Did the Fimbulwinter Eradicate Shetland's Picts?

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Introduction

IT HAS long been a bone of contention amongst archaeologists and historians as to whether a dearth of Pictish place-names surviving in the Shetland topography is due to genocide and ethnic cleansing by Viking invaders.[1] This may well be true if, at the time of a Viking 'invasion', there was a significant indigenous Late Iron Age/Pictish population in Shetland that had built up a lexicon of place-names which had been passed on orally down the centuries.

If there had been a long-established Pictish population in Shetland at the time of Viking invasion or Norse settlement in Shetland, place-names would have been too valuable a resource to eradicate. On place-names R Jones commented, 'They were designed to carry and communicate information of relevance for those that encountered them. They were invariably created to be meaningful and useful, to be reflective of local conditions and human experience, and they were intended to be understandable.'[2] There is no evidence of Pictish language place-names that have been 'Nornified' with possible exceptions of the large islands Yell, Unst and Fetlar.[3]

In Shetland Norse place-names were built up gradually through centuries of settlement, to be carried forward and evolve through a long chain of oral tradition. Over time the orthography has become either 'Scotified' or 'Anglified' to the extent that in some cases the original meaning of the name has become lost. We must be grateful for the works of Faroese scholar Jakob Jakobsen[4] and Shetland scholar John Stewart[5] for collecting and preserving Shetland place-names and derivations that would otherwise have completely vanished from the lexicon.

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1 Smith 2001.
2 Jones 2015, 209.
3 Coates 2007; 2019.
4 Jakobsen 1928-32; 1936
5 Stewart 1987.

When a population vanishes from an area, for whatever reason, the oral tradition link is broken and place-names are lost. In fact, the survival of most of Shetland's place-names is due to recording of these by cartographers, not least by the Ordnance Survey in the 19th century. The 20th century place-name project conducted / hosted / led by the Shetland Amenity Trust gathered up the last of Shetlandic oral tradition not recorded on maps. Even so, there are areas of Shetland where place-names have vanished due to the population being lost to the land before paper recording began. For example, the peninsula of Burra Ness in North Yell is reported to have 'supported seventeen families, one hundred and two people' until it was cleared by the infamous John Walker in 1868.[6] The Ordnance Survey map (six-inch 1st Edition of 1843-1882) for Shetland is remarkable for its record of naming geos, ayres, sands and stacks, however the coast of Burra Ness is almost completely blank because by the time Burra Ness was surveyed there was no one living there to pass on the information to the Ordnance Survey researchers.

The severe effects of climate change leading to mass mortality from famine and plague on the 6th century Pictish population have been alluded to before.[7] Depopulation from a climate disaster is a more likely cause of place-name absence than Viking genocide. This paper examines the conditions that would cause Shetland to become uninhabited following sudden, catastrophic and long-lasting climate-forcing events caused by multiple extra-tropical (high latitude) and tropical (low latitude) volcanic outpourings in the 6th century.[8] Shetland's proximity to extra-tropical volcanic sources (e.g. in Iceland) may have had more extreme effects than previously thought.[9]

Depopulation followed this abrupt global climate change which particularly affected regions that were always on the very margin of agricultural sustainability. Sampling of agricultural soils at the Iron Age settlement at Old Scatness on the southern tip of Shetland shows that agricultural activity ended in the Late Iron Age / Pictish period before resuming in the Norse period.[10] The most likely explanation is village abandonment rather than the postulated deflation, truncation, or continuous agricultural use through to the Norse period.[11] Shetland would have remained without any significant population for over a hundred years after the abandonment of the last occupied 6th century buildings at Old Scatness before reuse by the Norse.[12]

6 Gear 2005, 37.
7 Brown 2003, 191.
8 Sigl et al, 2015b.
9 Plunkett et al, 2023.
10 Dockrill et al 2010, 201-202.
11 Turner 2012, 362, 377-378.
12 Dockrill et al 2010, 84-88.

It is highly likely that, due to depopulation and abandonment, Shetland fell off the Northern Scottish Pictish radar, and re-inhabitation of Shetland only began again with the arrival of the voyaging Papar pioneer monks in the late 7th century. Papar in this instance is taken to be derived from the Old Norse 'Papi' referring to an Irish Christian Priest. By the time Viking raiding on the British Isles began in the late 8th century I suggest that Shetland's population consisted of no more than just a very few monastic (Papar) sites, (Figure 1).

Figure 1: Map of Shetland showing places referred to in the text and major lochs.

Climate forcing

Climate forcing models and refinements using ice-core and tree ring evidence over the last two decades have found a general agreement among scientists that a series of extra-tropical and tropical volcanic outpourings began in AD 536.[13] This initiated a sudden and rapid cooling event that affected north-west Europe, recovery from which was slow and intermittent for over a century afterwards.[14] This cooling period surpassed anything records show as occurring in the past 2500 years with regard to persistence, extent and magnitude. The exact locations of the multiple extra-tropical and tropical volcanic outpourings of AD 536, 540 and 547 are still debated, however scientists agree that they produced the largest, longest-lasting, and most widespread atmospheric loading event in recorded history.[15]

Climate forcings that originate outside the atmospheric system itself are a major cause of climate change. Negative climate forcing results in regional or global cooling. Vast outpourings of sulphurous gases from volcanic eruptions ejected into the stratosphere are recognised as a major factor in negative climate forcing on a global or regional scale.[16]

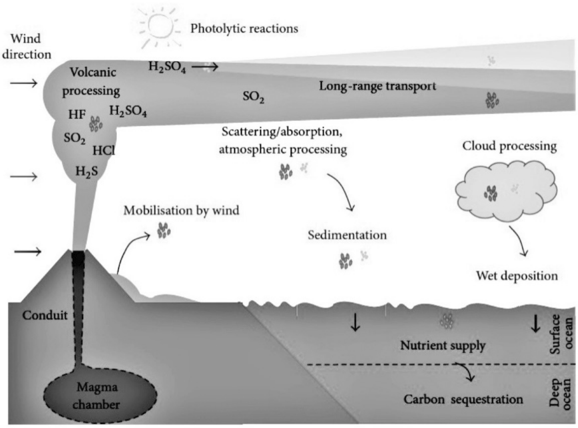

Figure 2: Schematic diagram showing the important processes controlling climate effects of volcanic ash and volcanic sulphate. (Copyright 2014 Baerbel Langmann. Used under Creative Commons Attribution License.)

