The characterisation of an openwork block deposit, Northern Buttress, Vjesleskarvet nunataks, Western Dronning Maud Land, Antarctica

HANSSEN, C.D., VAN DER BURG, J.H., AND TREL, H.C.
Geography Department, Rhodes University, GRAHAMSTOWN, SOUTH AFRICA
Department of Geography, and Environmental Science, University of Fort Hare, EAST LONDON, SOUTH AFRICA

Introduction
Openwork block accumulations are the subject of considerable academic debate and have generated much interest. In particular, their development and origins have been a topic of discussion. Investigation of these deposits can improve our understanding of the productions of substrates for biological colonisation, the impact of climate change on landforms, and the control of geologic structure. They have been shown to exist in a variety of settings, generally at high altitudes, such as montainstros, summits, ridges and plateaus, and occur worldwide at mid to high latitudes1, 2. They have been well documented for a number of regions around the world, such as Scandinavia, the Arctic, Canada, the United States of America, the Lesotho Highlands, Svalbard, and the Falkland Islands3, and have also been shown to occur in areas previously glaciated or never glaciated.

An openwork block deposit was investigated on the Northern Buttress of the Vjesleskarvet nunataks in Western Dronning Maud Land, Antarctica (Fig. 1 & 2). A holistic process was followed to identify blockfield origin, matrix and its developmental model. Furthermore, clast morphology and characteristics, potential aspect control on weathering, and ground thermal and moisture regimes were investigated and identified.

Setting
The block deposit covers the entirety of the Northern Buttress of the Vjesleskarvet nunataks (Fig. 3), in the vicinity of the South African research base at SANAE IV, located on the Southern Buttress. The nunatak is 841m high, forms part of the Borgenmassive intrusives and is of Mesoproterozoic origin. The blockfield consists of a doleritic (dioritic) sill, with angular clasts and evidence of weathering, pitting and flaking (Fig. 4). The nunataks of the area were exposed app. 8,000 BP during the Last Interglacial Transition4 and the deposit is located in a permafrost environment. It is app. 16ha in size and follows a north-south orientation along its longest axis.

Methods
More than 350 clasts were sampled across the deposit using random selection methods, as well as along predefined transect lines. In addition, ground thermal and moisture profiles were investigated at 23, and sediment samples taken at three locations for the study site. The following methods were employed:
- Clast dimension and orientation were measured.
- Clast facets were investigated, as were the location of clasts in the field.
- Rock hardness using the Schmidt Hammer and Equotip® 3 devices was measured for each clast face. These data were used as proxies to indicate weathering for each clast.
- Ground near-surface temperature (GST) and moisture regimes were recorded using ibutton thermochrons, XRThermistors, and Decagon EC5 sensors.
- Rock properties were determined after Cooke5.

Findings
- Sediment analyses were conducted using sieving methods and a SediGraph 5000. These data were used to determine the fine earth fraction, and as such used as an indication of the weathering environment.
- Data were interoplated using Geographical Information Systems (GIS). Zonal statistics and geostatistics were also calculated for specific parameters in GIS.

Findings
- The in situ production of clasts along pre-existing joints, random orientation of clasts, a slope gradient less than 25° and poorly disassociated clasts indicate an autochthonous deposit (Fig. 5).
- Analyses of clast support, textural analyses and poorly disassociated clasts from the underlying bedrock suggest a Type I matrix for the deposit, where the openwork blocky deposit is clast supported with fines forming a matrix at some depth below the surface (Fig. 6). However, fines are rare and ice prevalent, suggesting a new type of matrix dominated by ice and the presence of permafrost.
- Solar irradiation, slope gradients and snow cover were found to influence weathering of clasts across the site.

Lichen prefers the more sheltered west-facing aspect, with the least observed for the windward facing sides. Flaking and pitting is most likely found on top-facing sides, where weathering pits occur only in the top-most layer of clast surfaces.
- Rock hardness values suggest possible aspect control on weathering for clast surfaces. The southern aspect exhibits the highest mean rock hardness values, with consistently low values observed for the north-facing sides (Fig. 7).
- Ambient temperatures and wind speeds significantly influence ground thermal regimes; with air temperatures leading to an increase and wind speed to a decrease in GST. Snow cover has a stabilising effect on ground temperatures and a time lag of 12-24 hours is observed between ambient and ground regimes (Fig. 8).

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Contact Details
First author & presenting author: Christel Hansen (chansen@campus.ru.ac.za)
Principal investigator: Prof. Ir Meiklejohn (imeiklejohn@ru.ac.za)

References