RADAR SOUNDING OF TEMPERATE PERMAFROST IN ALASKA: ANALOGY TO THE MARTIAN MID-LATTITUDE ICE-RICH TERRAINS. J. Boisson[1], E. Heggy[1], S.M. Clifford[2], A. Anglade[1] and K. Yoshikawa[3], [1]Institut de Physique du Globe de Paris, 94107 St Maur des Fosses, France (boisson@ipgp.fr, Heggy@ipgp.fr, anglade@ipgp.fr), [2]Lunar and Planetary Institute, Houston, TX 77058-1113, USA (clifford@lpi.usra.edu), [3]Water and Environmental Research Center, University of Alaska Fairbanks, P.O. Box 755860, Fairbanks, AK 99775-55860, USA (ffky@uaf.edu).

Introduction: Subsurface water on Mars has been subject to several hypothesis and debates as it has important implications on the hydrogeologic and climatic evolution of Mars. To assess its potential distribution and state in the fractured Martian subsurface, two low-frequency radar sounders (MARSIS and SHARAD) are currently probing the Martian upper crust exploring dielectric evidence for presence of subsurface water and ice. However, the identification of volatiles signatures in the radar data is constrained by our understanding of both dielectric and scattering losses mechanisms that are generated by the dielectric complexity and heterogeneity of the Martian subsurface. Although some ground penetrating radar (GPR) investigations have been carried out on Mars analog volcanic terrains [1,2], low-frequency radar sounding on Mars analog frozen terrains (like permafrost) remain poorly investigated.

. To address this issue, we conducted wide-band GPR investigations and Electrical Resistivity Tomography (ERT) survey on a permafrost terrain, at the Vault Creek site located ~20 km North of Fairbanks (Alaska, USA). The site includes a 40 m deep mining tunnel, which allows validating the subsurface composition and the different geologic interfaces as inferred from the radar echoes. The area shows several geomorphological and geophysical analogies to recently observed terrains in the high and mid-latitudes on Mars (e.g. permafrost, ground polygons [3] and pingoos [4]). The GPR surveys were performed at four central frequencies along the same profile in order to monitor the attenuation mechanisms over the 40 - 1100 MHz frequency band. The obtained data set provided an insight into characterizing and quantifying the different frequency-dependant loss mechanisms (mainly scattering and dielectric attenuation) that occur on the radar signal in permafrost.

Site description and analogy: Fairbanks is located in the middle interior region of Alaska (USA), approximately 200km northeast of the Denali National Park. This region presents a subarctic climate which allows maintaining temperate permafrost all year long with an active layer (i.e. a layer which is unfrozen during the summer season) in the upper one to two meters of the ground. The survey was conducted in March 2008 when the ground, including the active layer, was totally frozen.

Study the different processes that occur in the terrestrial permafrost (periglacial regions) is of a great interest for the understanding of the physical processes and the water distribution in the Martian subsurface. In this context, several regions have been selected as terrestrial analog to Martian subsurface [5].

Alaska presents several landforms and polar processes (permafrost, glaciers, polygonal terrains, pingos...) which have been recognized as terrestrial analogs to similar landforms on Mars [5,6].

Methodology : . In order to probe the subsurface with a wide frequency band (to be able to compare with current and potential future Martian GPR, the radar unit was operated with four different central frequencies antennas: 40 MHz, 270 MHz, 400 MHz and 900 MHz. The ERT survey were conducted along the same profile, providing valuable information on subsurface resistivity for interpretation of the radar data. The resisitivity sounding was operated with the Wenner electrode configuration, which provides good horizontal resolution.

Results: To study the different loss phenomena, we analysed the frequency content of the same radar frame (5 m after the beginning of the profile) for each of the four frequency GPR profiles. We first calculated the frequency content of the total losses derived from the decay of the amplitude of the signal versus time (Figure 1).

Then, considering the radar equation for the case of an infinite planar target in the Fresnel zone [1,7], we removed the geometric spreading and dielectric losses which allowed us to quantify the losses caused by scattering (Figure 2). We can thus quantify the scattering loss rate, which increases with frequency (as the wavelength decreases, the signal will be affected by smaller subsurface heterogeneities). Indeed, the loss rate at 50 MHz is ~ -5dB/m whereas at 250 MHz, the loss rate is ~ -7dB/m.

These results provide insights into the potential losses and loss mechanisms that may be encountered on Mars during radar surveys of frozen terrains, which may, in turn, provide information on the scale and degree of subsurface heterogeneity.