13 Toohey et al 2019.
14 Büntgen et al 2020.
15 Plunkett et al 2023.
16 Langmann 2014, 1-3.

Sulphate aerosols form from UV photochemical reactions with the gases in the volcanic plume as it spreads outwards in the stratosphere (Figure 2). There they remain until downward motions bring them into the troposphere where they are removed by gravity settling (dust or fog) or wet deposition (snow and rainfall). Such aerosols can have a residence time of several years in the stratosphere, cooling the Earth's surface by reflecting incoming solar radiation, leading to colder summers. Past climate events from individual eruptions over the last two millennia can be determined from sulphate deposits preserved in ice-cores from Greenland and the Antarctic when correlated with tree-ring growth data.[17]

The Sun is the major driver of the Earth's climate system and a reduction in the Sun's radiance will reduce temperatures at the Earth's surface. Palaeo-changes in solar activity, Total Solar Irradiance (TSI), can be reconstructed from variations in Carbon-14 production found in ice-cores and sediments. Increased Carbon-14 production is associated with reduced solar activity and so generally cooler conditions on Earth. Major volcanic eruptions and/or a series of closely-spaced eruptions can induce decadal-scale climate downturns. Ocean-ice feedbacks may extend downturns to multi-decadal and potentially centennial time-scales.[18] TSI will also be reduced by a major reduction in the Sun's activity in its eleven-year cycle[19] and, significantly, a major solar minimum is shown to have occurred coincident with the Late Antique Little Ice Age.[20]

The North Atlantic Oscillation (NAO), which is the sea level pressure difference between the Icelandic Low and the Azores High, is recognised as a major driver of climate forcing in the Northern Hemisphere.[21] Climate modelling suggests that very large tropical eruptions may trigger a negative-NAO phase, due to cooling of the tropics causing a decrease in the pole to equator temperature gradient. Long term fluctuations in this pressure gradient exert control over wind direction and storm tracks across the Atlantic. For north-west Europe a positive-NAO phase generates warmer and wetter climate conditions, and a negative-NAO phase generates colder and drier climate conditions. NAO phases can vary in length from seasonal to decadal and are most pronounced during the winter months (Dec-Mar). Palaeo-NAO phases can be determined from ice-core and tree ring analysis, and longer-term records have been obtained from Norwegian fjord sediments.[22]

17 Sigl et al 2015a, 48-49.
18 Stenchikov 2009.
19 Steinhilber et al 2005, 1.
20 Ibid, 3. Figure 2.
21 Royal Meteorological Society, 2021.
22 Faust, et al 2015.

The Late Antique Little Ice Age (LALIA) and causes

Recent accurate dating of paleoclimate data from ice-cores refined by tree-ring data has now established that a series of volcanic eruptions from around AD 536 triggered a sudden, severe and long-lasting climate deterioration that lasted through the remainder of the 6th and well into the 7th century. This period is known as the Late Antique Little Ice Age and brought substantial societal change across most of Europe and Asia.[23] Extra-tropical eruptions in Iceland and North America began in early AD 536 and were followed by another in AD 540 which was accompanied by tropical eruptions, (Figure 3).

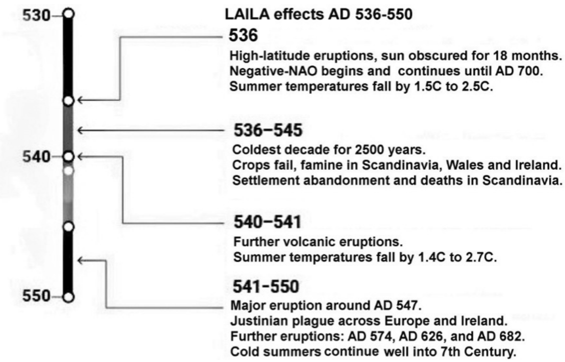

Figure 3: Timeline of volcanic eruptions that triggered the Late Antique Little Ice Age.

Both types occurred again in about AD 547 and these coincided with the exceptional solar minimum event.[24] Major eruptions in AD 574, AD 626 and AD 682 led to a long sequence of cold summers well into the 7th century.[25] Injection and persistence of sulphuric aerosols into the stratosphere from extra-tropical explosive eruptions have disproportionately strong climate-forcing effects in the Northern Hemisphere compared to tropical eruptions.[26] It may well be then that eruption products entering the stratosphere were extensive enough to significantly block sunlight for at least eighteen months, causing the coldest two decades in the past 2500 years.[27] Palaeo-NAO data from the Norwegian fjords show an abrupt end of a positive-NAO and the abrupt beginning of a negative-

23 Büntgen, et al 2016.
24 Sigl et al 2015b.
25 Newfield 2016, 9.
26 Toohey et al 2019.
27 Newfield 2018, 449.

NAO phase coincident with the volcanic outpouring in AD 536.[28] Modelling shows that the negative-NAO phase persisted until AD 700, along with a markedly sustained reduction in total solar irradiance variability (TSI); effects which spanned a period of 164 years. The tropical Tierra Blanca Joven eruption of Lake Ilopango (El Salvador) has been dated to AD 539-540 and is identified as a major negative climate-forcing eruption. As such it will have exacerbated the already severe climate downturn from the extra-tropical eruptions in the northern hemisphere.[29]

Evidence of further climate forcing from volcanic eruptions causing periods of marked cooling across Europe through the 7th and into 8th century come from proxy-scientific data and contemporary texts. A significant cooling episode to affect Europe and Britain occurred around AD 626 and is recorded in Annals of Tigernach and the Annals of Ulster; the severe winter of AD 736-734 is consistent with ice core chronology.[30]

Reduced sunshine

Aerosol Optical Depth (AOD) is the measure of aerosols distributed within the atmosphere and is used to calculate the amount of solar radiation reaching the Earth's surface. The greater the volcanic aerosol load in the atmosphere the greater the reduction in insolation for a given locality. Climate-forcing modelling from the calculated AD 536 aerosol build up in the atmosphere shows loading, hence solar dimming increasing with latitude towards the eruption sources. Modelling confirms contemporary accounts of prolonged solar dimming of at least eighteen months which increased in magnitude with latitude towards the source of the eruptions.[31] Modelling also shows that the prolonged period of blocking of solar radiation, particularly in the summer months, will reduce photosynthesis and thus primary plant and crop production, hence threatening food security for many for a multitude of years. Low crop production and lack of vitamin D in human skin makes populations more susceptible to famine and plague.[32]

Lowered temperatures and increased storminess

The western British Isles and Northern Isles of Scotland are warmed by the North Atlantic Current (aka North Atlantic Drift from the Gulf Stream), and by the Continental Slope Current flowing north from the Bay of Biscay and

28 Faust et al 2015, 90-91, Figure 7.
29 Dull et al 2019.
30 Kostick and Ludlow 2015, 17-23.
31 Toohey et al 2016, 406, Figure 2.
32 Helama et al 2018, 1.

