EDWARDS PLATEAU CHERT SOURCES AND THEIR PROXIMITY TO THE GAULT ARCHAEOLOGICAL SITE

GIS & GPS Applications in Earth Science (GEO327G)

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# Table of Contents

1. The Problem .............................................................................................................. 4
2. Data Collection ........................................................................................................... 6
3. Data Processing ........................................................................................................... 7
   Creating a Digital Elevation Model of Study Region ...................................................... 7
4. Data Analysis .............................................................................................................. 12
   Least Cost Path Analysis ............................................................................................. 12
5. Conclusions ................................................................................................................. 18
References ....................................................................................................................... 19
FIGUES

FIGURE 1: THE LOCATION OF THE GAULT SITE (41BL323). ................................................................. 5
FIGURE 2: NATIONAL ELEVATION DATA FOR STUDY REGION............................................................. 7
FIGURE 3: MOSAIC OF ALL NED TILES INTO SINGLE DEM RASTER AND HILLSHADE APPLIED .. 8
FIGURE 4: STUDY REGION AND ALL GEOLOGICAL DATA FOR TEXAS ........................................... 8
FIGURE 5: DEM WITH RELEVANT GEOLOGICAL INFORMATION OVERLAYED .............................. 10
FIGURE 6: DEM SHOWING LIMESTONE FORMATIONS WITHIN THE EDWARDS PLATEAU, ALL
GEOLOGICAL SOURCE LOCATIONS AND THE GAULT SITE ....................................................... 11
FIGURE 7: DEM SHOWING REDUCED STUDY AREA ........................................................................ 12
FIGURE 8: CLOSE UP OF SLOPE FOR STUDY AREA ......................................................................... 13
FIGURE 9: SLOPE OF SPECIFIC STUDY AREA, RED CIRCLES INDICATE GEOLOGICAL SOURCES
AND BLACK TRIGANLE INDICATES THE GAULT SITE .................................................................. 13
FIGURE 10: CLOSE DISTANCE FOR STUDY AREA ............................................................................ 13
FIGURE 11: COST BACK LINK FOR STUDY AREA ........................................................................... 14
FIGURE 12: RESULTS OF THE COST PATH ANALYSIS ..................................................................... 14
FIGURE 13: COST PATH ANALYSIS FOR GAULT SITE TO GAULT GEOLOGICAL SOURCE (1) ....... 16
FIGURE 14: COST PATH ANALYSIS RESULTS FOR GAULT SITE TO LEON CREEK GEOLOGICAL
SOURCE (1) .................................................................................................................................... 17

TABLES

TABLE 1: SOURCE INFORMATION FOR DATASETS USED IN PROJECT ............................................ 6
TABLE 2: ALL GEOLOGICAL FORMATIONS THAT MAY CONTAIN CHERT AND THEIR
ABBREVIATION .............................................................................................................................. 9
TABLE 3: ORIGIN TO DESTINATION DISTANCES ............................................................................. 14
1. THE PROBLEM

Chert was a key component in prehistoric toolkits in many regions, primarily due to its widespread availability and suitability for knapping. The occurrence of high-quality nonlocal and local lithic materials in Paleoindian sites is commonly reported and can provide archaeologists with the tools needed to answer questions about exchange networks, interaction zones, and resource procurement strategies. This research is especially relevant in central Texas, which hosts one of the largest chert bearing formations in Northern America, the Edwards Plateau.

The Edwards Plateau region and all associated limestone formations within the Edwards geological formations occur over an area nearly a fifth the size of Texas. The primary limestone rock comprising the Edwards Plateau region is the result of calcareous shelled organisms that filled the early Cretaceous Marine waters covering Texas from approximately 146 – 100 million years ago. The formation of chert through the Edwards Plateau is based upon pelagic sediments laid down during this period and subsequent diagenesis and consolidation of silica. Due to the characteristics of chert, Edwards Plateau chert are not macroscopically homogeneous and as a result, several archaeological studies have emerged that have attempted to geochemically trace chert artifacts from archaeological sites to their original formations. Speer (2013) was able to successfully trace artifacts from the Gault archaeological site (41BL323) to specific source locations within the Edwards Plateau. This study forms the foundation for the analysis conducted in this project, with aims to use least cost path analysis to determine possible routes of movement between the identified geological sources to the Gault site.

