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Landslide survey: High Lossit, near Machrihanish Bay, Mull of Kintyre

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Landslide survey: High Lossit, near Machrihanish Bay, Mull of Kintyre

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Front cover

Back scarp and related deformation of the landslide at High Lossit. Photo looking north from [NR 62655, 19980]

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Foreword

This report describes a walkover survey carried out by the British Geological Survey (BGS) to inspect a landslide that affected a section of the field at High Lossit, south of Machrihanish Bay, Mull of Kintyre, Scotland on the night of the 4th February 2014.

Acknowledgements

The authors would like to thank the following BGS staff for their advice during this study: David Boon, Diarmad Campbell, Vanessa Banks and Tim Kearsey. We would also like to thank Mr Adam Armour, the landowner, for reporting the landslide occurrence and escorting BGS staff around the site.

Contents

FIGURES

Summary

A walkover survey was carried out from the 20th to the 21st of February 2014 to inspect a landslide at High Lossit, Mull of Kintyre, Scotland [NR 62655, 19980]. The subsidence and ground deformation associated with the landslide affected an area of approximately 12 000 sq m of rough grazing land, bordering coastal cliffs, and causing minor damage to stone walls and fencing.

The reported landslide occurred within the boundary of a larger, pre-existing landslide that probably occurred following deglaciation of the area during the Late Devensian. The original landslide had an estimated area of 40 000 sq m and likely occurred by rotational failure or sliding of deeply weathered basalt of the Clyde Plateau Volcanic Formation, forming a mass movement deposit comprising angular blocks of bedrock in a matrix of gravelly clay within an area bound by a 5 to 30 m high back-scarp. The recently reported landslide (with an area of approximately 12 000 sq m) is classified as a dominantly translational slide within the older landslide deposit, with rotation at the head of the landslide, developing into a translational slide in the main body and toe. The landslide is developed in a north to north-west facing slope, in gently north-east dipping basalt of the Clyde Plateau Volcanic Formation.

The cause of the recent slope failure is likely due to a combination of driving forces including excessive water ingress after prolonged heavy rainfall, and existing slope instability due to the high slope angle and presence of large blocks of heavily weathered and altered basalt. The slope has a history of instability, reflected in the pre-existing scarp of the post-Late Devensian landslide and there is evidence for active soil movement prior to the recent slip recorded by offset of a stone wall at the foot of the recent slip.

Large Post-Late Devensian landslips have been identified in numerous coastal locations around the Mull of Kintyre. The causes of these large landslips are poorly understood, but in the High Lossit area, intense weathering of basalts and local faulting in addition to over-steepening of the slope through glacial erosion may have been contributing factors to slope instability soon after deglaciation. Further assessment, including detailed geological mapping, would be required to properly understand the effect of the highly weathered and altered basalt on the ground stability and to develop the ground model. To assess for likelihood of future movement, a hydrogeological study of the site would also be required as the drainage of the affected field has been altered following the landslide.

1 Introduction

1.1 BACKGROUND

On the morning of the 5th February 2014, Mr Adam Armour reported to the BGS that a landslide had occurred in his field the night before at High Lossit, south of Machrihanish Bay, Mull of Kintyre. On the 20th – 21st of February 2014 two BGS geologists (Katie Whitbread and Rachael Ellen) inspected the site to collect photographic evidence and record physical damage caused by the event for entry into the BGS National Landslide Database. During the visit Mr Armour said he had detected no further movement of the land following the initial event on the 4th.

1.2 LOCATION

The location of the landslide at High Lossit is shown in Figure 1. The site is located on the west coast of the Mull of Kintyre, adjacent to west-facing coastal cliffs, and the affected slope faces north to north-west. The crown of the landslide is located at [NR 62678, 19952] (Note: Grid References referred to in the text and captions are given as five-figure National Grid References).

