PHYSICAL MODELING OF GLACIODYANMICS AT FRONTIER MOUNTAIN, ANTARCTICA: TESTING THE IMPORTANCE OF ABLATION ON ICE FLOW AND METEORITE EXHUMATION.

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Introduction: The highest concentration of meteorites yet discovered on Earth is found in the ice sheet covering Antarctica. Major meteorite accumulation zones often occur in front of submerged or emerged bedrock obstacles, where the meteorite-bearing ice slows down, is uplifted by the buttressing effect and exhumed and concentrated by wind ablation ("ice-flow model"; e.g., [1]).

Meteorite traps have also been discovered in the downstream side of major emerged bedrock barriers, as in the Frontier Mountain (FM) region [2], a nunatak outcropping in the Northern Victoria Land, Antarctica, 250 km from the Italian Terra Nova Base. However, recent detailed glaciological analyses indicate that also for this site the "ice-flow model" remains the best concentration explanation, being present an important submerged barrier in the main blue-ice field [3].

A this site, during the last fifteen years, more than 1000 meteorites have been there collected.

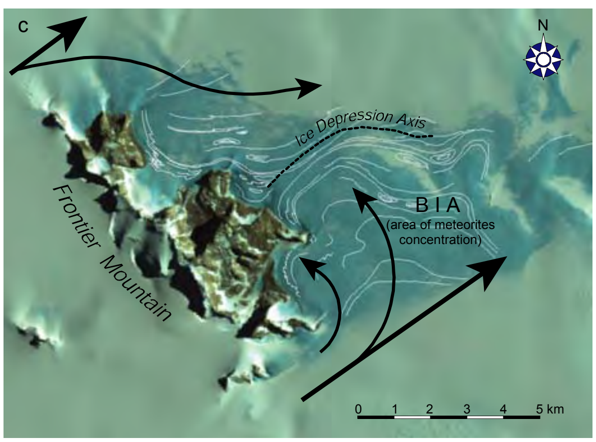

Figure 1: Close-up of the FM showing the blue-ice area (BIA) hosting the major meteorite trap (modified from [3]). Black arrow indicate the main ice flow; white line highlight the pattern of surface tephra layers.

During the various field expeditions, different data were acquired to allow a detailed study of the local glaciodynamics [3]. This large data set was used to constrain boundary conditions for performing a set of physical experiments designed to reproduce the main glaciodynamics characteristics of the FM region [4]. However, these experiments did not consider the effect of ablation on ice flow and meteorite exhumation and concentration; this gap is filled in this works by presenting new physical models.

Analogue modeling: Analogue experiments were performed at the Tectonic Modelling Laboratory of the CNR-IGG (Florence, Italy). Similarly to [4], models were built inside a Plexiglas box reproducing the topography of FM with a geometrical scaling ratio of 1.5 10-5 (1 cm in the model represented about 700 m in nature). The ice was simulated in the laboratory experiments using Polydimethilsyloxane (PDMS), a transparent Newtonian material; the use of this material ensured dynamic similarity of experiments. This material was poured inside the Plexiglas box and allowed to settle in order to obtain a flat free surface. The base of the PDMS layer was stuck to the analogue bedrock, such that no basal sliding was involved and glacier flow was only related to internal ductile deformation. During the experiment, the Plexiglas box was inclined of 3° and the PDMS was allowed to escape from the front end of the box (simulating the outward flow feeding Rennick Glacier). At regular time interval, narrow bands of PDMS were added at the rear end of box (simulating ice supply from the Polar Plateau region); this added material compensated for the escaped PDMS, keeping constant the topographic gradient. This set-up allowed to reproduce for the chosen viscosity the velocity of the "regional" ice flows flanking the FM. Similarly, downstream of FM, shallow portions of PDMS were physically removed in order to maintain a topographic depression on the ice surface, simulating ablation from catabathic winds. Model deformation was monitored by analysing the progressive displacement of passive markers both on the model surface and at a depth of ~1cm (i.e., 700m in nature).

Experimental results: As shown in [4], ice flow is mainly characterized by a divergence upstream of FM and a convergence downstream of this nunatak, well reproducing natural conditions (compare Fig. 1 with Fig. 2). In addition to the model by [3], the current experiments show a more prominent material recalling in the Ice Depression area, due to effect of the analogue ablation.

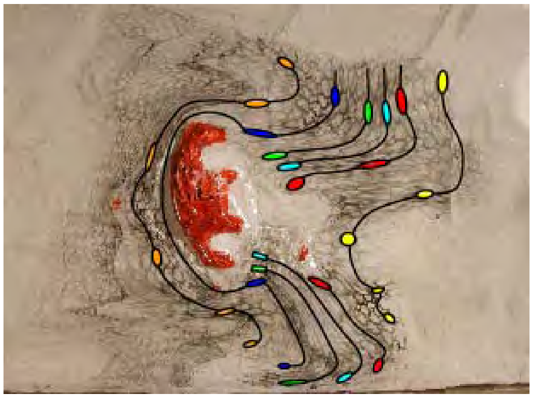

Figure 2: Line drawing of surface marker at the end of the experiment.

In this area, horizontal velocity of the passive markers are close to zero, configuring a stagnant region where vertical movements dominate allowing uplifit and exhumation of deep ice, as shown by internal marker deformation. In particular, due to the PDMS removal, ablation increases the velocity of incoming ice in the BIF and decreases the velocity of outcoming material, well matching local mass balance calculations [3].

Internal markers show outcrop geometries that indicate folding with maximum compression oriented parallel to the long axis of FM (i.e., to the converging ice flow), similarly to tephra layer patterns recorded in nature [5] [6].

The similarity between models and nature confirms a similar dynamics and suggests that the interaction between local bedrock topography and ablation results a fundamental parameters in controlling the concentration of exhumed material and in the development of the FM meteorite trap [3].

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