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## ABSTRACT BOOK

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## UAVs ORTHOIMAGES FOR IDENTIFYING AN MAPPING GEOMORPHIC INHERITANCE OF THE QUATERNARY GLACIERS AT THE SOAJO-PENEDA MOUNTAINS, PORTUGAL

Silva, António <sup>(1)</sup>, Marques, Miguel <sup>(2)</sup>, Calicis, Eva <sup>(3)</sup>, Martins, Cátia <sup>(4)</sup>, Péres-Alberti, <sup>(5)</sup>, Gomes, Alberto <sup>(6)</sup>,

<sup>(1)</sup> *Faculdade de Letras da Universidade do Porto, Via Panorâmica, s/n 4150-564 Portugal, mafalda.lopez7@gmail.com*

<sup>(2)</sup> *Geolevação, geoelevacao@gmail.com*

<sup>(3)</sup> *Faculdade de Letras da Universidade do Porto, Via Panorâmica, s/n 4150-564 Portugal, eva\_calicis@hotmail.com*

<sup>(4)</sup> *Faculdade de Letras da Universidade do Porto, Via Panorâmica, s/n 4150-564 Portugal, catia.martins.geographer.gis@gmail.com*

<sup>(5)</sup> *Universidade de Santiago de Compostela, xepalber@gmail.com*

<sup>(6)</sup> *Centro de Estudos de Geografia e Ordenamento do Território (FLUP), Via Panorâmica, s/n 4150-564 Portugal, albgomes@gmail.com*

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### ABSTRACT:

High mountain landscapes in the Iberian Peninsula are a consequence of both Quaternary glaciations and post-glacial environmental dynamics driven (mainly) by periglacial, slope and alluvial processes and shallow or deep-seated landslides [1]. A long discussion about the existence/non existence of clear glaciation evidences at low altitudes in the NW of Iberia take a lot of research efforts and discussions about the two theories. This indefiniteness was linked with the presence of few and poor clear evidences of the glacial extent, in terms of undisputed erosive and/or depositional glacial forms.

Nevertheless, for the Northwest of the Iberian Peninsula, several studies confirmed the presence of glacial forms at low altitudes [2]. In this way, the work done by other researchers [3,4,5,6,7], among others, is retaken by this study concerned with the geomorphic inheritance of the Pleistocene Glaciation at the Alto Vez spot, a sector of the Soajo-Peneda Mountains, placed in the Peneda-Gerês National Park. Located in the Northwest of Continental Portugal, in an area that covers part of the municipalities of Arcos de Valdevez, Melgaço and Monção, the Alto Vez spot has an altitude varying between 400m and 1416m, and slopes that surpass 600m of unevenness. The slopes are oriented 15% east and west and 14% southeast, with 71,4% of shady area.

The fieldwork recognition and the geomorphological mapping already executed during 2013-14 allowed sketching a preliminary view of the glaciated area and the registering of more geomorphic elements that prove the extension of the Alto Vez glaciation [8]. This previous work allowed the identification and the morphometry analysis of 25 glacier cirques, as well as the geomorphological cartography associated with intensive fieldwork, allowed to establish comparisons with other glaciated areas, namely, regarding the orientation of the glacial cirques to the east, particularly, in the sector Branda de Gorbela - Branda das Bosgalinhas.

Following this gaps, we present in this work the experimental results related with the Pleistocene glaciation in the Alto Vez sector, namely by the detailed analysis of the main cirque towards to east, the Ramisquedo Cirque (RC). Four main results are achieved: i) an high detailed orthoimage of sectors of the cirque; ii) a detailed map of the glacial inheritance forms; iii) a detailed geological map of the RC; iv) an update interpretation of the geomorphic inheritance of the low/medium size glacial forms existent on the RC.

In April of 2017 it was performed a recent survey and UAV flights (one morning for the flights, 5 in total, and two days for the posterior fieldwork), in order to have a global orthoimage of the Ramisquedo Cirque (RC). It was an opportunity to realize the specific characteristics of flights with an UAV (low altitude flight), allowing images offering many advantages, such as: excellent resolution, large overlap and reduced execution time [9]. The flights took place at 50/70m of the ground and around noon, in order to have the sun as upright as possible. Wind conditions were not perfect (frequent bursts over 20 km/h), which compromises the quality and overlap of some photos and obliged to do flights with short duration (<10min).