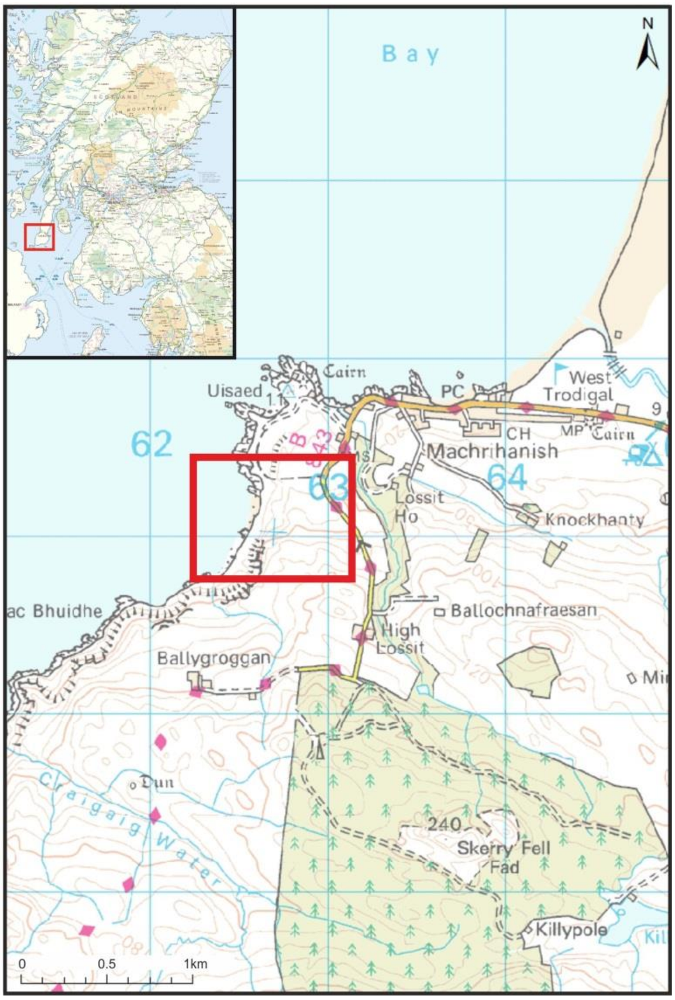

Figure 1: Extract from 1;50 000 scale Ordnance Survey map showing the location of the landslide event at High Lossit, Machrihanish, Mull of Kintyre Peninsula. Insert shows general location. *Ordnance Survey data © Crown Copyright 2013 Ordnance Survey 10037272.*

1.3 TOPOGRAPHY AND LAND USE

The terrain is a mixture of undulating steep grassy pastures and moorland (used for sheep grazing), and coastal beach and cliffs. The moorland at the site of the landslide contains large angular boulders at surface (up to at least 5 m in diameter). The base of the moorland ends where it meets the beach along the coast to the west, or where it meets steep rock cliffs. The field in which the landslide is located is used for sheep grazing, and is bordered by stone walls constructed using locally won basalt. In an adjoining field there is a disused lime kiln, reflecting the limestone rock beneath the basalt.

The aerial photograph in Figure 2 (taken prior to the recent landslide) shows that the ground at the site is undulating and rough with large scattered boulders. A distinct morphological break in slope surrounding the new landslide has been highlighted (solid line). The surrounding landscape is characterised by steep slopes, which likely represent the scarp of an older, pre-existing landslide (dashed line). The photograph also shows the central area has a hummocky appearance with boulders lying on the surface.

Figure 2: Pre-event aerial photograph (taken c. 2009) of the field at High Lossit, Mull of Kintyre. White dashed line marks location of pre-existing relict landslide scarp, and solid line marks the backscarp formed during the recent landslide event detailed in this report. Note also that the cliff line toward the south represents a former shore line, with a distinctive raised beach between the cliff and the modern foreshore. *Aerial photograph © Getmapping: Licence Number UKP2006/01.*

2 Geological Background

The area lies within British Geological Survey 1:50 000 map Sheet 12, Campbeltown (1996). A geological map of the study area is shown in Figure 3. The geological descriptions given below conform to the BGS Rock Classification Scheme (Gillespie & Styles, 1999; Hallsworth & Knox, 1999; McMillan & Powell, 1999).

2.1 BEDROCK

The site comprises mostly Carboniferous strata, dominated by two types of extrusive basalts belonging to the Clyde Plateau Volcanic Formation: younger, macrophyric olivine-clinopyroxene basalt (CPV-BAROCM), which overlies older macrophyric olivine-basalt (CPV-BAOM). This overlies the Carboniferous Kinnesswood Formation comprising limestone (KNW-LMSTN) and sandstone (KNW-SDSL), which overlie the Stonefield Schist Formation, belonging to the Dalradian Supergroup. The Kinnesswood and Stonefield Schist formations are not exposed within the immediate study area, but crop out in the cliffs to the south of the site. There are also Carboniferous-age microgabbroic intrusions (sills) within the bedrock sequence.