Iberia. A consequence of the post-eruption global cooling and a prolonged negative-NAO of AD 536 was the advance of Northern Hemisphere glaciers and Arctic sea-ice growth.

Research using climate model simulations show a decrease in surface temperature and an increase in Arctic sea-ice for fifteen years following the AD 536 eruptions.[33] It is likely that as the newly formed ice melted again it will have cooled the Atlantic Ocean. This in turn resulted in long-term sea-ice/ocean feedback with consequent weakened and reduced oceanic heat transport by these currents to higher latitudes.[34]

Although a negative-NAO may result in fewer storms, climate modelling of the later transition between the Medieval Climate Anomaly (AD 1000 to AD 1300) and the Little Ice Age (AD 1400 to AD 1800) indicates that storms, when they do occur, will be more severe.[35] The NAO is driven by winter weather patterns, so higher storminess during a negative-NAO may be explained by severe cyclones predominantly occurring in spring and autumn.[36] It is therefore highly likely that exceptionally severe storms affecting Shetland occurred during the post AD 536, negative-NAO period, with consequent storm surges affecting coastal settlements.

The low June-August summer temperature of AD 536 began the coldest decade for the next 2500 years that defined the start of the Late Antique Little Ice Age. Six of the coldest summers in the past two millennia occurred between AD 536 and AD 545 with another predominately cold summer in AD 627.[37] Tree ring and ice core evidence confirm that European summer temperatures were 1.6°C to 2.5°C below average following the AD 536 eruptions. Further eruptions AD 539-540 kept summer temperatures 1.4°C to 2.7°C below average, and below average temperatures continued until AD 559.[38] Beyond the defined Late Antique Little Ice Age period, analysis of ice core and tree ring data for AD 670 to AD 730 identify major negative climate-forcing events in the years AD 681, AD 684 to AD 686, and AD 706-707 along with several moderate events. These confirm high resolution modelling of a major climate downturn and prolonged temperature reductions over that period.[39]

33 Toohey et al 2016, 402.
34 Faust et al 2015, 91.
35 Trouet et al 2012, 53.
36 Lamb 1991.
37 Büntgen et al 2020, 5.
38 Sigl et al 2015b, 5.
39 Gao et al 2016, 180-193.

Crop failure

Climate downturn has a larger impact on populations living in areas of marginal agriculture where a temperature change represents a larger portion of the heat budget in the growing season, so a fall of just one or two degrees will have a greater effect on crop yield than in more fertile areas. Growing Degree Days (GDD) are the accumulated mean daily temperature statistics used to estimate the growth and development of plants during the growing season. Plant development will only occur if accumulated temperatures over the growing season exceed a minimum development threshold of GDD for each species. In simulations of the AD 536 temperature downturn, effect on growth, measured by using GDD as a predictor of crop development, indicates a fall of 30% across the British Isles and 40-50% across Scandinavia.[40] The value for Shetland is likely to be akin to that of Scandinavia.

Fimbulwinter

> First came the Fimbulwinter that lasted three years. This was a warning of the coming of Ragnarok, when everything living on Earth came to an end.[41]

In Norse mythology Fimbulwinter means 'great winter' and is the prelude to Ragnarök, the destruction of the world. This myth probably stemmed from folk memory of a sudden and long-lasting climatic catastrophe that occurred during the 6th century and which we now recognise as the LALIA. Historical texts tell of a darkness from the veiling of the sun that engulfed Europe, bringing cold, hunger, crop failures, famine and plague.[42] They tell of dwindling resources leading to famine and conflict; some historians link this climatic change to barbarian invasion and eventual collapse of the Roman Empire.[43] In Scandinavia this climatic disaster accelerated population movement during the Migration Period when about half the population of Norway and Sweden is thought to have died and agricultural land was abandoned.[44]

Famine, disease and plague

Gotland Island group has about twice the land area of Shetland and is

40 Toohey et al 2016, 409, Figure 5.
41 Science Norway 2019. Finnish national work of epic poetry, the *Kalevala*.
42 Procopius 1916, 329.
43 Arjava 2005.
44 Gräslund and Price 2012, 431-433.

low-lying (highest point 82 metres compared to Shetland's 450 metres). Like Shetland, the north is barren and rocky with the best agricultural land in the more fertile south. It also has walled pastures grazed by sheep and important beef, pork and dairy farming industries. Gotland has a typically coastal climate not much different from Shetland's, albeit with higher summer temperatures, particularly inland. Overall, there is more better-quality agricultural land and resources such as forestation than in Shetland.[45]

For southern Scandinavia low temperatures in the summers following AD 536 brought ruined harvests followed by famine, ending an agrarian economy that had existed for centuries. In Gotland cultivation was abandoned and villages wiped out and burned, including the Late Iron Age *Vallhagar* in eastern Gotland,[46] a long-established agricultural settlement not unlike Shetland's Old Scatness.[47] Recovery of the landscape to support production took four to seven generations in some areas:

> Ruined harvests and grazing for two years in a row, combined with several cold summers and shorter growing seasons for a further decade, would have led unavoidably to serious famine in archaic agricultural societies. It seems reasonable to suggest that the populations of Scandinavia in the mid sixth century may have been halved'.[48]

The effects of the post-AD 536 events were felt elsewhere. The Irish annals record that, between AD 540 and AD 795, that country was swept by a series of major epidemics affecting both humans and cattle, .[49] Furthermore, Grace has suggested a link between the climate downturn from the AD 536 eruptions and the Plague of Justinian.[50]

