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The Effect of Vadose Zone Thickness and Moisture Content on the Detectability of Subpermafrost Groundwater by Low-Frequency Radar Sounding on Mars

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One of the primary objectives of current Mars orbital radar sounding investigations is the potential detection of subpermafrost groundwater, at depths of a km or more beneath the surface. The potential for such detection is based on the relative strength of the radar reflection arising from the dielectric contrast between liquid water and frozen ground (the dielectric properties of ice and rock being similar, but differing significantly from liquid water).

Previous simulations to test the ability of low-frequency sounding radar to detect subpermafrost groundwater have assumed a sharp transition in dielectric properties at the water table. However, this assumption is likely invalid if a vadose zone is present, where the presence of a geothermal gradient can result in the formation of a low-temperature hydrothermal circulation system between the water table and the base of the cryosphere (Clifford, J. Geophys. Res., 98, 10973-11016, 1993). As the vapor from the water table rises, and encounters the cooler temperatures at shallower depth, the ascending vapor flux condenses, ultimately draining back to the aquifer below. This dynamic balance of opposing fluxes creates a vertical gradient in vadose zone moisture content – and corresponding gradient in dielectric properties – whose extent and magnitude are dependent on the thickness of the vadose zone, as well as its thermal, diffusive and hydraulic properties. Here we examine plausible values of these properties and examine their potential impact on the attenuation of low frequency radar, the dielectric contrast associated with the presence of a water table, and the likely

detectability of subpermafrost groundwater on Mars.