At High Lossit, the exposure of CPV-BAROCM is heavily weathered and altered, with a fine grained browny-yellow groundmass containing large (0.5-1 cm) phenocrysts of pyroxene and olivine, the latter of which have weathered out, or have been altered to iron-rich clay (leaving an olivine pseudomorph). The CPV-BAROCM is therefore particularly susceptible to weathering and in places, the upper 50 cm - 1 m of the exposure is weathered to angular gravel (regolith).

The underlying CPV_BAOM is finer grained than the CPV-BAROCM, containing small (<5 mm) phenocrysts of olivine (altered and weathered out) in a dark gray fine grained groundmass. The CPV_BAOM also contains laterally continuous zones of vesicles and amygdales, some vuggy in nature with infills of agate and zeolite/calcite. The basalt is characterised by massive flow centres with indistinct cooling joints, and the bases and tops of lava flows are distinguishable by their rubbly natures and high vesicle content (>70%). The CPV_BAOM does not appear to be as susceptible to weathering and breakdown into regolith as the overlying pyroxene-rich basalt.

In the cliffs beneath the site, outcrops of the KNW-SDSL and KNW-LMSTN are clearly definable and are intruded by a 5 m thick microgabbro sill of the Midland Valley Carboniferous to Early Permian Alkaline Basic Sill Suite, as well as microgabbro dykes of the North Britain Palaeogene Dyke Suite.

The beds locally dip 28° toward the north-east. Bedding plane dips may be locally variable however, as a result of tectonic and mass movement related displacements.

2.2 SUPERFICIAL

The coastal deposits at the site have been mapped previously as intertidal and raised beach deposits (BGS, 1996), with the latter being composed of rounded beach pebbles exposed up to 4 m above sea level. The raised beach extent is also clear from aerial photography, marked by raised sea cliffs **(**Figure 2**).** Following the survey, superficial deposits overlying the site were identified largely as previous landslide deposits (described in the Mass Movement section). Glacial Till of irregular thickness (maximum 1 m thick) was also found, and occurs over bedrock outside/adjacent to the pre-existing landslide scarp. The till contains sub-rounded gravel grade clasts composed of local rock types: basalt, sandstone, limestone, and schist.

2.3 MASS MOVEMENT

There are no Mass Movement deposits shown on the 1:50 000 scale BGS maps, however, an older and larger pre-existing landslide (post-Late Devensian) can be delineated through interpretation of the aerial photograph (Figure 2). Old scarps are seen bordering a depressed area of ground with an irregular topography containing multiple angular boulders. The boulders consist only of basalt, some exceeding 5 m in size, set in a silty, sandy clay matrix. Evidence of a previous landslide continues seaward, beyond the toe of the recent slide, where a boulder field is preserved below the current high tide mark. However, the definitive extent of the original deposit is complicated by the presence of raised coastline. At the top of the coastal slope the farmer's dry stone wall follows the crown of the relict landslide scarp marking out the southern and eastern edges of the older slip. Outside the area of the 4th February landslide event there is evidence for two smaller landslides sourced from the scarp of the older landslip. These minor slips have formed within the altered and highly-weathered basalts (CPV_BAROCM).

