Predictive Model of the Balatok- Tonglo- Aringay Ancient Gold Trade Trail in Southwestern Cordillera

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Using the Least Cost Path method in raster GIS analysis, a predictive model was created to estimate the location of an ancient gold trail connecting the Balatok/ Acupan mines with Tonglo gold bulking center and Aringay coastal settlement within Benguet and La Union Provinces. To derive the model, ASTER global digital elevation model was used in tandem with WorldView2 multispectral and high resolution imagery. The paper shows that GIS and Remote Sensing methods immensely aid in delimiting the research study area in the search for trails thereby resulting to efficient targeting of time and resources for second order excavations.

Key words: Ancient Gold Mining, Cordillera Archaeology, Geographic Information Systems, Least Cost Path, Remote Sensing, WorldView2

INTRODUCTION

The work is part of a broader research on evanescent markets (Canilao 2017; Allegre 1998) for gold in Northwestern Luzon Island during the Early Historical Period (10th to the early 20th centuries). Here, the focus was given to the journey of gold from the ancient gold mines of Akupan/ Balatok to Tonglo bulking village and eventually to Aringay and Agoo coastal villages. Predictive modelling using GIS in tandem with Satellite Imagery analysis was used in this paper.

The location of Tonglo Village has been pinpointed at Tuba, Benguet (Canilao 2013). As published in Scott (1988), Balatok/ Acupan is plotted in the map of Father Antolin dating back to 1789. This is corroborated by the Quirante account from 1624. Finally, Aringay has been historically documented as a coastal maritime trading settlement based on the 1574 account of Mirandaola. The maritime exchange network within which Akupan/ Balatok- Tonglo- Aringay was articulated into may have span the Indian Ocean and South China Sea wherein products such as porcelain, silk, cotton, beeswax, gems, beads, and precious minerals, most notably gold, were circulated.

The ability to efficiently transport bulked gold from Tonglo to Aringay coastal settlement was of primary importance so that Ibaloi gold miners would be able to participate in the tabu-tabuan or evanescent market encounter that was set-off by the arrival of a merchant vessel. At this juncture it should be mentioned that the tabu-tabuan is quite akin to the travelling bazaars that Braudel (1972) discusses in the Mediterranean setting. Also, one early historical source that describes the tabu-tabuan in the Philippine archipelago is the 12th to 13th century account by Chau JuKua (Hirth and Rockhill 1911). This entails a long hike over a Euclidean distance of approximately 19 km distance from the Tonglo to the Aringay with 11 km done over rugged Cordillera terrain.

Several historical accounts describe how the Cordillera indigenous groups from the highland interiors of Northwestern Luzon participated in gold evanescent market encounters occurring on the shores. The accounts include Mirandaola (1574), Rada (1569), and Carillo’s
1756 account in Scott (1988). These accounts indicate that there were direct dealings between interior gold miners and foreign borne maritime traders. The written historical accounts get corroboration from oral tradition sources specifically on the Ibaloi, which delineate the trading trails from gold mines to bulking stations and eventually the coastal maritime trading centers (Prill- Brett & Salinas-Ramos 1998; Bagamaspad & Hamada-Pawid 1985).

**Data Collection and Preparation**

There are new possibilities in applying Least cost path analysis in historical and archaeological contexts in the Philippine archipelago with the advent of open-access data. Least cost path analysis and other second order derivatives already command wide use in other parts of the world (Bell et al. 2002; Bell & Lock 2000; Llobera 2000; Madry & Rakos 1996; Gaffney & Stancic 1991).

The researcher acquired Advanced Spaceborne Thermal Emission and Reflection (ASTER) global digital elevation model at 30 m resolution from the Unites States Geological Survey. The researcher acquired 1000 sq km of high resolution multispectral WorldView2 images of the terrain courtesy of the DigitalGlobe foundation. The multispectral layer was subset into band one (coastal) alone, bands two to six (blue, green, yellow, red, red edge) stacked, and bands seven and eight (NIR1, NIR2) stacked. Band one and Bands seven and eight were resampled to 50 cm. Resolution merge was then implemented resulting to a 0.46 m resolution imagery.

**METHODS**

Using ArcMap 10.4.1 software the ASTER GDEM image of the study areas was converted into a hillshade raster map. The locations of Balatok mining settlement, Tonglo gold bulking center, and Aringay Coastal settlement were then digitized over this map. Using the hillshade map the researcher then implemented a cost distance analysis from Balatok to Tonglo and Tonglo to Aringay. This in turn was subjected to a back-link analysis. Both the cost distance raster and backlink raster were then used to implement a cost path analysis. The resulting cost distance path was overlaid on the hillshade relief map. The three sites and the least cost path were overlaid on WorldView2 satellite imagery and raw ASTER GDEM raster (Figure 1).

![Figure 1](image-url)
DISCUSSION

The least cost path from the highlands to the coast show a path that snakes through the rugged terrain. Because there are existing trails, tire paths, and gravel single lane roads adjacent to the predictive model it can be argued that some of the ancient trail segments may have been integrated into contemporary farm-to-market roads. Some of these more modern trails connect villages and some farms in the highland areas (e.g., 51Q 231767mE 1813707mN). Another example hugs the Aringay river (e.g., 51Q 222510mE 1814884mN) towards the coast (Figure 2). This presents some strengths and weaknesses in terms of the archaeology. On one hand, this shows the direct intersection between a predictive model and an observed human behavior whereas on the other hand the same earth moving activities would have resulted to complications on primary archaeological provenience.

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