THE VOLCANIC TERRAINS OF KAMCHATKA, EASTERN RUSSIA: A GLACIAL AND PERIGLACIAL ENVIRONMENT WITH POTENTIAL FOR MARS ANALOG-BASED RESEARCH. C. J. Souness[1], A. Abramov[2]. [1] Centre for Glaciology, Institute of Geography and Earth Sciences, Aberystwyth University, Ceredigion, Wales, UK, SY23 3DB. [2]Soil Cryology Laboratory, Institute of Physiochemical and Biological Problems of Soil Science, Russian Academy of Sciences, Pushchino, Russia (Primary author email: cjs07@aber.ac.uk).

Introduction: The study of landforms and processes on Mars presents many tantalizing challenges. Most martian sites are inaccessible and the processes which occur on Mars do so under a set of base conditions (e.g. gravity and atmospheric pressure) different to those that prevail on Earth [1]. This makes it difficult to ascertain how these processes operate and how Mars' surface was shaped.

Use of Earth-based analogs: Although improvements in technology have permitted the scientific community to gather data from Mars in ever-increasing volumes, and at an ever-increasing level of detail, we still depend heavily upon remote observation and Earth-based analogs to provide a basis for the interpretation of martian forms and processes. Some well-known Earth-based Mars analog sites are the McMurdo Dry Valleys in Antarctica (widely held as being Earth's closest approximation to a martian environment, e.g. [2]), certain parts of the Canadian high-arctic [3] and the islands of the Svalbard archipelago (e.g. [4]). However, some other examples have been as geographically diverse as the rivers of Siberia [5], icy debris fans in Alaskan volcanic fields [6] and Icelandic jokulhlaup flood deposits [7].

Kamchatka's high-altitude volcanic terrains: We propose the high-altitude volcanic landscapes of Kamchatka, the Russian Federation (Figure 1), as a potential Mars-analog environment.

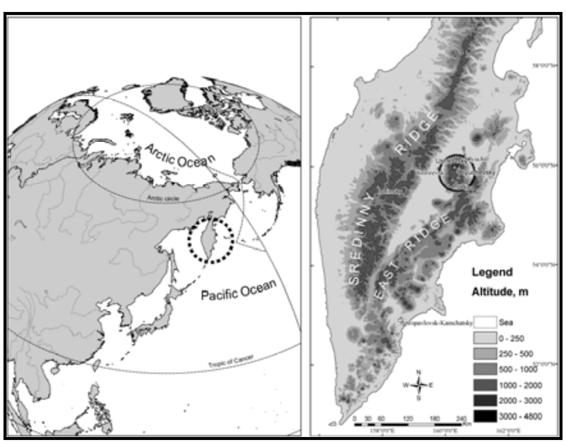

Fig. 1: Location of Kamchatka and, locally, the Klyuchevskaya volcano group and Petropavlovsk-Kamchatsky. Adapted from [8].

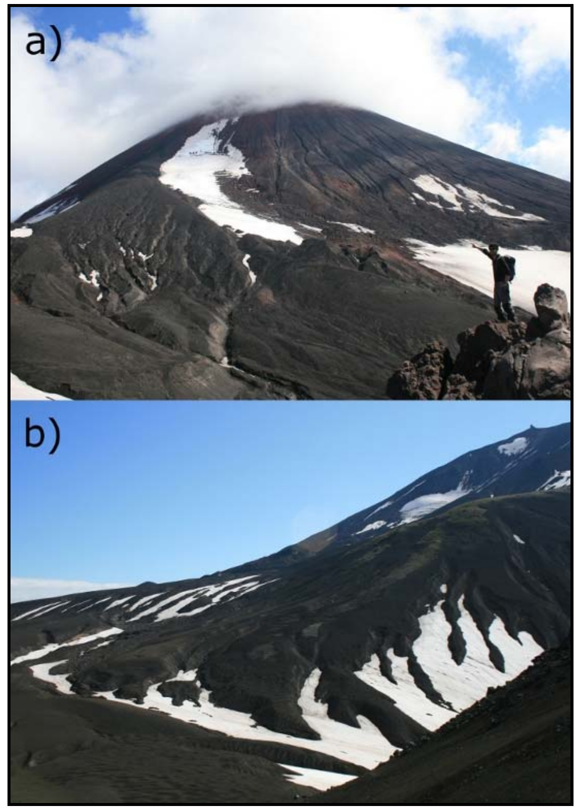

Fig. 2: a) The Avachinsky volcano (2741 m), near Petropavlovsk-Kamchatsky. b) Various gullies and periglacial formations reminiscent of those visible in certain areas of Mars can be seen in the volcano's loose, basaltic scoria-coated slopes. Photos by Colin Souness.

Specifically, we describe terrains in the Avachinsky area (Figure 2) and amongst the Klyuchevskaya volcano group (Figure 1).Avachinsky (2741 m [Figure 2a]) is situated close to Kamchatka's capital, Petropavlovsk-Kamchatsky. The Klyuchevskaya group are located in central Kamchatka at approximately 56º N, and include the active volcanoes Klyuchevskya (4800 m), Bezymianni (2900 m), Ushkovsky (3900 m) and Tolbachik (3100 m) [8].

