10.0 ANALYSIS: GEOLOGY, GEOMORPHOLOGY AND EROSION (Alan Stapf)

10.1 Table of Erosion Classes

(distances are given in kilometres)

Map	Area (Unit)	Eroding	E/S	Stable	A/S	A/E	Accr	Totals
1	Gideonfield	0.85	1.1	2				3.95
2	Roesound Skerry	0.9	5.65	4.32	0.4			11.27
3	Badni Taing	0.12	2.5	8.35		0.15		11.12
4	Fografiddle	0.45	1.1	5.5		0.6		7.65
5	Seli Stack	2.4	1.05	0.28	0.5	0.5		4.73
1-5	**South East**	**4.72**	**11.4**	**20.45**	**0.9**	**1.25**	**0**	**38.72**
6	Burrastow	0.75	3.7	1.7				6.15
7	Head of Keedon	1.88	3.5	0.9				6.28
8	Giddigill	0.9	2.35	4.05				7.3
9	Erne's Stack	3.05	1	2.2				6.25
10	Humabery	2.4	0.9	0.35		0.6		4.25
11	Bay of Garth	0	4	4.85				8.85
12	Snap Hevda	0	2.9	3				5.9
13	Turl Stack	0.12	0.55	3.7				4.37
6-13	**North & West**	**9.1**	**18.9**	**20.75**	**0**	**0.6**	**0**	**49.35**
1-13	**Walls**	**13.82**	**30.3**	**41.2**	**0.9**	**1.85**	**0**	**88.07**

10.2 Proportions of Erosion Classes

This table gives percentages for individual areas under respective erosional classes with total percentage for the two areas and the whole. Bold type is used to highlight the more important erosion classes within a unit which are mentioned to within the text.

Proportions are given as a percentage

Map	Area	Eroding	E/S	Stable	A/S	A/E
1	Gideonfield	22	28	**51**	0	0
2	Roesound Skerry	8	**50**	38	4	0
3	Badni Taing	1	22	**75**	0	1
4	Fografiddle	6	14	**72**	0	8
5	Seli Stack	**51**	22	6	11	11
1-5	South East	**12**	**29**	**53**	**2**	**3**
6	Burrastow	12	**60**	28	0	0
7	Head of Keedon	30	**56**	14	0	0
8	Giddigill	12	32	55	0	0
9	Erne's Stack	**49**	16	35	0	0
10	Humabery	**56**	21	8	0	14
11	Bay of Garth	0	**45**	**55**	0	0
12	Snap Hevda	0	**49**	**51**	0	0
13	Turl Stack	3	13	**85**	0	0
6-13	North & West	**18**	**38**	**42**	**0**	**1**
1-13	Walls	**16**	**34**	**47**	**1**	**2**

11.0 DISCUSSION:GEOLOGY, GEOMORPHOLOGY AND EROSION (Alan Stapf)

11.1 Maps 1-5: Summary

Within the Gideonfield unit (map 1) the coastal edge is generally stable. The main area of erosion lies to the east of the voe where weak, crushed (cataclastic) and undifferentiated metamorphic rocks underlie the eastern side of the Walls Boundary Fault. Localised erosion becomes widespread within the Roesound unit (map 2) with almost all of the erosion around Skelda Voe. The coastal edge becomes quite stable within the next two units (maps 3-4). Within the final unit, Seli Stack, (map 5) there is considerable erosion mainly due to the low coastal edge and the easily eroded soft sediments of till and peat.

Overall the major erosional class is stable. This does not take into account that the *eroding to stable* class probably has over half of the coastal edge in a stable condition at any one time. Therefore, adding this to the *stable* class, a realistic figure indicates that three quarters of the coastal edge is in a stable condition. The greatest erosion within this south eastern area occurs within and to the east of Olas Voe.

11.2 Maps 6-13: Summary

Localised erosion is the dominant erosional class within the first two units (maps 6-7) with more erosion within the second unit (map 7) and very little stable coastline. Most of the erosion is taking place on the south west or south-south west facing coasts, particularly along the stretches of Easter Phaill and The Hamar. Both of these areas have many small faults running through them although it is more likely that the sandstones are less coherent than elsewhere along this coastline.