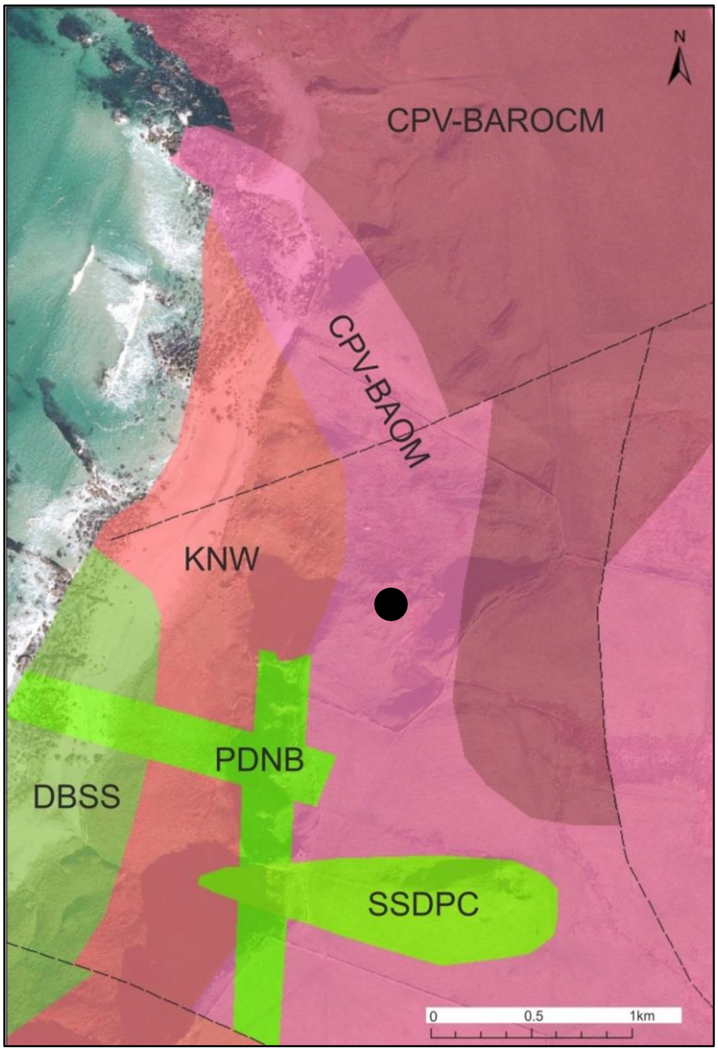

Figure 3: Extract from 1:50 000 digital geological map (DigMapGB50, Version 4, 2007) showing bedrock and fault lines (superficial layer not shown). Bedrock Legend: SSDPC, microgabbro (sheet intrusion); PDNB, microgabbro (dyke and sill); CPV-BAROCM, olivine-clinopyroxene-macrophyric basalt; CPV-BAOM, olivine-macrophyric basalt; KNW, Kinnesswood Formation sandstone and limestone; DBSS, Stonefield Schist Formation. The black dot shows the National Landslide Database location (Landslide ID 19462). *Geological map © NERC 2013. All rights reserved. Aerial photograph © Getmapping: Licence Number UKP2006/01.*

3 Field Observations

The field observations made during the visit are described in the following section, which is organised by the distinct regions that define different styles of deformation on the slope (Figure 4). All material displaced is composed of a deposit of large (<5 m) boulders in a matrix of silty, sandy clay. The boulders are angular and are composed almost entirely (>99%) of the CPV_BAOM basalt unit and weathered boulders of CPV_BAROCM basalt. Very occasional (<1%) gravel-sized fragments of the KNW-SDSL were identified within the landslide material. The recent landslip covers an area of 12 000 sq m, with a main scarp length of ~35 m.

