instructions as to what the additional images signify.

CONCLUSION

Three dimensional depth to basement modelling within the western NSW region known as the Teilta 1:100, 000 map sheet has allowed for a more detailed perspective of the stratigraphic extent of the Willyama Basement in this area. Such a visualisation demonstrates how multiple datasets can be integrated to gain a broader spatial coverage as well as displaying the benefits of geostatistical interpolation methods when data is unevenly distributed. The 3D basement model identified areas of both shallow outcrop and considerably deep bedrock whose distribution was enhanced when visualised in 3D.

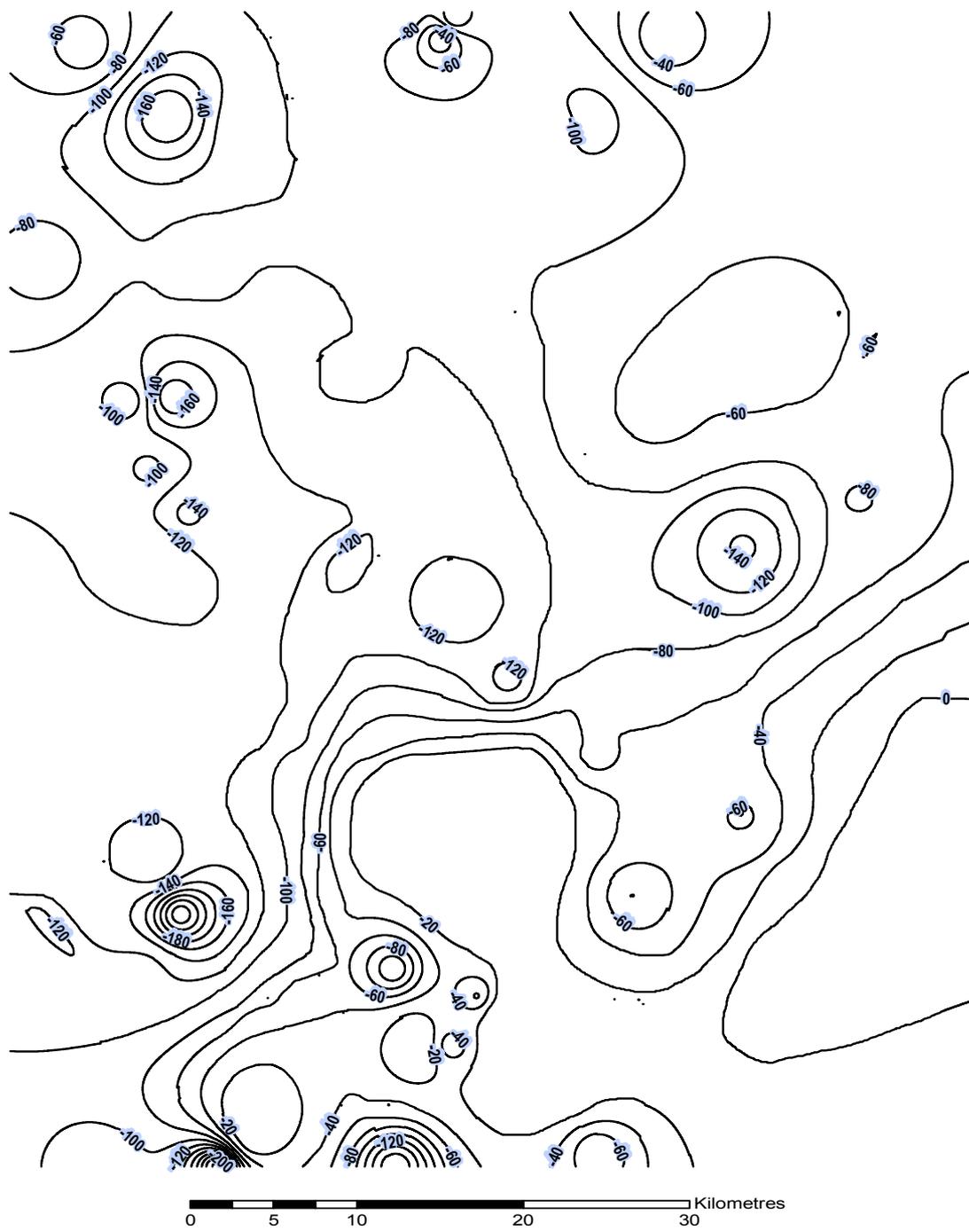


Figure 1.3. This contour map is of depth to basement within the Teilta 1: 100, 000 map sheet. Labelled are the 20m depth contours with a depth range of 0m to -251m below sea level of a kriged interpolation layer. Figure 1.4 may be underlain this image to see the spatial extent of the depth to basement contours with the actual measured drillhole depths seen in the depth_to_basement.dbf

