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Little Ice Age catastrophic storms and the destruction of a Shetland Island community

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ABSTRACT

Subarctic communities are useful bellwethers of human adaptability to climate change. Previous studies have compared the socio ecological adaptations of culturally comparable but geographically separated communities such as medieval Greenland and Iceland. In the Shetland Islands during the Little Ice Age (LIA) unusual storminess in the 16th and 17th centuries deposited wind driven sand in the township of Broo, Dunrosssness, and on its surrounding estates. Documents, historical records and optically stimulated luminescence (OSL) dated sand layers show the history of deposition, and reveal two episodes of sand movement one from the mid 16th century, the second from the late 17th or early 18th century. Artifacts, records and stratigraphy suggest Broo's inhabitants successfully resisted the 16th century sand incursion, but were driven from their homes by the early 18th century. Adjacent communities embedded in the same socio economic culture survived the same events and remain viable settlements to the present day. Wind simulations demonstrate that storm conditions are likely to produce markedly lower wind velocities in the area around Broo than over the surrounding landscape making it singularly vulnerable to sand inundation. In this instance human ingenuity and resilience could not counter the misfortune of location. We conclude that in this marginal environment small geographical differences had profound and lasting impact on survivability during an episode of catastrophic environmental change.

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1. Introduction

Climate processes and histories are frequently modeled on hemispheric or ocean basin scales; however the most common human impacts are local, and vary significantly over very small scales of space and time. Geographical differentiation between features separated by a few tens of meters can have significant and enduring consequences for communities. Close study of archaeological, archival and sedimentological evidence, cross scale analysis of regional climate trends and simulation of individual weather events offer novel perspectives on survival versus destruction at the scale on which people experience catastrophic events.

Human settlements are a compromise between risk and opportunity. The parameters of this balancing act are historically contingent, changing through time in response to both human and environmental forces. Subarctic communities are very delicately balanced, having lower population densities, harsher environmental conditions, and less diverse terrestrial ecosystems. They often benefit from rich marine ecosystems, but advantages are offset by adverse weather which can limit access to marine resources while decreasing terrestrial productivity. Consequently, these settlements can experience episodic abandonment or outright failure, making them useful case studies in human vulnerability and adaptation to environmental change. Comparison between long term survival stories such as Iceland and the Faroes, and more complex stories such as Greenland yield insights on the interplay between environmental change and human social and economic behavior over centuries, or even millennia. Dugmore has argued that the failure of the Norse Greenland settlement cannot entirely be attributed to climate change (Dugmore et al., 2012). Rather they note the combination of large scale historic processes and vulnerabilities created an insupportable situation. Elsewhere Streeter contrasts this situation with Iceland where “plagues and resultant demographic shocks in 15th century Iceland did not

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propagate into collapse, indicating that this social–ecological system was resilient" (Streeter et al., 2012).

Unlike its larger island neighbors to the west, Shetland appears to have had relatively extensive and continuous human occupations over its 6000 + years of settlement (Turner, 1998). Even during the severest years of the Little Ice Age in the 17th and 18th centuries multiple lines of evidence suggest that Shetland was a comparatively prosperous region supported by domestic farming, herding, and fishing for both subsistence and trade (Smith, 1984). A little known but prominent exception to this scenario of stability is examined here: the agriculturally rich township of Broo, at the southern end of Mainland Shetland, which was completely and permanently destroyed by blowing sand in the late 17th century. In contrast, adjacent communities in the same valley survived and remain viable agricultural settlements into the present. This differentiation underlines how small variations in local geographies may significantly influence survivability within a single landscape. Multidisciplinary research by the Shetland Island Climate and Settlement Project (SICSP) (Bigelow et al., 2005, 2007,2013; Bigelow, 2011) indicates increased LIA storminess combined with abundant sand to precipitate Broo's destruction. Once destabilized and set in motion sand continued to move keeping the landscape around Broo useless for cultivation and grazing until beach grasses – predominantly Marram grass, *Ammophila arenaria* and Lyme grass, *Elymus arenarius* – were planted, possibly in the 19th century. In this paper we argue that local variations in landscape morphology influenced past patterns of wind flow and sand deposition during storm events creating an anomaly that heavily impacted Broo. In other parts of Quendale, farms were not overwhelmed and these settlements remain intact to the present day.

