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Erosional patterns of ancient ignimbrite paleosurface in the Central Andes

Balázs Székely (1,2), Dávid Karátson (3), Melanie Brandmeier (4), Gerhard Wörner (4), Peter Dorninger (2), and Clemens Nothegger (2)

(1) Department of Geophysics and Space Sciences, Eötvös University, Budapest, Hungary (balazs.szekely@elte.hu), (2) Vienna University of Technology, Institute of Photogrammetry and Remote Sensing, Vienna, Austria, (3) Department of Physical Geography, Eötvös University, Budapest, Hungary, (4) Geoscience Center, Georg-August University, Göttingen, Germany

Tertiary magmatism of the Central Andes produced widespread plateau-forming ignimbrites (e.g. Nazca, Oxaya, Huyalillas) which cover hundreds of km^2 over the Western margin of the Central Andean Plateau.
In the arid to hyperarid climate of the Atacama Desert, the erosion patterns on these ignimbrite plateaus reflect long-term erosion processes during large time spans of up to possibly 22 Ma in response to uplift and climate.
After the emplacement, the surface of these plateau-ignimbrites was formed by the unconsolidated unwelded upper part of the flow units forming a gentle ramp dipping from the Altiplano towards the Longitudinal Valley between the Western and Coastal Cordilleras. This flat surface was subsequently modified by erosion with a preferential quasi-parallel drainage. Subsequently, these surfaces were modified by (1) tectonic uplift of the Western Cordilleras and tilting, (2) incision of deep canyons, (3) plateau edge erosion including gravitational collapse and large landslides, (4) cover by younger sediments or more recent ignimbrites and (5) cannibalizing fossilized river systems under arid climate conditions.
In spite of these modifications the ignimbrite surfaces often keep their characteristic original form as paleosurfaces. Due to their various and well-dated eruption ages, elevation and geomorphic setting, these surfaces developed distinct erosion patterns. Our aim is to describe these patterns in a quantitative way and to link parameters such as age, climate conditions and geomorphic setting.

In our approach we first determine the original ignimbrite paleosurface by considering the surface 3D points of the digital terrain model of the present surface while any other points (canyons, collapse scarps, volcanic edifices, etc) are considered as outliers and excluded. From a data processing point of view it is a segmentation of the input data. We found that applying a robust segmentation algorithm that has been developed previously for identifying roofs of buildings in high-resolution LIDAR data also gives meaningful results for these ignimbrite surfaces.

The similarity of the two problems arises from the fact that the ignimbrite surfaces also typically have a flat, yet patterned geometric shape comparable to the roofs, albeit at a completely different scale. Results show that in some cases this approach is successful, especially if the surface to be reconstructed is regular enough to produce a core set of 3D points of substantial size that spans the geometric shape. Incision and dissection features do not hamper finding an appropriate fit. However, correlated surfaces (e.g. other ignimbrite surfaces or other regular volcanic features such as low-angle cones or lava fields) may lead to inconclusive or erroneous results combining incompatible surface portions to artificial geometric features. Therefore, automated results must be ground-truthed by field observations and/or age data and a final identification of a studied paleosurface always needs to be verified.

Deciphering the sequence of various paleosurface formation by our approach, completed by a variety of observations such as drainage pattern and age data, contributes to a better understanding of the volcanic and geomorphic history of the remote area of the Central Andes.