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Electrical Tomography applied to image the 3D extent of the permafrost of three different Rock Glaciers of the Arid Andes of Argentina

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Three different rock glaciers (El Paso, Dos Lenguas, and Agua Negra) were studied with a suite of geophysical techniques in order to define their internal structure with emphasis in their ice content. Refraction seismics demonstrated its usefulness in tracking the top of the frozen ground throughout the year and to estimate the ice content of the permafrost, while vertical electrical sounding were used to rapidly define the depth of it. However, the most cost and time-efficient method for producing 3D mappings of the permafrost core of rock glaciers, from 2D sections showed to be the electrical tomography. We applied successfully this method to the three selected rock glaciers with expected different origins, showing significant differences of the permafrost characteristics. The first difference noted was related to the average resistivity of the frozen core, interpreted as different proportions of ice. The other differences were related to the varied depths of development of the frozen ground and to the frontal structure which is the downslope termination of the frozen core. The application of the method showed in general a progressive wedging out of the permafrost until the front of all these three rock glaciers. Permafrost wedging was also observed towards both sides but it occurs in a more abrupt way. These surveys allowed re-defining the volumetric content of ice of these rock glaciers, and in a few cases there was a significant increase of previously estimated resources. The electrical tomography also suggested that the El Paso rock glacier may have a glacigenic origin due to the high resistivity of the frozen core, while the other two seems to have evolved as cryogenic rock glaciers but in slightly different ways. A cryogenic origin was clear for the Dos Lenguas rock glacier due to is position in a dry and closed circus, but it was unexpected for the

Agua Negra rock glacier initially interpreted to be glacigenic in origin, as it was located below the terminus of the homonymous normal glacier. Electrical tomography results suggest that instead, it was formed by the plastic mobilization of glacier's frontal moraines mixed together with proglacial stream deposits. As shown for other rock glaciers, the quantity of ice at the frozen core, and hence its value as hydrological resource, is very much related to their origin, pointing to both scientific and applied usefulness of this geophysical tool.