The coastal edge becomes a great deal more stable within the next unit from Giddigill (map 8) although erosion does occur within Voe of Dale where volcanic rocks intrude and within Sel Ayre where there are greater depths of soft till overlying the sandstone.

Further north there is a dramatic change in geology within the next unit (map 9) and is marked by the Melby Fault. This is reflected in the erosional class where the rocks are much more easily eroded as the sea undermines the cliffs by scouring out the lower shale beds. The erosion is even more pronounced in the next unit (map 10) where soft metamorphic rocks, (mica schists) of the Snarra Ness Group dominate the coastline. There is very little stable coastal edge within these two units of the north western peninsula.

Perhaps due to the erosion and longshore drift there is also a large area which can be classed as *accreting and eroding*. Within The Crook there is a build up of sand along the hinterland however there is also evidence to suggest that the beach is migrating landwards as there is erosion within the corner edges of the bay. The western side has been stabilised by sea defences.

The following two units (maps 11-12) are fairly stable with much localised erosion in evidence and the last unit (map 13) has the most stable of all the coastline surveyed over the Walls peninsula. The underlying geology of this latter unit is made up of the Neeans Group which although a metamorphic schist like the Snarra Ness group is much tougher and coherent with a greater silicate content, (feldspathic).

Overall although erosion is fairly dominant to the south west of the peninsula the erosion is far more extreme to the north east of the peninsula, the Melby and Sandness coast. There is relatively little erosion along the mid section of the west coast and the north eastern side of the survey area is very stable.

11.3 Types of Erosion

The sea is the main agent of erosion in the survey area and leads to landslip after mechanical undercutting of the cliff face or scouring of the coastal edge. Separation of a landmass leading to sea arches and stacks can be instigated by the cutting of geos and coves. Here the sea is directly responsible for erosion. If the wave height, speed and direction are constant along the coast then the rate of erosion is also moderated by the rock platform gradient and the depth of the cove. A deeper cove and a longer, more shallow rock platform tend to dissipate the waves energy before hitting the coastal edge.

Marine erosion also takes place as a storm beach gradually migrates landwards. This type of erosion is not always obvious and a cursory look or a snap-shot in time may lead one to assume an accretion of shingle as one cannot see the gradual landward migration of the coast. Chemical erosion by salt spray is rather more insidious and has not been alluded to in this survey other than in combination with observable weathering processes of rocks.

Subaerial erosion is the other main eroding agent and is mainly due to rain water and wind. With rain water the affects are seen as soil creep, peat flow, land slip and water erosion, i.e. rill and gully formation or stream erosion. This tends to be locally confined yet aids sea erosion. It is quite likely that in some areas this is the primary cause of drift erosion.

Wind erosion is usually manifested in soft drift deposits, mainly sand in this case, where wind blow may lead to deflation troughs and scouring of sand dunes. There is only one area where sand has accumulated on the hinterland within the confines of the survey area, this is on the hinterland of The Crook close to Norby on the north coast.

Other eroding agents are biological. In this survey the agents are limited to animal, (rabbit, sheep, cattle, etc.) and human disturbance all of which can be controlled by management policies.

Land use practices and management tend to aggravate or alleviate subaerial erosion but appear to have little effect on sea erosion without large resource input.

11.4 Susceptibility to Erosion

The coastlines most susceptible to erosion are the low coastal edges, less than five metres, and areas of soft drift materials, tills, peats and the soft geological beds of shales.

Most of the coastal edge of Shetland has a steeply shelving or almost non-existent rock platform and consequently there is little moderation of the high energy waves. Here the intertidal rock platforms tend to be steep and so forms a much narrower foreshore which is not capable of dissipating the wave's energy as does a long shallow platform.

Another main factor is the exposure of the coast to the long reaches of storm waves. There is little long-term information on wind speeds and direction, the two main affecters of wave size, although Wright, (1976), reviewed meteorological data and found that between 1920 - 1974 there was an increase in north westerly and northerly winds at the expense of westerly and south westerly winds. Work by Palutikof *et al* (1997) has found that there is cycle of severe gales which appear to crop up every 12 to 18 years. Using the Gale Index for Northern British Isles they observed that storms have increased in severity since 1920. Although there was a short period in 1970 where the number of storms decreased, the number is increasing again.