Ergotism is a particularly nasty form of food poisoning with a wide array of symptoms, often leading to death. Epidemics of ergotism in the Middle Ages were caused by eating ergot-contaminated bread, and these could result in the deaths of tens of thousands of people. Extreme weather conditions following AD 536 may have been conducive to contamination of stored food and fodder by poisonous ergot (*Claviceps purpurea)* leading to an epidemic of ergotism.[51] Ergotism was most common in those colder, damp areas of Europe, as noted by Bondeson 'the extreme climate change beginning in AD 536, with a darkened

45 Region Gotland 2017.
46 Gräslund and Price 2012, 431-433.
47 Svedjemo 2014, 31-46.
48 Gräslund and Price 2012, 431-433.
49 Grace 2018.
50 Ibid, 74, 80.
51 Bondeson 2014.

sky, colder winters, wet springs and cold summers, constituted optimal conditions for growth of ergot'.[52]

Shetland: impact, vulnerability and resilience

'… disasters have pasts, presents, and futures' and 'they unfold over time, often considerable amounts of time.'[53] Persistence of populations and cultural behaviour must be measured on longer timescales than just the immediate aftermath of a volcanic event, as Torrance stated, 'social scientists have developed the concept of 'vulnerability', defined as 'susceptibility to harm', because it focuses attention on the social groups that have been affected, rather than simply the material damage that had previously been the major subject of disaster assessments'.[54]

The Highlands and the Western and Northern Isles of Scotland have always teetered on the margin of sustainability and, as historical records show, have often been tipped over the edge by climate downturn.[55] The vulnerability of the marginal land is highlighted by the fact that between the years 1550 and 1800, in the Little Ice Age, there were twenty-one periods of famine in Scotland, often leading to settlement abandonment. Although not of the same scale as the LALIA-Fimbulwinter, the decadal cold downturn of the 1690s, also caused by volcanic eruptions, brought widespread harvest failure, famine, death and population movement across Europe.[56] Scotland was very badly affected by crop failure and famine resulting in mass migration during this period which became known as the 'Ill Years'.[57]

Shetland's largest Late Iron Age/Pictish population settlements were on the best agricultural land, particularly in South Mainland. The largest of these have been revealed by excavations at Jarlshof[58] and Old Scatness.[59] Smaller settlements have been revealed by excavations, such as those at St Ninian's Isle,[60] Upper Scalloway,[61] Kebister[62] and Tafts of Bayanne in Yell.[63]

52 Ibid, 63.
53 Oliver-Smith and Hoffman 2002.
54 Torrance 2018, 259.
55 Dodghson et al 2000, 276, Table 1.
56 D'Arrigo 2020.
57 Cullen 2010.
58 Hamilton 1956.
59 Dockrill et al 2010.
60 Barrowman et al 2011.
61 Sharples 2002.
62 Owen and Lowe 1999.
63 Moore and Wilson 2014.

The agrarian settlement of Old Scatness, like that of Vallhagar[64], was a settled farming community keeping a variety of livestock[65] and farming grain and pasture within walled field systems. Fish, mainly inshore species,[66] probably caught by tidal fish traps in the nearby Pool of Virkie, or possibly by nets, rod and line, supplemented the Pictish diet and was their only 'fallback' resource in times of harvest failure. At that time Shetland had no game land mammals, while sea and land birds constituted a very minor food source.[67] Seals were hunted with some success and small cetaceans such as pilot whales may have been hunted by forced stranding.[68]

Considering the causes and effects of the LALIA-Fimbulwinter from climate forcing, as discussed above, the likely situation in Shetland from AD 536 onwards can be determined from the set of key variable criteria for assessing impacts, vulnerability and resilience set out in Torrence (2019).[69]

Primary productivity robustness

The most immediate impacts of the extreme climate forcing event discussed above occurred between AD 536 and AD 550, although forcing mechanisms continued an overall temperature downturn for well over a century after AD 536. The initial eruption occurred in March of that year just before the onset of Spring in Shetland and the start of the new agricultural year. As Martin (2015) commented:

> In 1982, a Macaulay Institute soil survey of Shetland estimated that only about 3% (4,300 ha) of the land area was considered suitable for arable cropping. Most of this occurs close to coastal areas where calcareous sands are available for raising the pH, also in sheltered limestone valleys (e.g., Tingwall) or on localised drifts from ultrabasic rocks.[70]

There is no reason to suppose that land quality in AD 536 was better; without the evolution of land management and reclamation to modern standards it was almost certainly worse.

Shetland's Late Iron Age population practised a subsistence economy, depending on a mixture of animal husbandry, pasture and cereal growing. Land quality determines the amount of crop production balanced against

64 Svedjemo 2014
65 Dockrill et al 2010, 135 Table 5.2.1. Pictish phase 7.
66 Ibid, 157 Table 5.3.1. Pictish phase 7.
67 Ibid, 171.
68 Ibid, 135 Table 5.2.1. Pictish phase 7.
69 Torrence 2019, 259.
70 Martin 2015, 3-4.

animal husbandry, particularly overwintering. The numbers of cattle versus sheep are also determined by land quality and this is critical in the management of the farming landscape. Land quality also determines settlement patterns so even a small change in land quality or growing conditions will have a large knock-on effect on crop production and animal husbandry, particularly fodder for overwintering. Agriculture was community based, rather than undertaken by individual farming families, with these communities being settled close to arable land. At the Jarlshof and Old Scatness settlements, grazing pasture was adjacent to Shetland's best arable land.

Harvest

Primary production of crops and grass is determined by the accumulated temperatures (Growing Degree Days) for the summer months where the GDD must exceed the critical number for the life cycle of the plant taxon.