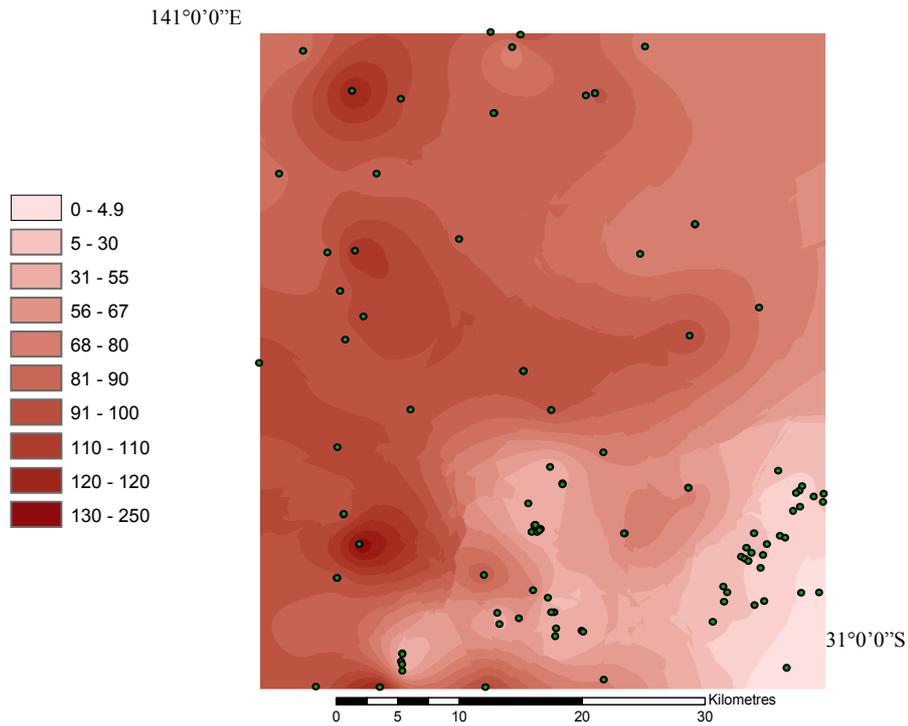


Figure 1.5a Kriged interpolation

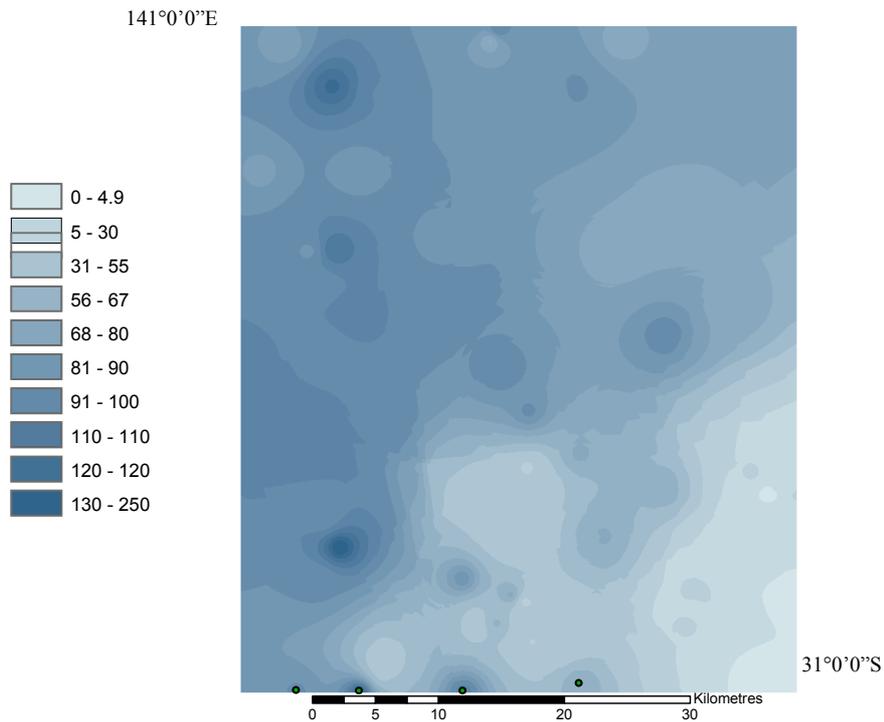


Figure 1.5b IDW Interpolation

The kriged interpolated surface of the Teilta 1: 100, 000 Map Sheet Figure 1.5a was generated using 12 points in the variable search radius and 10 as the cell size output. This same ratio was used for the IDW surface featured in Figure 1.5b, with the south-eastern corner exhibits extensive bedrock outcrops. The variance between the two methods of interpolation with the same cell parameters is visible within the middle and northern regions of the Teilta area which have significantly different zonal distribution despite the same point data.