References: [1] Grimm R.E. et al. (2006) *JGR*, 111, E06S02. [2] Heggy E. et al. (2006) *JGR*, 111, E06S04. [3] Boike J. and Yoshikawa K. (2003) *Permafrost Periglac. Process., 14*. [4] Yoshikawa K. et al. (2006) *JGR*, E06S19. [5] Farr T.G. et al. (2001) *Natl. Res. Counc., Washington, D. C.* [6] Kargel J.S. et al. (1993) *LPI Technical Report*, No. 93-04. [7] Annan and Davis (1977), *Geol. Soc. Can. Rev. Activ.*, 77.

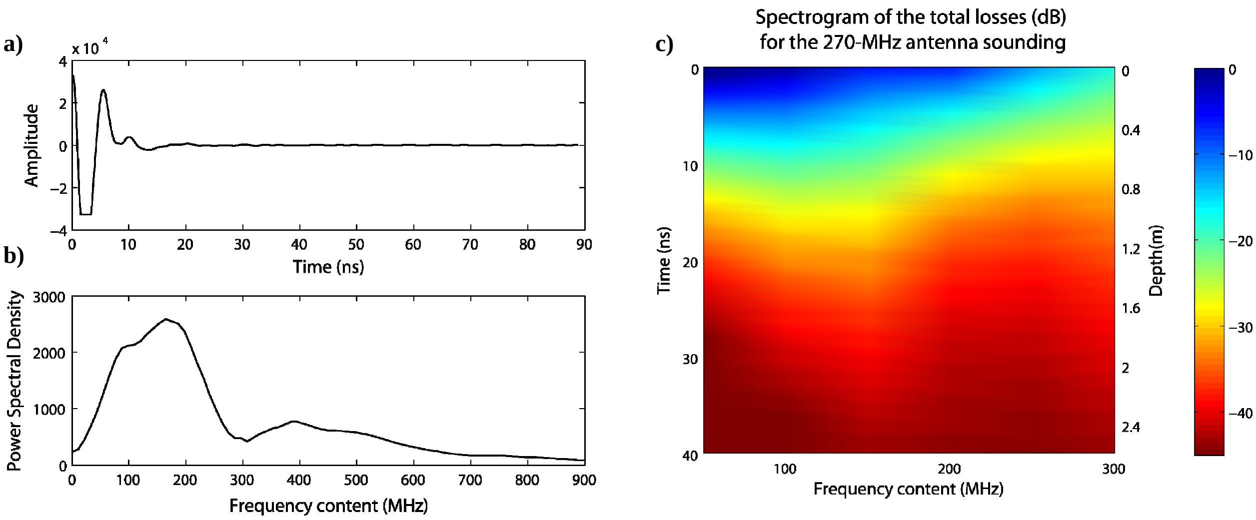

Figure 1: 270 MHz antenna Amplitude vs. time decay (a) and the power spectral density of the signal (b). The spectrogram of the total losses (c) shows a decrease of losses with the frequency decrease. We use a velocity of 0.13m/ns (average radar wave velocity in a permafrost) to convert time to depth.

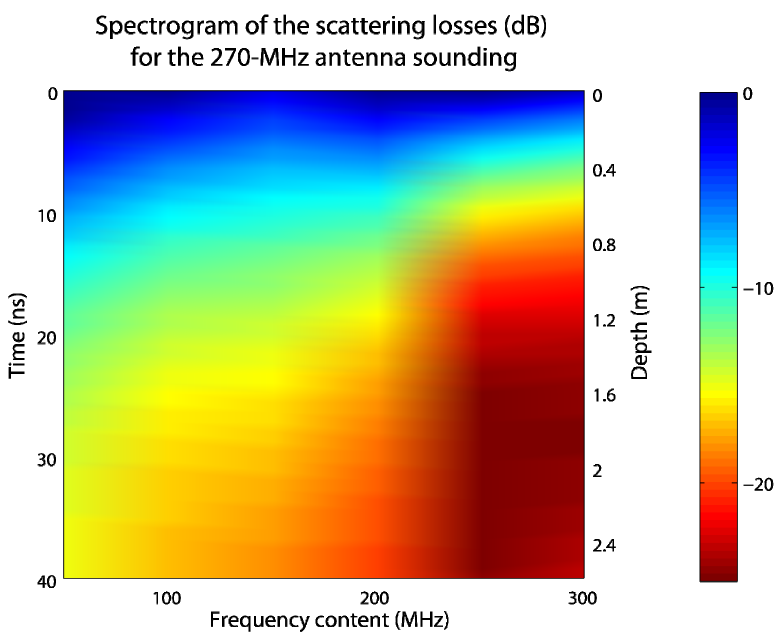

Figure 2: Spectrogram of the scattering losses for the 270 MHz antenna sounding. We applied the radar equation for the case of an infinite planar target in the Fresnel zone in order to remove the geometric spreading and the dielectric losses. The residual losses are attributed to the scattering phenomena.