Aberystwyth University Kamchatka Expedition: During an exploratory expedition to the Russian Federation's far-eastern region of Kamchatka (supported by the Mount Everest Foundation and the Earth and Space Foundation) observations were made of glaciers as well as glacial and periglacial landforms in some of Kamchatka's active volcanic areas. The unique geology, climate and morphology of various locales in Kamchatka have created environments that may be of utility as Mars analog sites. These include:

Volcanic debris-covered glaciers. Many glaciers in the Kamchatka area are almost completely buried beneath a layer of volcanic debris (Figure 3). The predominantly small size, lightweight nature and comprehensive cover of these deposits make Kamchatka's debris-covered glaciers different to those found in many of Earth's other glacierised regions and, arguably, more analogous to the glacier-like forms (GLFs, e.g. [9]; [10]) found in Mars' mid-latitudes. These are also buried beneath a layer of dust and regolith, albeit composed of 'massive' water ice at depth ([11]; [12]).

Patterned ground and landscapes of periglacial activity. Permafrost is present even on the active volcanic summits of Kamchatka's highest volcanoes. Abramov et al. [8] have calculated that this permafrost extends to depths of up to 1000 m, and have observed active wedges of almost pure ice in near-surface scoria deposits on Tolbachik volcano (Figure 4a). These ice wedges cause localised ground heave, opening cracks which often merge, developing into large-scale patterned ground (Figure 4b) such as is often visible on mars [13].

Dry gullies in scoria deposits. Many scoria surfaces against various volcanoes (e.g. Avachinsky, Koriaksky and Tolbachik) are incised by shallow (~5-10 m), medium length (~10 – 50 m) gullies. These gullies appear fluvial in origin but are dry-based, doubtless due to the porous nature of the substrate. However, morphologically, they strongly resemble the valleys and gullies seen in glaciated areas on Mars (Figure 2).

Fig. 3: An un-named volcanic debris-covered glacier flowing northward (away from camera) from the slopes of Avachinsky near Petropavlovsk-Kamchatsky (lat, 53.29, lon, 158.81). Photo by Colin Souness.

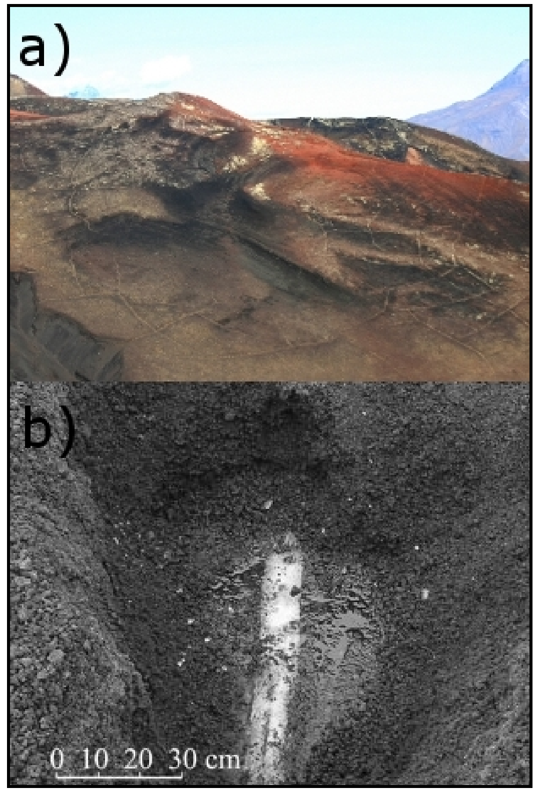

Fig. 4: a) Patterned ground on the slopes of Tolbachik to the south of the Klyuchevskaya volcano group. b) An ice wedge in volcanic scoria excavated by Abramov et al., (2008), also on the slopes of Tolbachik. Photos by Colin Souness (a) and adapted from [8] (b).

Conclusions: We observe that Kamchatka hosts many unique volcanic glacial and periglacial environments. Most of the formations in question are blanketed beneath a lightweight scoria debris layer and thus, being both climatically arctic and relatively accessible, Kamchatka's glacial catchments could be valuable Mars analog environments.

References: [1] Howard, A. (2009) in: Garcia, C. A., *River, Coastal and Estuarine Morphodynamics:* CRC Press. Boca Raton. [2] Levy, J. S. et al. (2008) *Antarctic Science, 20.* 565-579. [3] Pollard, W. et al. (2009) *Planetary and Space Science, 57.* 646-659. [4] Steele, A. et al. (2004) *Lunar and Planetary Science XXXV.* 2076.pdf. [5] Costard, F. and Gautier, E. (1998) *Lunar and Planetary Science, XXIX.* 1268.pdf. [6] Kochel, C. and Trop, J. M. (2008) *Icarus, 196.* 63-77. [7] Warner, N. H. et al. (2010) *Astrobiology Science Conference, 2010.* 5602.pdf. [8] Abramov, A. et al. (2008) *Permafrost and Periglacial Processes, 19.* 261-277. [9] Hubbard, B. et al. (2010) *Icarus, 211.* 330-346. [10] Souness, C. et al (in press) *Icarus.* [11] Holt, J. W. et al. (2008) *Science 322.* 1235-1238. [12] Plaut, J. J. et al. (2009) *Geophys. Res. Lett, 36.* L02203. [13] Hiesinger, H. and Head, J. W. (2000) *J. Geophys Res, 105.* 11,999-12,022.