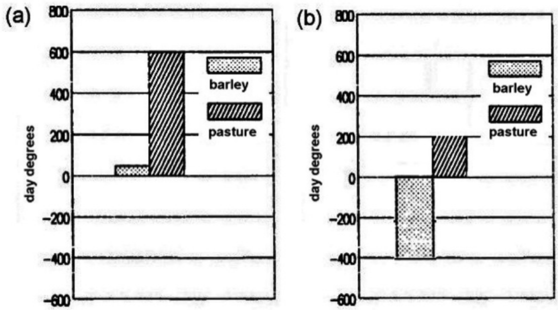

Figure 4: Adapted from McGovern et al 1988. Temperature data from Baltasound, Unst (1931-1947, 1953-1960). (a) Normal growing season. Baseline temperatures and GDD critical level: 4.4°C, 1050 GDD barley; 5°C, 350 GDD pasture grasses. Surplus: 50 GDD barley, 600 GDD pasture grasses. (b) Temperature drop of two degrees for the growing season. Deficit: 450 GDD barley. Surplus: 200 GDD pasture grasses.

Following the AD 536 eruptions the GDD will have fallen below the critical level for many crops by a drop of two degrees in summer temperatures. The effects of this are likely to have lasted over a period of at least fifteen years.[71]

Using a baseline temperature of 4.4°C with a critical level of 1050 GDD for barley and 5.0°C with a critical level of 350 GDD for pasture grasses, a rough index for the viability of both has been calculated in Figure 4.[72] Figure 4(a) is

71 Newfield 2018, 44.
72 McGovern et al 1988, 234.

for a ‘normal’ growing season using climate data from a low-level coastal site in Baltasound, Unst and approximates a GDD surplus above the critical level of about 50 days for barley and 600 days for pasture grasses.[73]

Figure 4(b) uses the same coastal site data with a fall in average summer temperature of two degrees below the baseline and shows a deficit of 450 GDD for barley and a drop of 400 GDD for grass pastures. These figures do not consider soil variability and shelter, insolation etc., nor are they precise cut-off values for plant survival, but they do serve as proxy indicators for the probability of cereal and hay harvest failure from temperature downturn alone.

Figure 4(a) demonstrates the vulnerability of the cereal crop to even a small decline in summer temperatures. Figure 4(b), for a fall of two degrees, indicates a complete harvest failure and much reduced pasture. Even a modest recovery of summer temperatures by degree or so will make any sustainable grain production highly unlikely throughout the long climate downturn. In addition to the temperature drop, the insolation blocking by volcanic aerosols will reduce photosynthesis, thus further reducing all primary plant and crop production for the eighteen months following the eruptions.

By the 6th century six-row barley (*Hordeum vulgare var. vulgare*) was the dominant crop in Shetland,[74] however only a very small proportion of Shetland’s total land mass was suitable for growing barley. There is also evidence from about this time of the introduction of oats to the arable land.[75] The introduction of oats indicated cropping of poorer land, an increase of stock numbers and probably more overwintering of animals, including dairy stock.[76] It has been proposed that by this time a proportion of grain harvest was being stored for later processing.[77]

Successive crop failures lead to famine, a frequent occurrence in Shetland’s recorded history. Following good harvests it is necessary for about 25% of grain production to be stored for planting the next year. In years of poorer harvests, a greater percentage of yield needs to be held back for planting for food production levels to be sustained.

Successive bad harvests in the 6th century dramatically reduced the amount of cereal available for human food, and fodder for overwintering animals. Cattle and other livestock numbers continued to fall as they either starved to death or were killed off for food. Iron Age cattle are believed to have

73 Ibid.
74 Bond et al 2004, 142.
75 Ibid.
76 Ibid
77 Ibid

descended from a gene pool with little or no importation of fresh bloodstock[78] so there would have been no prospect of replenishing stock during the ravages of the long climatic downturn. A further consideration is the possibility of contamination of stored grain in souterrains by poisonous ergot. This was likely in a period of climate deterioration resulting in an epidemic of ergotism poisoning, particularly if grain was held in community storage.

In the event of crop failure, the only fallback food resources were the seashore, the freshwater lochs and burns, and seasonal bird life. The abundance of fish and fish species in Shetland waters depends on the upwelling of nutrients brought by the Continental Slope Current.[79] This current, which delivers nutrient-rich waters around Shetland and into the North Sea Basin, would have been deflected westward by the prolonged low-NAO values[80], resulting in a colder and nutrient-poor North Sea.[81] A similar event occurred in the historic long cold period of 1680-1730 when Shetland's ling fishery and Faroe's cod fishery failed during a negative-NAO.[82]

Fishing

The most abundant Pictish fish remains from Old Scatness are the nearshore species gadids.[83] It is highly likely that there was a collapse of Pictish nearshore fish species due to lack of nutrients and colder waters. The last buildings occupied by the Picts in the mid-6th century (structures 5[84] and 7[85]) 'contain relatively few fish bones and those which are present are typically from small gadids'[86], which may well be indicative of fish scarcity.

Migratory fish, i.e. salmon, sea trout or eels, do not appear in the fishbone record of Old Scatness. Salmon may well have been a prized and seasonal part of Pictish diet as a fragment of a Class I symbol stone depicting a salmon was retrieved from the rubble at Old Scatness.[87] There are few burns and lochs in the vicinity of Old Scatness capable of taking trout or salmon runs: Loch of Hillwell is about a 3.5 km walk and Brow Loch 5 km, although the nearby large freshwater Loch of Spiggie may have still been open to the sea at this time. However, the larger burns from the voes of Shetland's North and

78 SCHBS 2016-2023.
79 Maravelias et al 1997, 1.
80 Chafik 2012, 11, Figure 11.
81 Pingree 2005, 1310-1312.
82 Simpson 2022, 24.
83 Dockrill et al 2010, 156-164.
84 Ibid 44.
85 Ibid 35-38.
86 Ibid 158. 161.165.
87 Ibid 306-307.

West Mainland and North Isles can accommodate much more of the Spring, Summer and Autumn runs of grilse, salmon, and sea trout well inland to the fresh water lochs. The seasonal runs of these fish from Shetland voes into burns capable of taking them up to lochs is likely to have continued for a while during the prolonged negative-NAO, but their size and abundance will have decreased markedly.[88] All Shetland's lochs and burns have a native population of resident brown trout but no bones from these are evident in the Old Scatness records.

Limpets, other shellfish, and seaweed have, in historical times, been referred to as 'famine food' and 'poor food' in famine-hit Scotland and Ireland.[89] It is likely that a near-shore Pictish community could soon exhaust the shellfish in their local area.