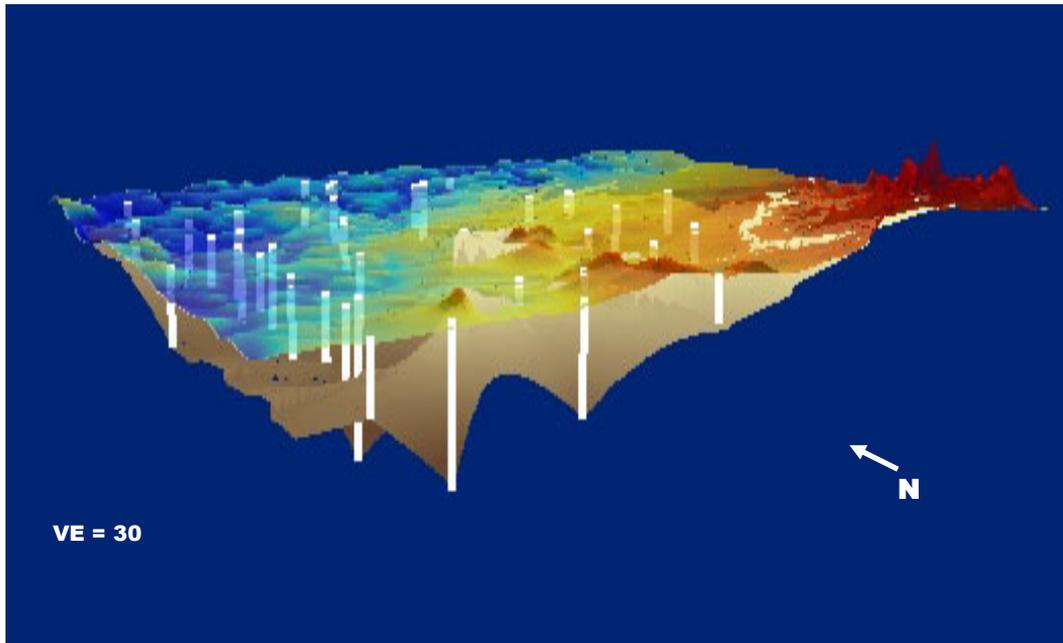


Figure 1.6a

Figures 1.6a and 1.6b display the topographic land surface of the Teilta map sheet represented by the pseudocolour DEM layer with a height range of 0 masl to ~250 masl. The extruded drillholes are displayed as the white lines joining the topographic land surface and the Willyama basement shown here by the brown kriged raster using a cell output ratio of 10:5. Figure 1.6a (above) displays the Teilta Map Sheet area from a south-westerly perspective while Figure 1.6b (below) is taken from a westerly aspect.