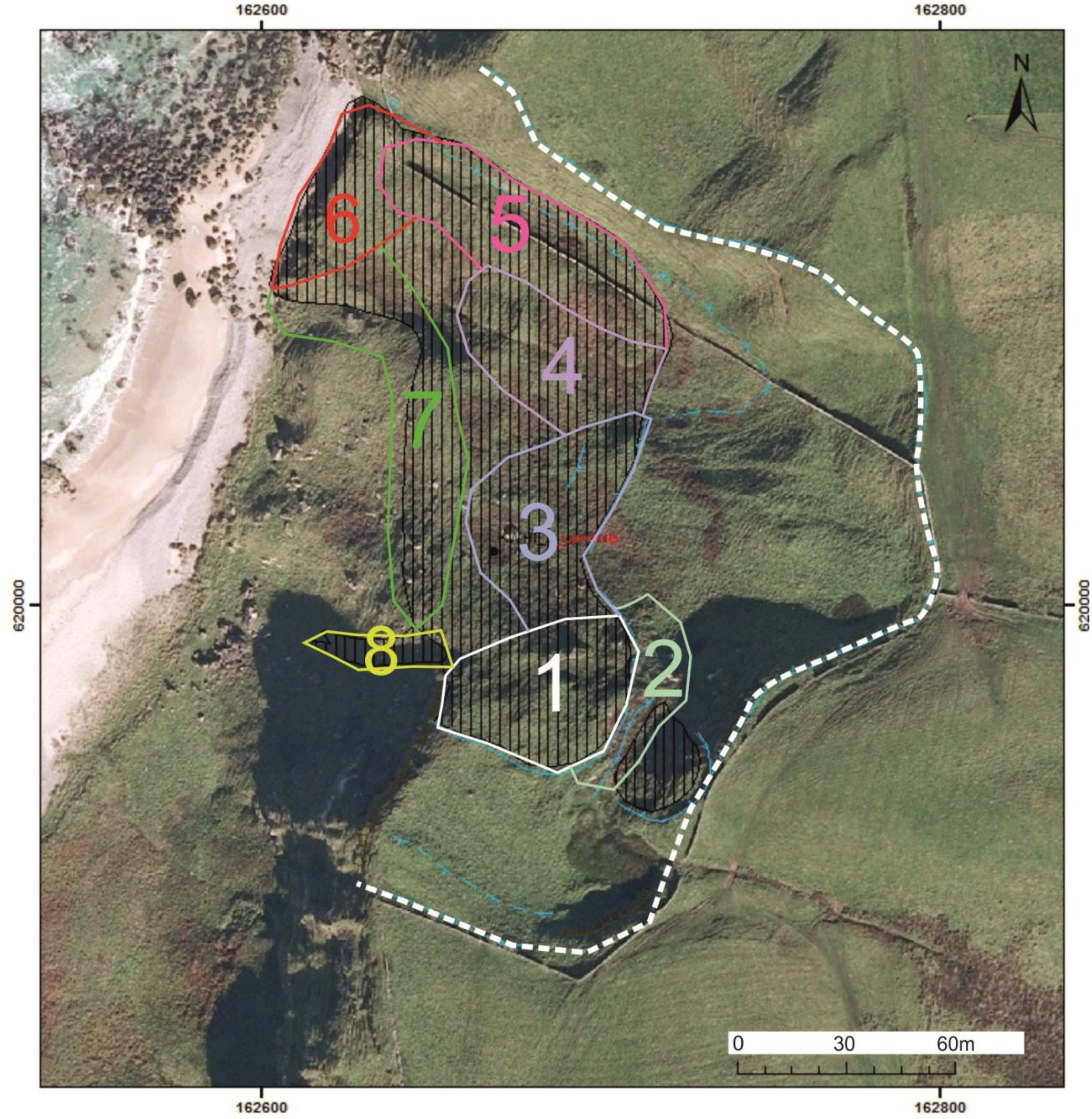

Figure 4: Aerial photograph showing extent of recent landslide ground movement (hatched area) at High Lossit. Regions 1-8, described in the text, are numbered. Blue lines represent breaks in slope, and outline the top of the scarps of both the recent landslide and pre-existing landslides. *Aerial photograph © Getmapping: Licence Number UKP2006/01.*

3.1 REGION 1 – CROWN, MAIN SCARP AND UPPER BODY

Region 1 (Figure 4) comprises the upper body of the landslip, which is 60 m long, including the 35 m long, 3-4 m high main scarp at the top of the slip, along with the area of highly deformed material affected by rotational slumping. The position of the crown and main scarp of the recent landslide are shown in Figure 4 [centred at NR 619950, 162689].

Observations

1. Up to 5 m beyond the main scarp of the slip, the crown of the recent landslide contains open tension cracks aligned parallel to the main back scarp (Figure 5a). The tension cracks are at least 3 m in length, with at least 10 cm vertical displacement, in places up to 50 cm.
2. A curvilinear, continuous main scarp, (shown in Figure 5b) marks the southern-most extent of the recently active landslide. The main scarp shows a normal offset of 3 – 4 m, with open fissures extending for an unknown depth below the surface. For the most part these fissures at the base of the scarps are filled with loose debris. The main scarp feature has a slope of >70° and faces north.
3. The area of ground immediately below the main scarp is severely deformed, with numerous synthetic, low displacement (<1 m) scarps occurring within a few metres of the main scarp, and higher displacement (>1 m, <1.5 m) antithetic scarps extending up to 20 – 25 m away from the main scarp (Figure 5c). In this zone of deformation, boulders have been rotated downslope (to the north) by at least 50°, still with an apparent normal displacement (i.e. no lateral movement).
4. The landslide material in Region 1 consists typically of large boulders of CPV-BAOM, c. 1 – 3 m in diameter, within a matrix of sandy clay with abundant boulders, cobbles and gravel of CPV-BAOM basalt (Figure 5d).