Architectural and human robustness

Our knowledge of Late Iron Age/Pictish architecture comes mainly from the two largest archaeological sites in Shetland, Jarlshof and Old Scatness. The excavations at Old Scatness are the most recent and detailed.[90] Both sites show a transition in architectural style by the Pictish inhabitants during the LALIA-Fimbulwinter. At the time of the AD 536 climate downturn the inhabitants of these two settlements were living in substantial dry-stone buildings, known as 'roundhouses', situated next to remnants of brochs that were abandoned around AD 200. Coinciding with the advance of the climate downturn smaller diameter 'wheelhouses' were being constructed. Wheelhouses differ from 'open plan' roundhouses by having a smaller ground footprint and internally are divided into cells by corbelled stone piers.

At Old Scatness some wheelhouses were built by reconstruction within existing roundhouses (Structures 23, 21, and 11). A wheelhouse was constructed inside the previously abandoned broch (Figure 5), then later again, a smaller multicellular dwelling (Structure 7) was constructed inside that.[91]

The earliest Pictish dwelling at Old Scatness, roundhouse Structure 25, was altered to a wheelhouse (Structure 6) by the mid-6th century.[92] The multicellular dwelling (Structure 7) within the broch has also returned mid-6th century dates.[93] Mid-6th century dates have been returned from a smaller building 'figure-of-eight' cellular building on the periphery of the site (Structure 5).[94] Old Scatness

88 Gordon 2020.
89 Firth 2021, 3.
90 Dockrill et al 2010.
91 Ibid, 10-11 Table 1.1. Figure 1.3.
92 Ibid, 29, 62.
93 Ibid, 35-38.
94 Ibid, 44.

Figure 5: The dismembered primary dwelling broch at Old Scatness. The six cells of the multicellular dwelling representing the third phase of use of the broch is in the centre. Cells are also formed by pillars between the outer wall of the multicellular dwelling and the secondary wheelhouse dwelling wall. Photo: Courtesy of Southspear Media & Surveys Ltd.

has evidence of reuse of some of the long abandoned Pictish buildings by Norse or Viking visitors.[95]

The start of changes in architectural style of the Pictish dwellings at Old Scatness and Jarlshof coincided with the start of the mid-6th century climate downturn. Obtaining peat fuel would have been an even more labour intensive and time-consuming community effort than in historical times. Turf was a major building material that had to be cut and transported and required a lot of community effort. It is likely that part of their strategy was to accommodate a much-reduced population in the more fuel efficient and winter resistant multicellular dwellings.

The shift to living in small corbelled cells demonstrates the need of a much-reduced population to conserve wood by negating the use of roofing timbers and conserving fuel. Entrance to an almost subterranean cell by crawling through a small entrance to live in a choking, smoky atmosphere demonstrates the desperate plight of the Picts of the time. Such was the contrast from the large extended families living in the open plan, airy and comfortable roundhouses of more abundant times.

As well as bringing bitter weather, the higher incidence of north-easterly wind and weakened Atlantic currents will have reduced their wood supply for

95 Ibid, 84-88.

roofing and so on. Away from the large, long established Iron Age settlements where building reconstruction was possible, the survival strategy was to build small, semi-subterranean figure-of-eight dwellings, described by Anna Ritchie as 'jelly-baby' houses because of their shape.[96]

A similar pattern of architectural change to, and occupation of, multicellular and 'jelly-baby' structures followed in Shetland's other Late Iron Age/Pictish sites. At St Ninian's Isle excavations uncovered Pictish cellular buildings that had been abandoned in the 7th century. These were described by Barrowman as '… small and circular, possibly comprising conjoining cells and reminiscent of huts rather than substantial round houses.'[97] At Upper Scalloway broch and village site there are 6th century multicellular buildings, including a rebuilding of the 'Late Phase 3' structure inside the broch to '… an apparently quite low standard'.[98] Outside the broch a figure-of-eight house was found in the ruins of previous dwellings. At the long-standing settlement site of Kebister near Lerwick there was a change to cellular structures before the settlement was finally abandoned.[99] The same pattern was found at Bayanne on Yell.[100]

The changes at Kebister and Bayanne appear to have begun possibly as much as a century earlier than at Old Scatness. This may indicate that there was a period of climate downturn preceding, and leading up to, the AD 536 eruptions that forced these changes earlier in settlements on poorer agricultural land than that associated with Old Scatness and Jarlshof.

A recent landscape and architectural survey of North Roe area of Shetland's North Mainland has highlighted the presence of many multicellular, semi-subterranean dwellings at five sites that are almost certainly Pictish.[101] Buildings identified in this survey have, for the most part, not been excavated or have gone unrecorded. At Giant's Garden a large circular structure is partially surrounded by at least twenty or so semi-subterranean cellular structures. At Grut Ness, there are eleven cells organised around two larger circular structures. Both these sites do not have access to arable or pastoral land and shore resources like those found at Jarlshof and Old Scatness. Although still superficial, the evidence from these two sites would suggest the same pattern of change in Late Iron Age/Pictish architecture as discussed at the other excavated sites in Shetland. Because of the semi-subterranean nature of this type of architecture there may be others as yet undiscovered in the Shetland landscape.

96 Ritchie 1977.
97 Barrowman et al 2011,189-190.
98 Sharples 2002.
99 Owen and Lowe 1999, 276-279.
100 Moore and Wilson 2014, 121-122.
101 Jennings 2021, Phase II.

Of particular interest to this paper are the other three sites at Burn of Roer Water, Roer Water and Birka Water.[102] All three consist of multiples of semi-subterranean cellular dwellings, almost all non-excavated or previously unrecorded.[103] These three sites lie well inland following a broad glacial valley rainfall catchment area that feeds many lochs of all sizes along its floor. The lochs are almost all interlinked by watercourses and feed one of Shetland's largest burns that flows south-east to the sea at the Voe of the Brig, Collafirth. The granite bedrock of the valley is an active freeze-thaw shattering fellfield developed since the last glaciation with scree adding to abundant glacial-rip boulder fields.

All three sites are at valley floor level, around one hundred metres above mean sea level. Soil has been practically non-existent since the end of the last glaciation and vegetation is tiny alpine plants or heather growing on patches of peat that has formed in scarce sheltered hollows. Clearly there was no scope anywhere within the valley for pastoral or arable agricultural production in Pictish times. I suggest that all three sites were built to cope with an extremely harsh climate in this upland valley floor. It is reasonable to suppose that in the event of the long-term crop and shore fish failure, starving survivors of famine moved to set up dwellings near the only remaining food source; loch trout and seasonal runs of salmon and sea trout.