The Gault site is situated in the upper valley of Buttermilk Creek in southwestern Bell country in central Texas (Fig. 1). The site boasts a prolific record of prehistoric occupation and has produced compelling evidence for pre-Clovis occupation. The first excavations were conducted in 1929 by Professor J.E. Pearce of the University of Texas and since then the site has produced an extensive collection of Clovis stone tools and manufacturing debris of approximately 800,000 artefacts.
The source of these artifacts most likely lie within the limestone formations in the Edwards Plateau, and movement of prehistoric people between geological source and settlement would have taken place. Theoretically, this movement would have followed the least anisotropically ‘costly’ movement across the topography. To model this movement, this project uses the elevation of this region to identify the path of least resistance from point of origin to destination with an expectation that this path will have little elevation gain.

FIGURE 1: THE LOCATION OF THE GAULT SITE (41BL323).
2. **DATA COLLECTION**

The spatial and geological data collected for this analysis was obtained from United States Geological Survey (USGS) and the archaeological information was extracted from Speer (2013) (Table 1). National elevation datasets with a 10m resolution (NED) were downloaded from USGS for the region of study. The geological dataset was downloaded from the USGS geologic database of Texas. The hydrological information was downloaded from the National hydrological dataset (NHD) from the Texas National Resource information system (TNRIS).

All the archaeological information was obtained from Speer (2013), in which coordinates were provided from geological sources areas and the Gault site location. These coordinates were transferred to a csv file ready to be imported into ArcMap.

**TABLE 1: SOURCE INFORMATION FOR DATASETS USED IN PROJECT.**

<table>
<thead>
<tr>
<th>Source Name</th>
<th>URL</th>
<th>Spatial reference</th>
<th>Resolution</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texas National Resource information system: National Hydrological dataset</td>
<td><a href="http://www.tnris.org/stratmap/hydrology">www.tnris.org/stratmap/hydrology</a></td>
<td>GCS North America 1983</td>
<td>N/A (shapefile)</td>
<td>Main river systems within the study region</td>
</tr>
<tr>
<td>Texas Water Development Board, USGS</td>
<td>\b8653abc\abc02\Final\Data\Geologic Database of Texas\Geologic Database of Texas.mdb</td>
<td>GCS_GRS_190 80</td>
<td>N/A (shapefile)</td>
<td>All geological information for the State of Texas</td>
</tr>
</tbody>
</table>

6
3. DATA PROCESSING

CREATING A DIGITAL ELEVATION MODEL OF STUDY REGION

All the data processing was conducted in ArcMap (version 10.8.1). The first step of this project was to create a digital elevation model of the study region, with all relevant geological and archaeological data. The following steps were taken to complete this first step.

First, import all USGS national elevation data into ArcMap, total of 12 tiles that contain data for the entire region of study. To create one single raster out of these datasets, the “mosaic to new raster” tool was used to merge all the DEM files into one unit (Fig. 2) The “project raster” tool from data management was then used to change to coordinate system to UTM Zone 14. To visualize the elevation, a hillshade was created using the tool from the spatial analyst toolbox (Fig. 3).
The next step was to add the geological data downloaded from USGS to the workspace. Within the data folder provided by USGS, there are several useful elements including a geological index to show which geological database (24K, 62K, 125K, 250K) was relevant to the study (Fig. 4). In this case the 250K rock unit layer was appropriate. This data was imported into ArcMap and due to the size of the raster, it was clear only data relevant to the region of interested could stay.
The information was clipped to a more manageable size in the following steps. First, a boundary around the DEM mosaic was created using the “raster domain tool” from 3D analyst. Then, the “clip” tool was used to isolate the geological data from the specific study region. At this point, only the geological formation that may contain chert material are needed, i.e., all limestone formations. To extract the relevant formations (see table 1 for geological key), the data is selected from the attribute table and exported into a new layer and then symbolized appropriately (Fig. 5). The final environmental feature, the main river systems, were added to ArcMap and symbolized appropriately.

**TABLE 2: ALL GEOLOGICAL FORMATIONS THAT MAY CONTAIN CHERT AND THEIR ABBREVIATION**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ipmf</td>
<td>Marble falls formation</td>
</tr>
<tr>
<td>Kbu</td>
<td>Buda limestone</td>
</tr>
<tr>
<td>Ke</td>
<td>Comanche peak limestone</td>
</tr>
<tr>
<td>Kcc</td>
<td>Cow creek limestone</td>
</tr>
<tr>
<td>Kdvr</td>
<td>Devils’ river limestone</td>
</tr>
<tr>
<td>Ked</td>
<td>Edwards’s limestone</td>
</tr>
<tr>
<td>Kfr</td>
<td>Fredericksburg group limestone</td>
</tr>
<tr>
<td>Kgru</td>
<td>Upper glen rose limestone</td>
</tr>
<tr>
<td>Kked</td>
<td>Kiamichi clay and Edwards’s limestone</td>
</tr>
<tr>
<td>Ks</td>
<td>Segovia member of Edwards limestone</td>
</tr>
<tr>
<td>Ksa</td>
<td>Salmon peak limestone</td>
</tr>
<tr>
<td>Kwa</td>
<td>Walnut formation</td>
</tr>
</tbody>
</table>
The final step in data processing was to import all the geological source location and the archaeological site location that was outlined previously (obtained from Speer 2016). The csv files created when the data was first obtained (one containing the coordinate for the geological source, and the other the archaeological site coordinates) were imported into ArcMap using “add XY data” under “Add data” in file. These sites were symbolized appropriately, and a label was added for the Gault site (Fig. 6). This marks the end of the step involved in the basic map creation.
FIGURE 6: DEM SHOWING LIMESTONE FORMATIONS WITHIN THE EDWARDS PLATEAU, ALL GEOLOGICAL SOURCE LOCATIONS AND THE GAULT SITE.
4. DATA ANALYSIS