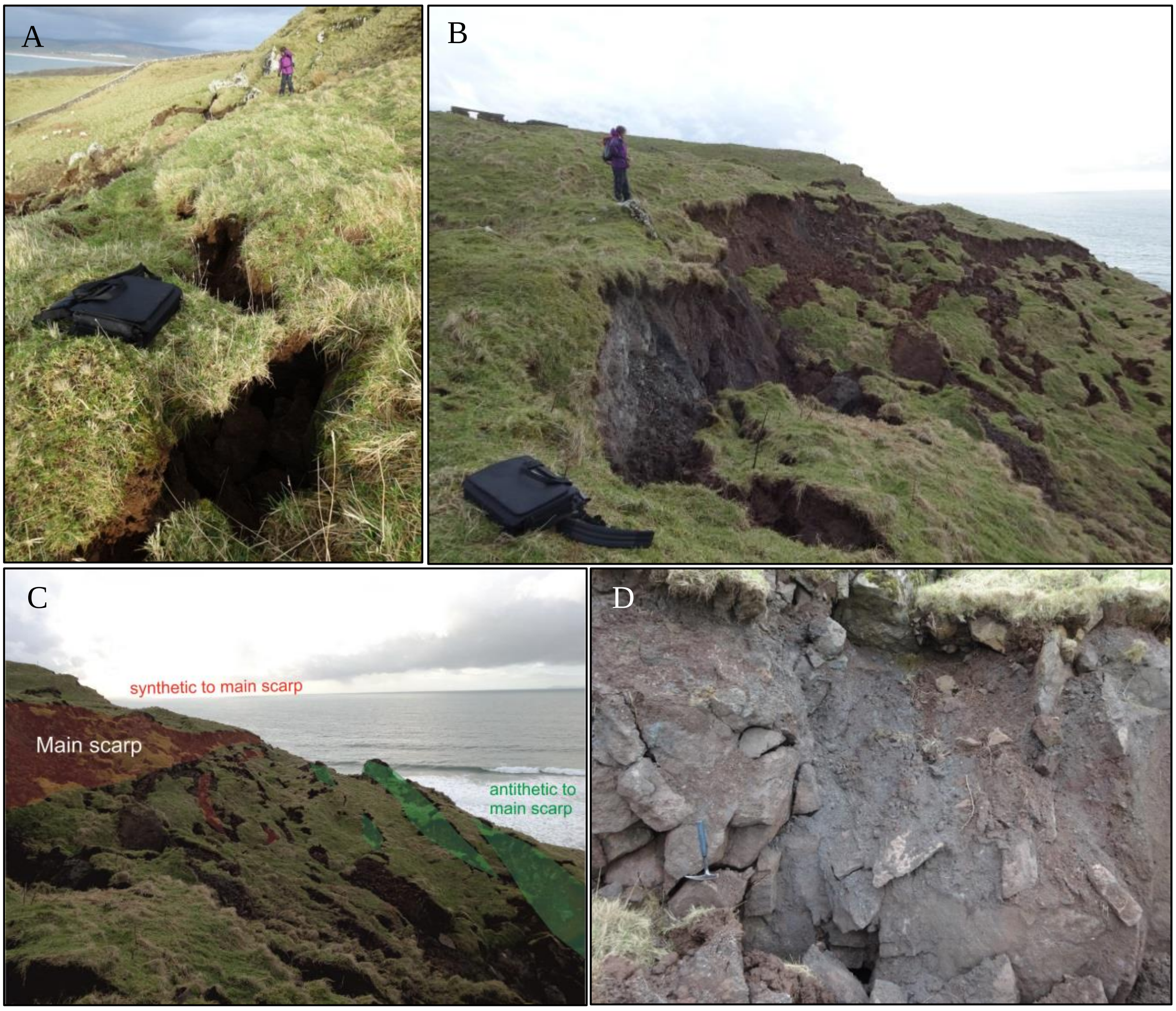

Figure 5: Features in Region 1: a) Tension crack in rear scarp of recent landslide (photo facing north east). b) Detail of north facing main scarp, exposing grey slope debris composed of angular boulders of basalt in a brown sandy clay matrix. c) Zone of deformation immediately north of main scarp, containing synthetic and antithetic minor scarps. Photo facing west. d) Detail of slope debris exposed in main scarp composing zone of deformation. Note angular boulders are weathered basalt. Photo facing south.