A change in architecture was not the only change coincident with the 6th century climate downturn. Late Iron Age pottery style changed too, 'By the LIA un-tempered and quartz only tempering takes precedence. Vessels become much finer, perhaps as potters become more skilled both in production technique and firing capabilities. This increased skill is also evident in the technique required by the potter to perfect a rolled rim as noted in the MIA and LIA'.[104] It may be that this change in the skill-set of potters to produce quality un-tempered vessels was due to the need to conserve fuel for the fires in the harshening climate.

Effectiveness of communication

Doubtless there would have been communication and societal intercourse between Late Iron Age/Pictish settlements on Shetland. There would have been well known trails linking settlements on each island and established boat routes between islands. Links with Orkney, northern Scotland and the Western Isles would require boats capable of making the journeys and crews with the necessary experience and knowledge. Journeys up and down from

102 Ibid.
103 Ibid.
104 Murray 2016,159.

Shetland by boat would have only been possible during the most favourable conditions in the long daylight hours of the summer months.

As the effects of the climate disaster continued to bite, population declined and settlements were abandoned, societal intercourse died out. Information about abandoned areas, such as place-names, would have been lost forever. The ongoing climate downturn would have made weather windows for the summer crossing to mainland Scotland less frequent. The sea link between Shetland and the rest of Scotland, where the population was suffering just as badly, is likely to have been broken for long periods, eventually the break would become permanent.

There is evidence of a tsunami type event (probably a high storm surge) affecting Shetland sometime between AD 380 and AD 650 (1570-1300 cal. years BP).[105] From Basta Voe in Yell the run-up from this event has been traced for a considerable distance inland up to nine metres above ordnance datum.[106] The full extent of the event across the rest of Shetland is unknown but a similarly dated event has been recorded in Dury Voe forty kilometres south of Basta Voe.[107] This event, dated as occurring within the period of the climate downturn, would have had a devastating effect by sweeping away low-lying coastal settlements and any boats capable of making the crossing to Scotland.

Ideology

Belief systems guiding behaviour relating to disasters range from having positive to deleterious consequences.[108] There is no evidence of Christianity having reached Shetland before the onset of the LALIA-Fimbulwinter.

A feature of response to LALIA-Fimbulwinter in western Norway was the burying of gold hoards as votive offerings,[109] which are defined in the *Oxford Classical Dictionary* as 'voluntary dedications to the gods, resulting not from prescribed ritual or sacred calendars but from ad hoc vows of individuals or communities in circumstances usually of anxiety, transition, or achievement.'[110] No doubt Shetland's Pictish population had its own deities but venerated the land as well. Clearly the Late Iron Age/Pictish Shetland would have been experiencing extreme anxiety and distress from the ongoing climate disaster.

In her paper (2011), Murray discusses the placement of agricultural

105 Dawson et al 2006.
106 Ibid.
107 Bondevik et al 2005.
108 Torrence 2019, 259.
109 Axboe 1999.
110 *Oxford Classical Dictionary* 2016.

implements into peat moor as votive offerings.[111] A foot plough was discovered in a peat cutting near the crofting township of Dalsetter, Basta Voe, Yell. This has been radiocarbon dated as AD 570±30[112] and falls within the date range obtained for the tsunami type event recorded in Basta Voe. The offering was made within a kilometre of marine sands deposited by this event. This foot plough was an extremely high value item in the wood-scarce Shetland context.[113] It was probably a high value votive offering from a local Pictish settlement in response to failed harvests and/or the tsunami type event.

Discussion

There was no respite in the LALIA-Fimbulwinter climate downturn following the eruptions of AD 536 to AD 540 for at least a century and a half. The temperature downturn resulting in loss of GGD and wipe out of 'seed banks' meant that cereal production ceased altogether, accompanied by pasture abandonment and the end of animal husbandry. Negative-NAO deflection of ocean currents resulted in a marked reduction of nutrient supply, lowered sea temperatures, and lack of fish.

The health and resilience of Shetland's Pictish populations must have been weakened by incessant cold weather, lack of sunshine, famine and disease. Change in architecture from roundhouse to wheelhouse to 'jelly-baby' houses and partially subterranean cellular dwellings is indicative of a falling population and their response to the deteriorating climate and lack of resources. I suggest that the starving population crashed to a level below which the agrarian communities could sustain themselves.

Shetland's Pictish weather-dependent sea-links with the rest of Scotland were probably tenuous at best and ended during the climate downturn. Trapped on their island group the remaining population had to seek out what meagre food resources were still available. A tiny remanent of the Pictish population probably reverted to a hunter-gatherer type existence. However, shore fish became very scarce due to the colder waters from the negative-NAO. The intertidal shellfish supply such as limpets and mussels were comparatively small in a local gathering area and easily depleted. Seabirds, ground nesting birds and their eggs were a seasonal food source and, other than possibly some smoking effort, not suitable for winter storage. Other than perhaps some wild sheep on heather pasture there was no game to hunt.

The only possible sustainable food source for those trying to survive

111 Murray 2011, 22-32, 84-85.
112 Ibid, 50.
113 Ibid, 22.

through LALIA-Fimbulwinter was to be found in Shetland's lochs, particularly those fed by the largest burns. As well as a loch population of brown trout, the larger burns will have accommodated seasonal runs to the lochs of sea-trout and Atlantic salmon. However, these were liable to be reduced in size and number by lack of nutrients and continual harvesting of breeding stock.

Numerous dug-in cellular dwellings following the Roer Water burn and the lochs in North Roe are almost certainly Pictish. Compared to the architecture that went before, I believe that these miserable hovels by the burns and lochs were designed to withstand severe weather and were situated in an agriculturally barren landscape because the only remaining food source available was in the hill lochs and burns. This too was almost certainly not a sustainable resource and so the Pictish population of Shetland died out.