It was used a self-construction UAV, an equipment of carbon with 900mm of maximum distance between the motors axes (class 900) with four motors (quadcopter) and pixhawk flight controller of the 3DR. This flight controller features inboard barometer and accelerometers, and a peripheral GPS antenna and compass. With a total weight in flight of about 2,5kg carries on board a Canon Powershot SX260 (12 Mp) conventional camera equipped with GPS. In order to provide the timer camera, which is indispensable for the acquisition of photographs during flight, this camera has a CHDK script on its memory card. For the flight planning, it was used the open source Mission Planner software, making it possible to plan the flight independently using various base maps, selecting the Google Satellite View for this work.

At the field, it was used the differential GPS model Leica SR20, with a stationary and a mobile equipment allowing the positioning improvement by differential correction in post-processing. In addition, some control points (marked with red crosses on the terrain surface and in observable positions on aerial photos) were also collected. The photos obtained were processed with Agisoft software, resulting a global orthoimage with 5 cm of pixel size. Digital terrain and surface models were also processed as auxiliary base maps to identify and differentiate exposed inherited glacial forms from other types of erosional or deposition features/forms.

Fieldwork recognition and referencing of the glacial forms was assisted by the orthoimage and complemented with a portable Garmin GPSMAP® 64st. Figure 1 shows the integration between the fieldwork data and the UAV orthoimage on a little sector of the Ramisquedo cirque. The UAV orthoimage (Fig. 1e) is the result of the third flight, covering an area of ~35000m<sup>2</sup>, performed 50m above ground, with a duration of 5 minutes, including 55 photos with a pixel resolution of 2m.

Regarding the area lithology, since we cover a small area, the variations of colour and tonality are not significant, but allows distinguishing with great clarity the lithological differentiation. As it was already published in the Geological Map of Arcos de Valdevez, scale 1/50000 [10], the field knowledge acquired from the area reveals that there is only one type of granite with slight textured differences, and several metamorphic rock spots mainly at the base and specific slopes of the cirque. Plotting the contacts identified during the fieldwork it was obtained a rigorous geological map that reveals some differences (mainly, more precision) with previous maps and allows new interpretation about the cirque forms and the real displacement of erratic blocks.

In relation with the geomorphic elements it was possible to identify sets of salient and polished quartz veins, flutes, polished granite surfaces in various cirque locations, an interior depression at the base of the circus (a former lake?), several erratic shale blocks placed along the flat granite surfaces. With all measured data it was possible to obtain the average direction of the grooves existing in various forms and thus define the relative movement of the ice mass on the surface of the circus.

Concluding, the quality of the orthoimage obtained by the aerial photos of the UAV to perform detailed cartography on this former glaciated area was excellent. One great advantage comes from the precise and detailed characterization of geological and geomorphological features exposed along the cirque area, allowing rigorous position, detailed morphometric measures and establishing relations about ice mass dynamics on the cirque surface.



