Geothermal Prospecting using Interactive Analytics: Ethiopian Applications

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Summary

Geothermal is an energy source for both base-load electricity generation and direct-use heat applications. Geothermal is gaining momentum as part of a strong renewable energy sector that is rising to meet growing energy demand. Not only is geothermal energy renewable, it is independent of the weather, base-load and has the lowest land footprint per MWh/year of all renewable energy sources (McDonald, 2014).

Geothermal still has major challenges to overcome. Economics and feasibility of geothermal energy production are sensitive to not only geology, but distance to infrastructure and local markets. Thus an integrated prospecting approach must be taken.

In this presentation, a variety of datasets will be used to perform a prospectivity analysis in the country of Ethiopia. Ethiopia is at the northern end off the East African Rift System (EARS). The EARS is a regionally extensive system where the earth's tectonic forces are pulling apart the African continental plate resulting in a rift complex greater than 4,000 km in length. As a result of the crustal pull-apart, there is a zone of thinned continental crust within the rift (Wood and Guth, 2014) and a string of high volcanic activity and high heat flow. This results in a prospective fairway for high potential geothermal energy resources. Geothermal systems along the fairway have been studied by many and the region is on the cusp of large-scale geothermal development.

The current state of geothermal prospectivity in the EARS is driven by the observation and correlation of surface manifestations such as volcanoes, hot springs, fumaroles, and faults as an expression of geothermal resources below. This paper presents an Interactive Analytics approach for investigating geothermal prospectivity at a regional scale by mapping and analyzing relevant surface features and their relationships through an objective, data-driven workflow.

In this approach, geothermal project indicators are identified and extracted from available datasets. Prospectivity attributes are generated to compare surface and subsurface feature relationships and potential geothermal resources at depth. Spatial relationships with other features such as distance to roads, power lines, and centers of human activity and energy use are generated to further frame geothermal opportunities.

The Interactive Analytics approach, especially at a regional scale, is not a replacement for high quality geoscience and localized site exploration. It provides an opportunity to develop a data driven understanding of a region and systematic ranking of opportunities resulting in targeted exploration efforts maximizing precious exploration capital. The methodology can highlight potential geographic synergies between geothermal potential, emerging energy developments, existing industry and local stakeholders.

Method

The methodology divides a study area into a dense number of grid points and assigns attributes to these points. Attributes can be explored across multiple visualizations such as cross plots and graphical charts. Filtering and selecting can be used and the results are interactively viewed in the map domain. Attributes are processed in such a way that spatial information is enhanced for these types of analyses. A Python script automates the geoprocessing tasks allowing for rapid iteration, parameter testing, optimization, and idea generation (figure 1).

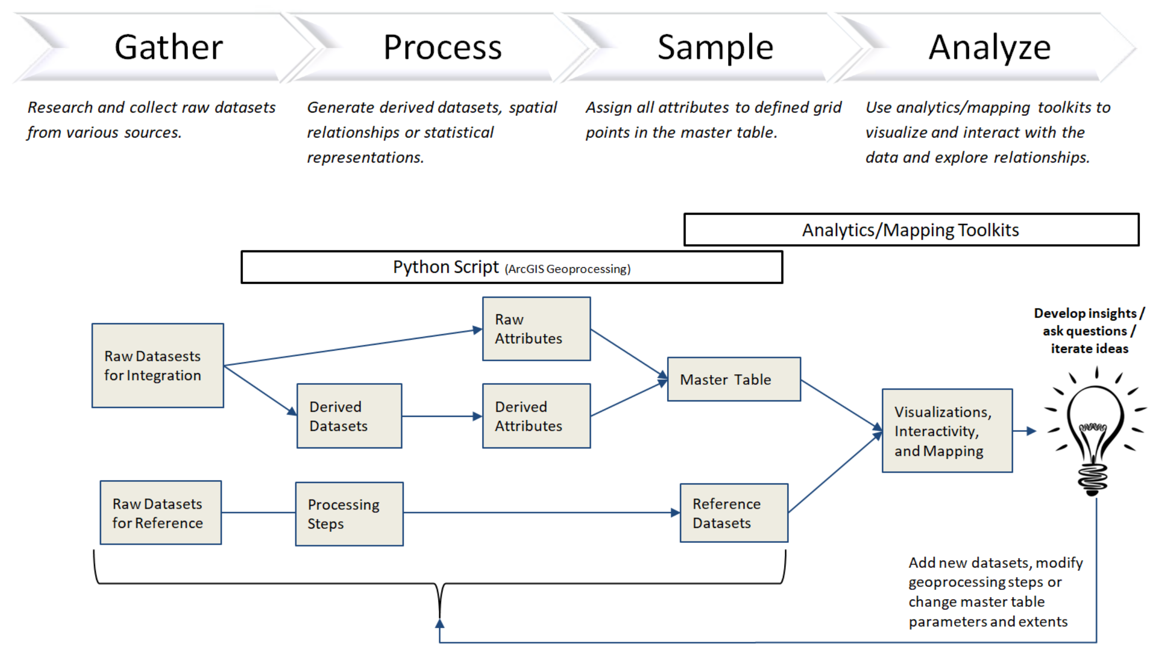

Figure 1: Data analysis flow diagram

Identifying the right data types to use at certain scales is important. At a regional scale, longer period datasets and trends can be utilized. To demonstrate the methodology, attributes such as existing geothermal sites, regional heat flow, hot springs, surfaces lineaments, volcanoes, and infrastructure data will be analyzed. The data gathered for this study is grouped into three attribute classifications:

1. **Geothermal Resource Indicators** are measures (direct) or proxies (indirect) of the geothermal resource. In general, these can be further classified into heat, permeability, or fluid indicators (Hinz et al, 2016).
2. **Infrastructure Indicators** are attributes that influence the developability of geothermal projects such as powerline infrastructure. Market demand such as population densities and power/heat intensive industries are also included.
3. **Reference Data** include attributes that can be used to contextualize the analysis such as regional boundaries and land use designations.

