

Case study 26: Soils and palaeo-climate based evidence for irrigation requirements in Norse Greenland

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This case study is based on Adderley, W.P. and I.A. Simpson (2006) Soils and Palaeo-climate based evidence for irrigation requirements in Norse Greenland *Journal of Archaeological Science* 33: 1666-1679

Introduction

Norse settlements in Greenland collapsed or were abandoned in the late 15th or early 16th centuries. Climate deterioration and other factors may have contributed, including the development of hierarchical societies underpinned by control of access to fodder resources, or, over-grazing by sheep and goats leading to soil erosion. An understanding of the management of the early agricultural activity is crucial to developing an insight to the long-term sustainability of the Norse settlement in Greenland.

For a range of Norse contexts in the Faroe Islands and Iceland, it has been demonstrated that, for successful home-field production, management of nutrients through manure applications is essential to maintain fertility and, furthermore, that such manure management may help alleviate short-term, i.e. year to year, climate fluctuations.

In most inland areas, which previously formed part of the Norse Østerbygden or Eastern Settlement, present day farmers periodically require irrigation for grass production. With previous surveys of farms in the Eastern Settlement interpreting relict channels, seen in field systems, as irrigation ditches, two questions are raised:

1. Was irrigation required by the Norse settlers of Greenland to maintain grass production on the home field?
2. If so, was irrigation of the home-field required every year, or only infrequently?

Two study sites in the area of the Norse Eastern Settlement, towards the head of Tunindliarfik Fjord were examined. The first site is the present day settlement of Qassiarsuk, commonly considered to be the location of Brattahlíð. Brattahlíð was the site of the first settlement by Eric þorvaldsson (also known as Eric the Red), which later developed into a more extensive Medieval Norse settlement. The second site is at Tasersuaq, between the Tunindliarfik and Sermilik Fjords. This site has no present-day settlement but Norse ruins are visible.



Figure 1: Guelph Permeameter.

Methodology

To assess the transfer of water through the Norse home-field soils a set of *in situ* measurements of field-saturated hydraulic conductivity were obtained. These measurements were made using a Guelph Permeameter, a constant-head in-hole permeameter apparatus which is based on the principle of a Mariotte bottle (Figures 1 and 2). The apparatus is used to measure the steady-state recharge into unsaturated soil required to maintain a constant depth, or head, of water above the bottom of a cylindrical well hole.



Figure 2: Guelph permeameter.

To consider the need for water management on grass growth at the two sites, contemporary climate measurements have been used. Changes in water inputs and losses due to both climate and plant growth factors have effects on the depth of the water table and the water content of the soil in the plant-root zone. If there is prolonged lack of water in the plant-root zone, then plant growth will suffer. Conversely, if there is too much water in the plant root zone, then the soil may become anoxic, which is again detrimental to plant growth. Using a field-level model of soil-water-plant interactions, WaSim, the soil-water balance has been calculated on a daily basis for the period 1980-2003. The WaSim model considers water input from precipitation, water movement through the soil, and removal of water through site drainage and evapotranspiration.

Results

The physical soil and water permeability measurements reveal clear differences between the two sites. Tasersuaq is characterised by greater mean field-saturated hydraulic conductivity values and by stonier soils than those found at Qassiarsuk. The results of the Guelph Permeameter measurements show large ranges of values and standard deviations at each site. This variability is undoubtedly due to soil heterogeneity including the relative stoniness of each profile. It can also be ascribed in part to the shallow depth of the soils. At Tasersuaq, the mean field saturated hydraulic conductivity values are greater at the 40cm depth than the 20cm and correspond to the coarser soil material.

The model soil-plant-water balance shows a water deficit in the plant-root zone occurring each year of values up to *c.* 70mm and for varying periods. Differences between both Qassiarsuk and Tasersuaq at 20cm depth, and 40cm depth at Tasersuaq are revealed. Since the climatic data modelled are consistent for each location, these differences represent the effects of inherent soil properties including organic matter content and particle size distribution. It is the combination of the magnitude of the water deficit and the period that the deficit persists that is important. Both the establishment of plants, growth after dormancy and the ultimate fodder production of the grassland each year will be dependent upon this factor.

From the 24 year period considered, five years (1985, 1991, 1995, 2001 and 2003) show pronounced deficits that would warrant irrigation inputs to maintain plant growth at both sites considered. These moisture deficit periods follow relatively warm winters and/or where wind speeds are generally higher.

Conclusion

The evidence shows that there is a frequent requirement for irrigation. The demand for irrigation is particularly sensitive to the soil and site drainage parameters; these, in turn, relate to both the nature of the soil itself (organic content, particle size, stone content). It is clear that the Greenlandic Norse settlers regularly faced one of two different soil-plant-climate issues to maintain fodder production. In years with relative warm winters, the increased growing season will have led to increased water demand from the grass crop, potentially demanding irrigation. Conversely, exceptionally cold

winters appear to be linked to subsequent moisture deficits, and again a demand for irrigation despite the impact on crop productivity through reduction of the growing season length.