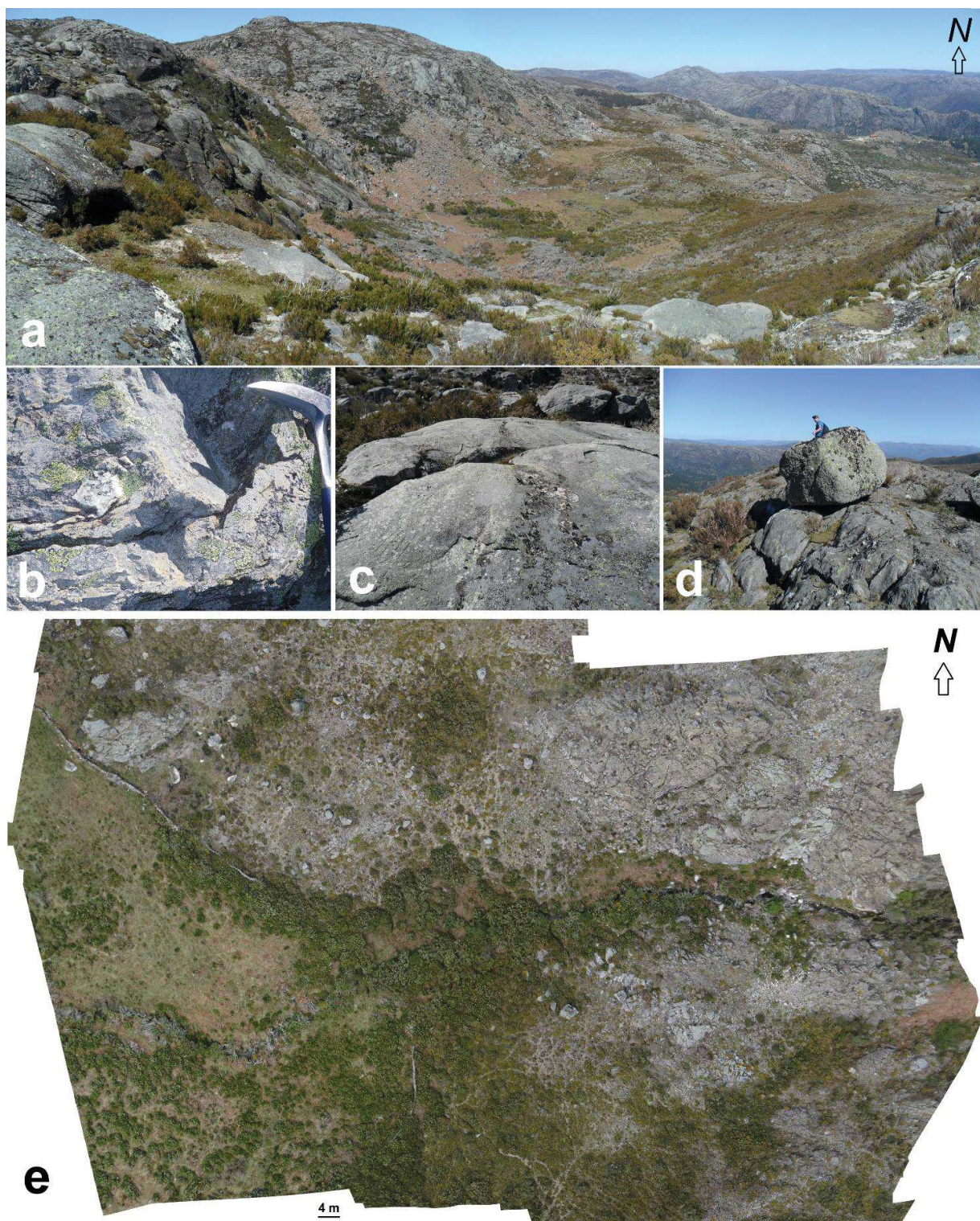


Figure 1. Drone orthoimage and field evidences of the quaternary glaciation at the Ramisquedo cirque: a) panoramic view of the Ramisquedo cirque; b) polished surfaces on the metamorphic basement and quartz veins; c) polished surfaces on granite outcrops; d) erratic granitic blocks over metamorphic basement; e) drone orthoimage of the central/bottom sector of the cirque, with many erratic blocks and polished/eroded surfaces, and clear quartz veins.

The use of UAVs in comparison with other data acquisition techniques is very advantageous since the costs and time spent in collecting and processing the data are relatively short. Processing images can even be



carried out on-site, which allows an immediate result to be visualized and facilitates the correction of errors through repeated flights, which is very important for these places of difficult access. The great and sudden variety of wind conditions could be a difficulty to operate in this environment. Since the inherited glacial forms are dispersed over a large area (several kilometres), the use of UAV devices with low autonomy (covered area and flight duration) requires more efforts and flights to perform a good survey. Nevertheless, flights easiness repetition and speed of data processing makes it an accessible tool and very effective for detailed studies of the geomorphic evidences of low altitudes glaciation in the Iberian Mountains.

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