Attributes can be raw or derived. Raw attributes are assigned from source datasets with minimal processing applied and are intended to honour the source datasets as best possible. Derived attributes are enhanced from the source datasets through a sequence of geoprocessing steps (figure 1). Data specific techniques are used for interpolation, aggregation, and resampling. The data are reorganized into a master table with one row per grid point and one column per attribute.

The master table and other reference datasets are loaded into analytics and mapping toolkits. These tools have been configured to visualize and interact with the data and explore relationships. These data relationships are interactively explored in cross plots, maps, and other visualizations.

The iteration speed and rapid "what if" scenario building is the key part of the workflow. As concepts are developed, rapid iteration allows for the identification and integration of new datasets, modification of geoprocessing steps or changes to master table parameters and extents. A Python script facilitates repeatable and efficient data iterations.

Prospect scale mapping is not targeted in this paper. However, the methodology can be applied with appropriate data at continually decreased scales eventually to the prospect level.

Results

Analysis pathways will be explored using the Interactive Analytics methodology and presented to the audience. Using enhanced attributes such as Lineament Density (figure 2) allows the explorer to gain insights from remote sensing data and combine with cultural datasets.

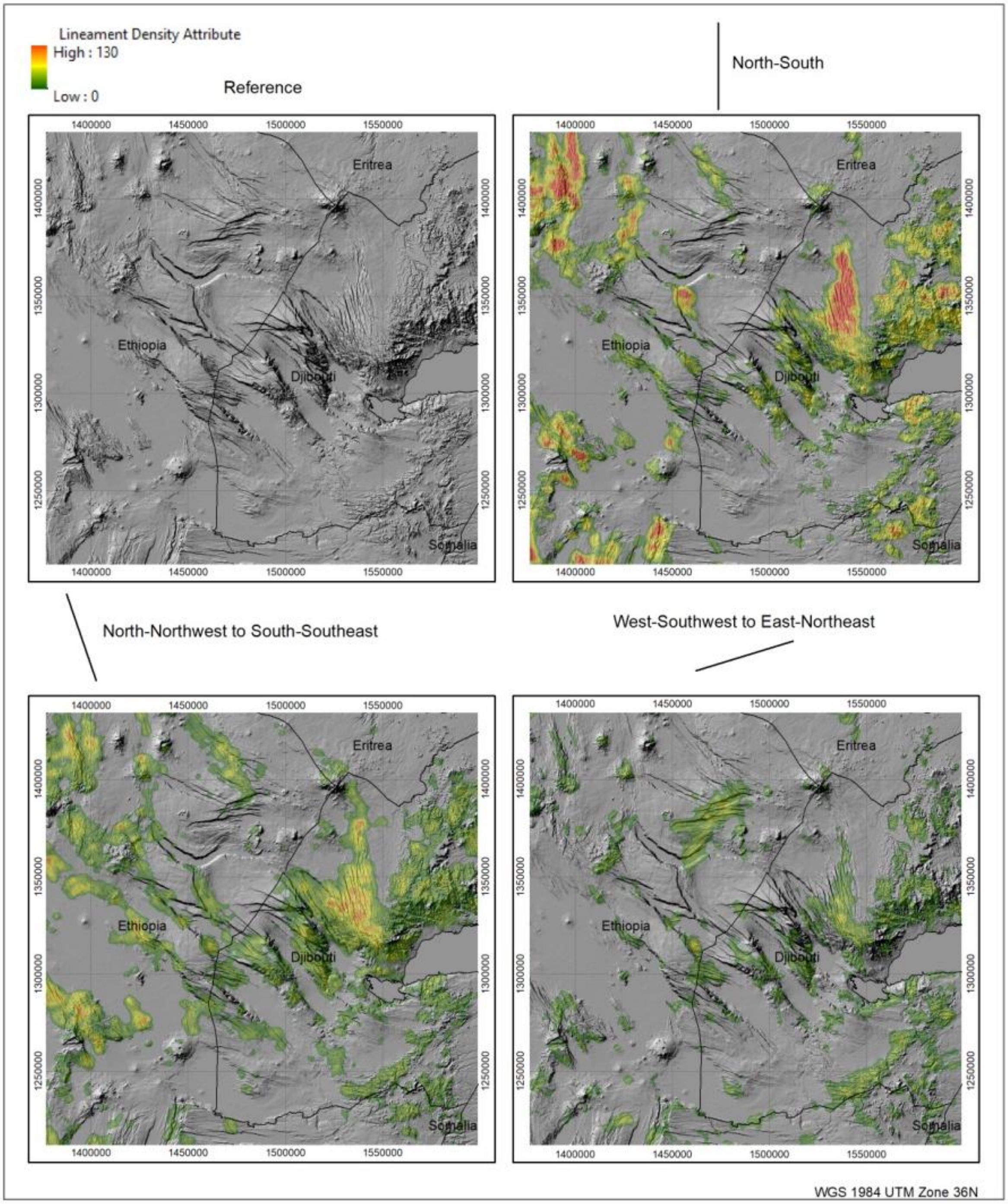

Figure 2: Surface lineament density results for select azimuths overlain on a hill shade image in the Afar triangle.

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