2. Archaeological site description

The Broo archaeological sites borders the Quendale valley, in Dunrossness Parish on Mainland Shetland, 175 km north east of Scotland, at 59°54′34″ N, 1°18′45″ W (Fig. 1). The 3 km long valley is situated due north from Quendale Bay (Fig. 2 a, 2 b). The Broo Sites complex is 1.5 km from the high tide line, and sits on the eastern edge of the valley (Fig. 3). To the west, the metamorphic phyllites and grandiorites of Fitful Head rise to 280 m; to the east the Old Red Sandstone of Ward's Hill rises to 90 m. The boundary between these units runs along the eastern side of the valley paralleling its north south axis (Flinn, 1967). The valley bottom, defined by Scottish Natural Heritage as a Site of Special Scientific Interest (SSSI), is rough pasture, and is accessible only by foot, or along unpaved roads. At over 450 Ha, it is the largest dune field in Shetland, and covers most of the low lying landscape, extending inland and up the eastern slopes of the valley (Dargie, 1998). The sands are derived from a large foreshore dune approximately 7 m high comprised of reworked glacial materials and carbonate shells derived from more modern marine organism. Small till deposits are still actively eroding along the eastern and western shores of the bay, and suggest that till mantles the bedrock in most of the region. In many respects the region resembles the machair landscapes of Scotland's Western Isles.

In 1791 Dunrossness was: "comparatively the most fertile district in the Shetland Isles." and in Scotland's first official census had a population 2295, second only to Sandwick in Shetland (Mill, 1791; Kyd, 1952). 16th century documents describe Broo as a valuable township comprising four farms with dwellings, outbuildings, and fields, with associated rights to moorlands for grazing and peat extraction (Irvine, 1987). The physical evidence supports this picture of prosperity. In 2002, SICSP surveys discovered an archaeological site complex 1.5 km inland from Quendale Beach. Subsequent excavation, testing, and progressive uncovering of the complex have demonstrated that it is one of the four farms of the Broo township. It is possible that the structure was initially a tenant farm. However artifacts and architectural features indicate that the township's elite, its Sinclair proprietors, certainly occupied the farm during its final years (Plate 1).

3. History of abandonment

The history of sand movement across Quendale and over Broo can be interpreted from four sources: geomorphology, artifacts, historical documents, and OSL dated sands. There is abundant geomorphological evidence indicating a long history of sand movement in the region. The immediate sand source is the foreshore dune. Four truncated foredunes are visible on the eastern cliffs seaward of the current shoreline indicating a landward progression of dune formation. There is extensive evidence of wind action (Fig. 2 c): relics of dune forms are evident towards the western side of the valley floor, small transverse dunes are visible through the middle section, and patches of windblown sand are visible extending to the summit of Ward's Hill, impinging upon an Iron Age structure close to its summit (Sorrell, 2013). Artefactual, documentary and OSL dates constrain the final full use of the Broo farms to the decade and a half between 1690 and 1705 (Bigelow et al., 2013; Kinnaird et al., 2014).

Sections excavated adjacent to the Broo site complex show sands interlayered with organic materials (Plate 2). This suggests that the inhabitants of Broo faced multiple episodes of sand deposition, and may have responded by trying to reestablish soils on top of aeolian materials. Preliminary analysis indicates that these organics include peat ash, manure, and waste materials (Saunders and Simpson, 2012; Bigelow et al., 2013). This may be a result of the inhabitants' determination to maintain the township's productivity in the face of sand blows. Historical records narrow the onset of the most destructive sand blows to the second half of the 17th century, and the final destruction of the majority of the fertile land to the first decade of the eighteenth century.

Predictably there are some ambiguities in combining geomorphological and historical chronologies. There are isolated remnants of sand blows with OSL dates from the mid-16th century on the protected, lee side of the Broo Site complex. This may indicate that these structures were present in the 1500s, and that they survived significant sandstorms, though further excavation is needed to confirm this interpretation. OSL dates from the more extensive sand blows that finally inundated the farm are dated to the 18th century. Documents indicate by the 1740s the landscape was blanketed by sand, but the foundations of buildings and field walls could still be seen (Low 1774 in Anderson, 1879). Although complex, Broo's chronology of deposition and abandonment contrasts with settlements on the western slopes of the Quendale valley, where sites of similar or greater antiquity are still farmed.

3.1. OSL data

The OSL record developed by the SICSP provides a general chronology of the development of the Quendale dune field. Table 1 shows five OSL dates from the Quendale dune field. Table 2 shows ten OSL dates produced from in and around Broo (Kinnaird et al., 2014). Together the two tables span a period from >4k BP to 60 BP.

There are some caveats required in the interpretation of this record. Samples from Table 1 provide age constraints on the dune–field as a whole; samples from Table 2 date specific parts of the Broo excavation. Dynamic dune environments frequently defy simple superpositional interpretation. Emplacement, removal, burial and reburial of surface materials during complex synchronic

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