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Electromagnetic Prospecting in Alpine Permafrost: Examples from the Southern Swiss Alps

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Within the framework of geomorphological and glaciological investigations of the Lateglacial and Holocene glacier/permafrost evolution in the Canton Ticino (Southern Swiss Alps), several geophysical methods (frequency-domain electromagnetic lateral mapping and 2D resistivity profiling, direct-current resistivity soundings, self-potential measurements and thermal prospecting) have been used for mapping the permafrost distribution at the local scale (Scapozza 2008; Scapozza et al. 2008). In this context, the application of electromagnetic geophysical methods in the prospecting of alpine permafrost is a recent and not well-developed approach (see, for example, Hauck 2001).

In this study, two frequency-domain electromagnetic methods were used: the field ground conductivity-meter Geonics EM-31 and the VLF-R (Very-Low Frequency Resistivity) resistivity-meter Geonics EM-16R. The Geonics EM-31 operates at a fixed frequency and allows to determine the spatial apparent conductivity and inphase variations in the survey area (McNeill 1980). The inphase is proportional to the magnetic susceptibility of the ground. The depth of investigation depends to the spacing between transmitter and receiver (3.66 m for the EM-31) and to the frequency (9.8 kHz). According to the polarisation of the instrument, the depth of investigations is around 6 m with the vertical dipoles (VD) and around 3 m with the horizontal dipoles (VH). The VLF-R technique uses electromagnetic energy radiated by a very low frequency (VLF) transmitter (Cagniard 1953). In this study the Rhauderfehn transmitter (23.4 kHz) located in Germany (near Bremen) was used. The measurement of the horizontal component of the electric field (E) and of the horizontal magnetic component (H) perpendicular to the azimuth of the transmitting station allows to know the apparent resistivity of the near surface. The ratio between H and E gives a phase angle that changes according to variations of resistivity with the depth. The combined inversion of apparent resistivity and phase angle data allows us to realize 2D VLF-R tomography with a two-layer resolution.

The measurement carried out on the Piancabella rockglacier (Blenio Valley) (Fig. 1A) show that permafrost occurrence is probable, with maximal resistivities at the front of the rockglacier and a decrease of the values toward upslope, as expected by geomorphological observations and other geophysical measurements (see Scapozza 2008). In particular, the electromagnetic prospecting allows us to know approximately the active layer depth and the permafrost resistivity, as shown in the VLF-R tomography (Fig. 1B). This example shows that electromagnetic prospecting in alpine permafrost offers good possibilities to map the spatial apparent resistivity (i.e. the permafrost distribution) (EM-31 and VLF-R) and/or to obtain information concerning the structure of the prospected terrains (VLF-R tomography).

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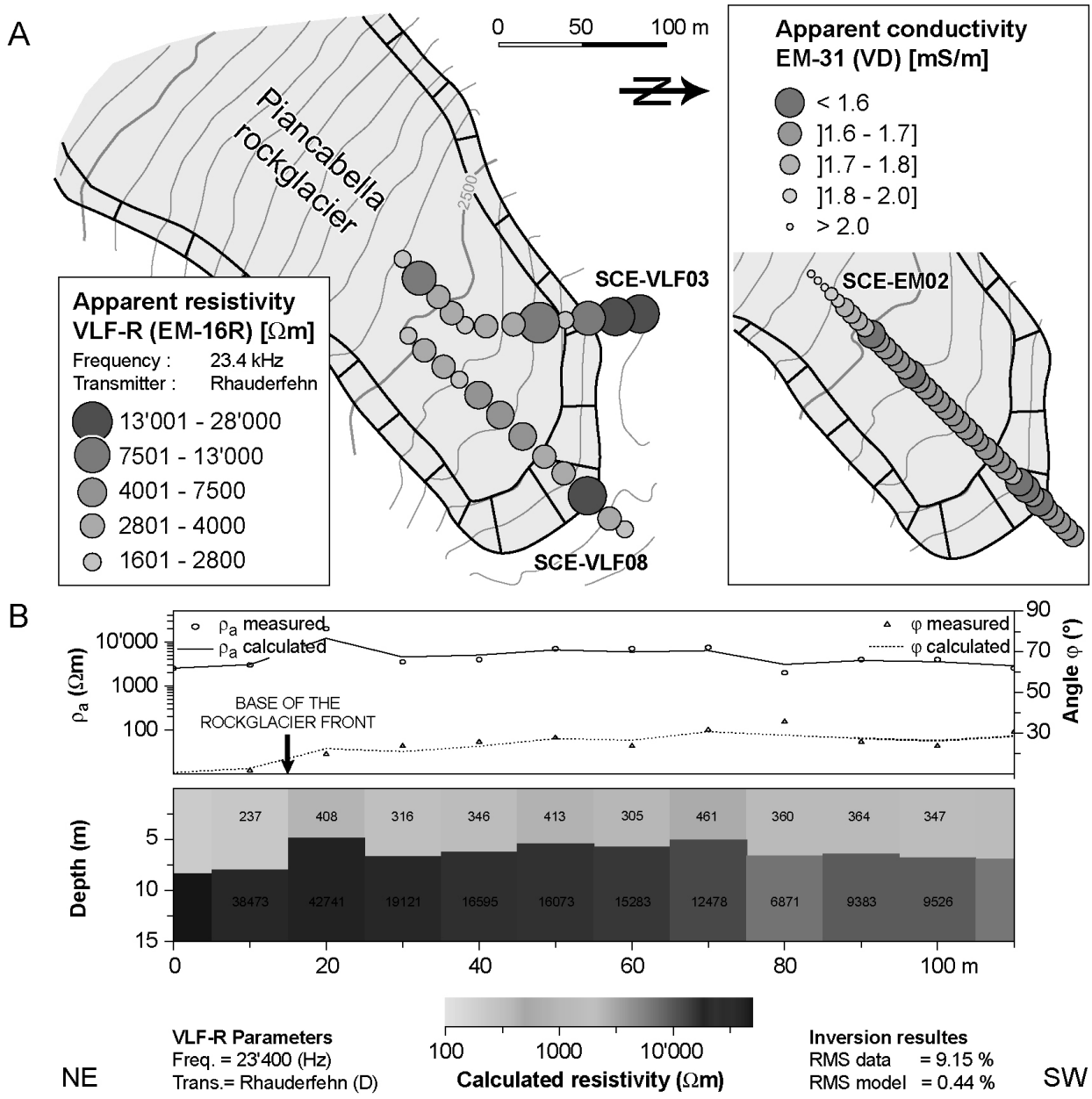

Figure 1. A: VLF-R (EM-16R) and EM-31 profiles along the Piancabella rockglacier. B: VLF-R tomography of the profile SCE-VLF08.