LEAST COST PATH ANALYSIS

When looking at archaeological sites in comparison to potential source locations, a very useful model to create is the most likely path to take when travelling from one location to the next. The “cost path” tool does exactly this, by determining the last-cost path from a destination point to a source.

The first step here is to reduce the size of the study region to reduce processing time. To do this, we create a new feature class in ArcCatalog and edit this layer to provide a rectangle around the specific region we want to look at (Fig. 7).

The cost path tool requires two main elements in the form rasters: the least-cost distance raster and the back-link raster. First, slope values are created for the study region as this will become the factor that “cost” is based off. To do this, the “slope” tool from spatial analysis is applied to the DEM mosaic (Fig. 8 and 10). Then the “cost distance” tool from spatial analysis is used to calculate the accumulative cost to source location over a cost surface (i.e., slope) for each cell (Fig. 9).
Next, the cost back link needs to be calculated. This provides the direction of travel from source to destination using the “cost back link” tool from spatial analysist with the archaeological site as the feature source and the slope as the input cost (Fig. 11).
Next, the cost path is run for two different scenarios. The results of Speer’s (2013) geochemical study indicate that 9% of the assemblage from the Gault site were sourced to the Leon Creek geological group (Leon Creek 1 and 2) and 27% were sourced to the Gault geological group (Gault source 1 and 2). None of the assemblages was sourced to the Wolf creek source so this will be excluded to the cost path analysis. The results of this analysis are displayed in Figures 12, 13, and 14.

The results of this analysis show that the two routes taken between the gault sites and the gault and Leon creek geological sources were along paths that maintained a low elevation to no elevation gain. The total distance for both paths are displayed in table 3.

### TABLE 3: ORIGIN TO DESTINATION DISTANCES.

<table>
<thead>
<tr>
<th>Destination from site</th>
<th>Distance (meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gault geological group</td>
<td>60627</td>
</tr>
<tr>
<td>Leon Creek geological group</td>
<td>322644</td>
</tr>
</tbody>
</table>
Edwards Plateau chert

Map showing the result of the cost path analysis in terms of elevation. Yellow line shows the path of least resistance from the Gault site to the cluster of Gault geological sources and the red line shows the path of least resistance from the Gault site to Leon Creek geological sources.

FIGURE 12: RESULTS OF THE COST PATH ANALYSIS.
Edwards Plateau chert

Map showing the result of the cost path analysis in terms of elevation, from the Gault site to the Gault geological source 1.

FIGURE 13: COST PATH ANALYSIS FOR GAULT SITE TO GAULT GEOLOGICAL SOURCE (1)
Edwards Plateau chert

Map showing the result of the cost path analysis in terms of elevation, from the Gault site to the Leon Creek Geological source 1

FIGURE 14: COST PATH ANALYSIS RESULTS FOR GAULT SITE TO LEON CREEK GEOLOGICAL SOURCE (1)
5. CONCLUSIONS

The results of the analysis conducted in this project successfully show the path of least resistance between the archaeological site in question and geological sources where raw material for artifacts are known to have occurred. This type of analysis is incredibly useful in trying to understand how prehistoric (or even modern groups) interaction with their landscape and natural resources. While several other factors can affect the movement of groups (e.g., ecological surroundings or cultural influences), using elevation as a factor effecting movement is an essential first step in modelling mobility and can form the foundation for more complex analysis, for example, agent-based modelling. In addition, this analysis also has the potential to help identify possible target areas of archaeological prospection. As demonstrated in the initial stages of this project, the area in which chert materials could be located is extensive and it seems likely that there are more source locations utilised by prehistoric groups.

The use of ArcGIS software and specific analysis, like cost path, in this project has shown the value of such software for archaeological purposes. While some factors may need to be developed to be more relevant to real world situations, the results of this analysis provide a foundation for further archaeological investigations in the region.
REFERENCES