Conclusions

Historians and archaeologists only present two possible scenarios for what happened to the population of the islands of Scotland when the Viking invaders supposedly appeared over the horizon; cultural assimilation or genocide. Much of their argument seems to hinge on the lack of Pictish place-names within the Scottish islands, and Shetland in particular. Knowledge of place-names can vanish from an area within a generation, but it will take many generations for a lexicon of places-names to become established again. Many of Shetland's Norse place-names would have died out during the first half of the 20th century as the islands' population halved, and were only saved because they were written down.

The acidic soils of the Scottish Highlands and Islands are such that they were always on the very edge of agrarian sustainability and highly vulnerable to climatic downturn and resultant famine. Populations in Shetland only survived 18th and 19th century famines because grain was imported from elsewhere,[114] not an option during LALIA-Fimbulwinter for Shetland's Picts. In pre-history population bounce back could only happen if societal resilience was such that they could cope with and outlast the climate downturn.

I have collated recent proxy-scientific data and climate-simulation modelling to analyse the vulnerability of the Shetland Pictish population to LALIA-Fimbulwinter. At the end of the Roman Warm Period (about AD 400)

114 Shetland Archives D8/150. 'Sketch of a computation upon the quantity of victual necessary to maintain the inhabitants of Shetland for a twelvemonth, and by what means they have been maintained from July 1784 to July 1785, being the third year of famine in these islands. With lengthy observations thereon.' ca.1785.

Shetland's population was probably at its highest pre-historic level[115] making it extremely vulnerable to a harvest-limiting climate downturn. A climate deterioration had already begun before the AD 536 climate forcing rapidly brought on the LALIA-Fimbulwinter. The AD 536 and subsequent climate-forcing eruptions, a prolonged negative-NAO, a deep solar minimum, and lowered sea temperatures, all combined to greatly suppress summer temperatures and bring severe winters for over at least a century.

Shetland would not have missed the worst effects of the longest and severest climate event in the last two and a half millennia. It would have been at least as bad as in Scandinavia, perhaps worse. The physical and social resilience of the population was such that it could not cope with, respond effectively to, move away from, or outlast the situation they found themselves in. As the effects of LALIA-Fimbulwinter bit deep into the population, architecture changed from large comfortable dwellings for extended families, to miserable hovels designed to protect just a small number of occupants against a harsh environment. As harvests failed, and with no seed to plant, famine and disease prevailed so it is likely that the starving remnants of the population tried to survive by exploiting the only food sources still available. The probable Pictish hovels noted next to lochs in a recent survey of North Roe may be just that; an excavation and assessment of these dwellings may have answers.

Climate induced famine and disease doubtless affected Orkney, the Western Isles and Northern Pictland of Mainland Scotland during the LALIA. Some of the Western Isles may have suffered the same fate as Shetland while Northern Pictland saw population movements and conflict. Iona had been established by St. Columba around AD 563 and, over the next few decades, he and his followers set about converting the Picts of mainland Scotland. Interestingly, St Columba also had to deal with an outbreak of plague in Ireland during climate downturn.[116] Conflict in Pictish communities on the Scottish mainland and the spread of Christianity outward from Iona also coincided with the LALIA-Fimbulwinter. Perhaps the old gods of Pictish harvests had failed and this was an opportune time to welcome a new God to take charge.

In the more fertile Orkney, a small remnant of a Pictish population may have survived on an enclave of still productive land[117] as indicated by a continuum of populations' DNA through to Norse settlement.[118] Orkney may have regained some contact with greater Pictland and is mentioned

115 Fojut 1982, 53.
116 Newfield 2016, 89-90.
117 Lyons 2000, 15.
118 Morez et al 2023

in Medieval, pre-Norse settlement texts such as in Adamnan's *Life of Saint Columba*.[119] Adamnan, writing 100 years after the death of Columba ca.AD 597, seems to regard Orkney as the farthest reaches of his known world, indicating that all contact and knowledge of Shetland had been lost until the arrival of the first pioneer monks from Ireland and Scotland.

Only twenty-eight Papar place-names are known throughout the Northern and Western Isles of Scotland, of which nine are in Shetland.[120] On Shetland most of these sites were on, by Shetland standards, high or good quality land, six of which produced cereal surplus in historic times (corn tiends).[121] The Papar settlements on Unst, Yell, Fetlar, Papa Stour, Burra and Bressay all were capable of cereal production with access to pasture. Each of these settlement sites are so remote from each other that any communication between them would be infrequent at best (Figure: 1). The scattered and independent nature of these six probable agrarian sites suggest to me that they were there to support isolated eremitic hermitages of the first post LALIA-Fimbulwinter settlers in Shetland.

Egils Saga[122] tells us that in the time of King Harold Fairhair (ca. AD 850-932) many men fled from Norway and settled in many deserted places including Shetland, Orkney Caithness and the Hebrides. This is confirmation that even by the mid- to late-9th century post LALIA-Fimbulwinter populations of these areas had not rebounded to previous levels.

From of the first Viking raids on the Irish coasts (AD 795)[123] until the mid- to late-9th century settlers, Shetland was probably a staging post for traders and raiders. Reoccupation of pre-existing Pictish structures such as some at Old Scatness[124] appear to be transient,[125] although Griffiths does envisage contemporary Pictish inhabitants without citing any evidence. The *Orkneyinga Saga* intimated that Shetland was an overwintering base for a group of Viking raiders in the late 9th century.[126] This would suggest that using Shetland as a base for temporary settlement was nothing new, perhaps using handy abandoned Pictish structures.

Repopulation of Shetland began with Irish/Pictish monks and their eremitic settlements that were the Papar of the Norse traders and Viking raiders. The fact that the tiny Papar settlements in Shetland survived and grew during the Viking Age shows that a relationship of mutual benefit existed during that time.

119 Sharpe 1995.
120 Simpson et al 2014.
121 Ibid, Table 1.
122 Eddison 1930.
123 Purcell 2015.
124 Dockrill et al 2010, 82-88.
125 Griffiths 2019, 474.
126 Maher and Bond 2019, 202.

When the Norse settlers began farming from about the mid-9th century and put down roots, they began a lexicon of place-names that we still use today. It was not, as has often been postulated, a case of the Viking or Norse settlers killing off or completely dominating the native Picts and wiping out their language and place-names. Shetland's Pictish place-names disappeared along with its population during the LALIA-Fimbulwinter.

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