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Retrieving Self Potential anomalies in a complex volcanic environment : a SP/elevation horizontal gradient approach

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The Self Potential (SP) method is well known for its capacity to detect fluids flows in various environments, such as volcanoes, where electrokinetic potentials are the dominant SP source. Many surveys on volcanoes have shown the presence of a purely hydrogeological zone on the flanks and of an hydrothermal zone in the central area. The hydrogeological zone is characterized by negative SP/elevation horizontal gradients, ranging typically between 0 and -2 mVm^{-1}. We show, using simple theoretical models how these gradients will be perturbed in presence of perched water tables, lateral variations of physical properties (e.g. resistivity) or by positive anomalies associated with upward hydrothermal circulations of fluids. The SP/elevation horizontal gradient is much more sensitive to the perturbations than the SP. We therefore propose to use the gradient to enhance the anomalies. Using digital SP and topographic grids, the gradient can be easily computed in 2D. We show an illustration using a regional SP map of Piton de la Fournaise volcano (La Réunion, Indian Ocean). Owing to the large elevation variations (0 to 2600 m), the largest signal is the broad decrease of the SP with elevation. Some relative positive anomalies are recognized in the active central area, but it is difficult to identify without doubt other positive anomalies that can be suspected in other areas. Conversely, the abnormal zones are very clearly shown on the gradient map as well as the different types of terrains (i.e. with different SP/elevation horizontal gradient values) in the hydrogeological zone. In the summit area, where the data coverage is dense, a comparison of the gradient information as a function of the SP map resolution is carried out (grid sizes of 25 and 100 m). The 2D horizontal gradient approach appears to be very promising for the qualitative interpretation of SP

surveys in volcanic areas as well as in other environments.