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Remote sensing data applied to the reconstruction of volcanic activity in the Valley of the Volcanoes, Central Volcanic Zone, Peru

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ABSTRACT

The Valley of the Volcanoes is a representative area of the extension of the Quaternary Andahua Group with which it overlaps. Some of its eruption centres have renewed activity after more than 500 ka. Recreating the history of the Valley of the Volcanoes activity required satellite data and remote sensing-based methods for visualizing the terrain surface. We used SRTM 30 m DEM, channels 4, 3, 2; Landsat 7, 8 and ASTER images. We verified and refined the obtained data during field works using Structure-from-Motion (SfM) to create of 3D models of selected geoforms. Satellite data allowed us to create: Red Relief Image Map, Topographic Position Index and Normalised Difference Vegetation Index (NDVI) maps. In the Valley of the Volcanoes, we analysed 12 lava fields with a total area of 326.3 km^2 and a volume of approx. 20 km^3. We determined the number of eruption centres that yielded to 41 small lava domes and 23 scoria cones. This domes are classified as monogenetic volcanoes, however five of them can be considered polygenetic e.g. Puca Mauras. We used NDVI to develop chronology map of lavas. This allowed us to extract same-age eruption centres and associated volcanoes that represent the same eruptive time phase connected by fault lines: first generation (0.5–0.27 Ma) NW-SE and NE-SW, second (Pleistocene/Holocene) NNW-SSE and third (Holocene-Historical) again NW-SE and NE-SW. We carried out the reconstruction of the central part of the Valley of the Volcanoes because only there repeated phases of volcanic activity can be inferred with remote sensing and geological mapping. The results of this study led us to indicate that this area should be observed since it is very likely that future eruptions will occur.

1. Introduction

Satellite-based data has been used for many years in analysing various volcanic areas (De Silva, Francis, 1991). New techniques of data acquisition and data processing have allowed for more detailed analysis of volcanoes, volcanic fields and their effect on the surrounding terrain (Favalli and Pareschi, 2004; Kervyn et al., 2008; Inbar et al., 2011; Nakano et al., 2014; Bretón et al., 2022). Volcanic morphometry, based on Digital Elevation Models (DEM) derived from satellite imagery, mostly applied for large areas analyses (stratovolcanoes, lava fields, volcanic group or provinces) (Grosse et al., 2012). This is a good way for comparing, classifying and organizing knowledge about volcanoes from different parts of the Earth (e.g., Hone et al., 2007; Grosse et al., 2009; Karátson et al., 2010; Kereszturi et al. 2010; Rodriguez-Gonzalez et al., 2011; Di Traglia et al., 2014). The study area, is a 60 km long region named as Valley of the Volcanoes (also known as Andagua Valley) in Central Volcanic Zone (CVZ, southern Peru) (Fig. 1a), covered with volcanic landforms developed from the Pleistocene to historical times.

The CVZ (14–27°S) is an active volcanic arc related to the subduction of the Nazca Plate underneath the South American Plate along the Peruvian Trench. In this zone Nazca Plate submerges under the continental plate with 20–30° dip (Müller et al., 2008). The North part of the CVZ is limited by flat subduction associated with aseismic Nazca Ridge (Hu et al., 2016). This high-angle subduction occurs at about 9 cm/year (Romanyuk, 2009) in a N80° direction (Sébrier and Soler, 1991) resulting in magmatism and volcanism. The study area is located in the most

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