Figure 1.6b

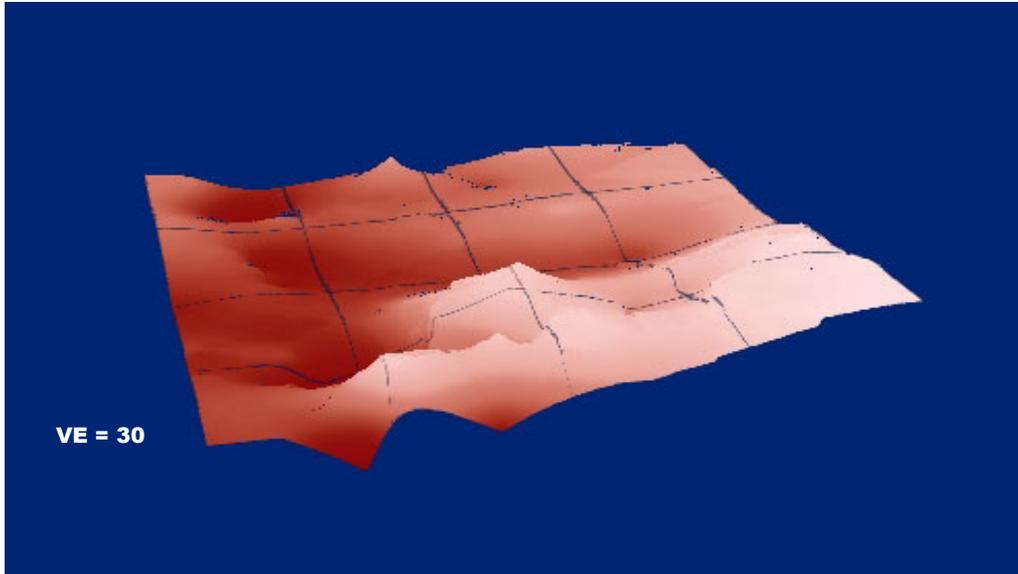


Figure 1.7a

Figure 1.7a and 1.7b display the apparent differences in the two different interpolation methods when visualised in 3D with DEM removed. Here the peaks and troughs of the basement layer are more smoothed in the Kriged interpolation (Figure 1.7a) and are more stretched (emphasised) in Figure 1.7b which used IDW interpolation. In a 3D scene, these differences can lead to an analysis which may be biased based upon the chosen interpolation method.

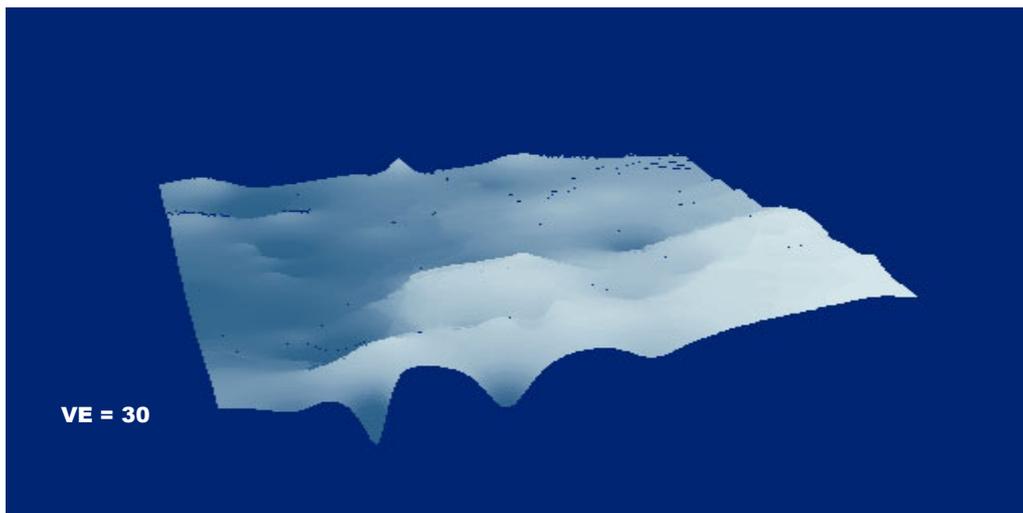


Figure 1.7b

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