11.5 Accretion

Within the survey accretion was found to be limited and localised. Shingle is the major accreting material. Although cliff erosion may contribute to the sediments there is also a substantial input from sea bottom sediments. Under rainy temperate to rainy marine climatic zones sand makes up almost a half to two thirds of bottom sediments respectively, (Hanson, 1988).

Shingle storm beaches may or may not be accreting, in nearly all cases there appears to be erosion co-existing with the accretion. Generally it is suggested that they are eroding the shoreline.

Ayres may also be accreting and may be symptomatic of longshore drift of sediments, notably shingle in relatively sheltered waters. Overall these are probably stable or accreting at a very slow rate.

The accretion of many ayres and bars is not generally obvious as it occurs over hundreds of years and may be linked to the gradual submergence of the islands.

11.6 Results and Recommendations in Brief

The majority of the coasts surveyed have a foreshore of rock platform with a clear distinctive coastal edge. Most high energy storm beaches are south west facing.

Overall the main erosion class is *stable* with *eroding to stable* the next most common. The main agent of erosion is the sea which dominates both the *eroding* and *eroding to stable* classes.

Looking at more specific areas, the Melby formation with the softer mudstone and shale layers are most easily eroded along with the weak, mica-schist metamorphic rocks of the Snarra Ness Group to the north of Sandness. Low lying areas with deep tills or peats are also easily eroded and is especially true of the coastal edge west of Olas Voe.

Subaerial erosion is associated with less than a third of the localised erosion in the *eroding to stable* class. Although land management and practices account for some of the subaerial erosion which in turn enhances the sea erosion there was very little evidence of coastal management mal practice.

12.0 CONCLUSIONS AND RECOMMENDATIONS: GEOLOGY, GEOMORPHOLOGY AND EROSION (Alan Stapf)

Although no direct evidence was found during this survey of island submergence taking place the mass of geomorphological evidence suggests that the sea level has been and is still rising due to the relative down-warping of the islands since the last glaciation.

As regards the areas of erosion the main factor within this survey appeared to be the underlying geology with perhaps both aspect and coastal edge height of slightly less importance overall.

With regard to the coastal edge height it must be borne in mind that a much higher coastal edge lessens the observable landward migration of marine erosion in as the much as for the same loss of hinterland area a much larger volume of material has to be eroded away in comparison to the volume of a low coastal edged hinterland. Hence even though the erosion is as bad if not worse along the mid western coast of the peninsula the rate of landward migration must be considerably lower than for the lower edged Olas Voe.

There is very little accretion within the surveyed area. Most of the accretion lies close by large areas of erosion such as Olas Voe and The Crook. This leads to the supposition that the accreting material is likely to be redeposited local material and although this may be true for the shingle areas it may not be true of the sands along The Crook which have grains that are well rounded and so likely to have been subject to long term weathering and mechanical action. Longshore drift may account for only the more localised deposit of larger unweathered material.

It seems that there is little that can be done to negate marine erosion unless huge resources are committed to the control. Ultimately, where there are monuments of singular and significant importance the cost of more elaborate sea defences may be the only option in order to slow down marine erosion.

The softer geological units and the lower lying areas are more at risk from erosion than the tougher geological units and higher coastlines. The coast lines around the north west and south west of the peninsula and the coast line along Olas Voe are more likely to undergo further erosion in the future. Erosion along the north west coast are primarily due to geological features, the south west coast due to aspect from south westerly gales and the Olas Voe area due to both geological and a lower coastal edge.

Subaerial erosion, although damaging to archaeology, is very limited around the coast and is not contributing significantly to coastal erosion

As regards further work there are two recommendations:

The main recommendation is that monitoring of coastal erosion be implemented to assess the rate of erosion especially of the more vulnerable low lying areas. There is no firm data at present on rates of erosion. Perhaps a second survey of the more sensitive areas could be carried out in five or so years time to give an average annual erosion rate.

A second recommendation is that with increasing amounts of data becoming available of coastal erosion a more complete statistical analysis of erosional classes versus geology, coastal height and aspect would be justified in assessing the risk of erosion.

Both of these recommendations will identify areas that are likely to be at risk within the near future which in turn will enable efficient allocation of funding to rescue or take preventative action for the more vulnerable monuments.