3.2 REGION 2 – WET GROUND ABOVE MAIN SCARP

The vegetation in Region 2 comprises marsh and bog plants, with well-developed root systems, and is indicative of an area of land with poor natural drainage. The marshy wet area lies just behind the join of the main scarp (Region 1) and the eastern flank scarp (Region 3). The source of water is from a minor stream which enters the field just to the south [NR 619921, 16272]. A small alluvial fan has formed above, where the minor stream passes over the scarp of the post-Late Devensian landslip.

Observations

1. Active drainage from this marsh bed can be seen running into the recent landslide deposit – the ground was saturated and wet underfoot at time of survey, and a steady flow of water was observed entering a tension crack at the crown just beyond the eastern flank scarp.
2. There are also areas of marshy ground which were relatively dry at time of the survey, suggesting the landslide has significantly affected the previous drainage system of the

site, and that groundwater no longer flows to those areas as much as it did prior to the landslide.

3.3 REGION 3 – EASTERN FLANK OF LANDSLIDE

A linear, broadly north-south trending scarp (with one north-west – south-east trending deflection) marks the eastern extent of the landslide (see Region 3 limit in Figure 4), and faces westward. For the purposes of this report, this scarp feature is termed the ‘eastern flank minor scarp’.

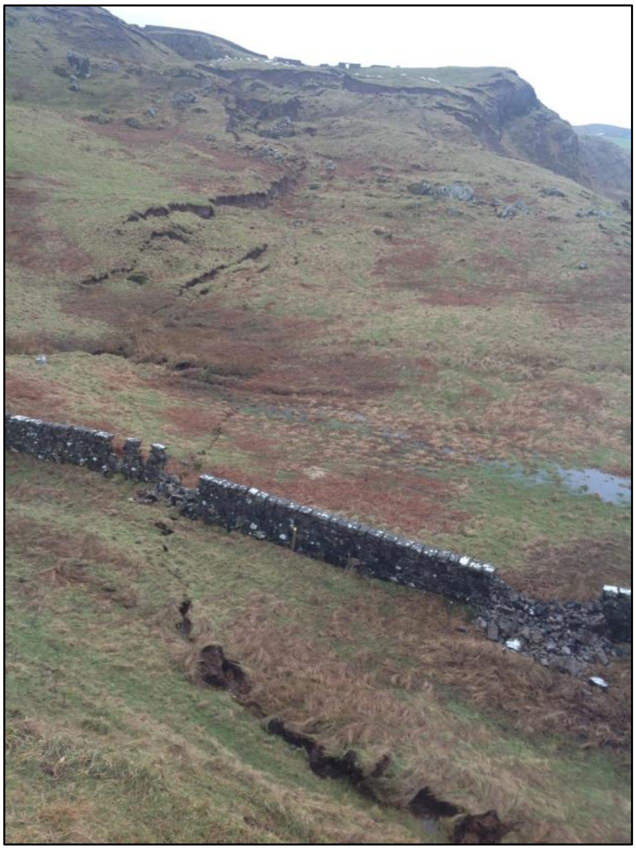

Figure 6: Overview of the eastern flank minor scarp. Photo looking toward the south. Taken by Adam Armour on 5th February 2014.

Observations

1. The main scarp on the eastern flank (Figure 6) shows a normal offset of 1 – 2 m displacement, with evidence for lateral dextral movement of at least 1 m. Two very large boulders, which were originally in line with each other on the c. 2009 aerial photography, are very prominently displaced by at least 1 m in a dextral motion.
2. An antithetic scarp with less displacement (<1 m, facing eastward) has formed approximately 5 m down slope from the eastern flank scarp. This zone resembles a small graben like feature; however, unlike a conventional graben, there is evidence for both extensional and compressional movement within this zone.
3. Additional evidence for lateral movement includes transverse ridges (small thrust zones formed by compressional movement within the body of the landslide) along the bounding edge of the eastern flank scarp.
4. The slip material in this region is typically sandy clay with some angular cobbles and boulders of basalt (CPV-BAOM) and sub-rounded cobbles of sandstone (KNW-SDSL).

3.4 REGION 4 – FOOT OF LANDSLIDE

Toward the foot of the landslide, tension scarps and internal deformation decrease whilst evidence for transtensional and compressional deformation increase, as the mass of the landslide meets lateral resistance provided by a topographic rise at the northern margin of the basin. This rise is interpreted as an older landslide side scarp feature which is probably post-Late Devensian in age.

Observations

1. The height of the eastern flank minor scarp decreases northward down slope, until the scarp is little more than 10 cm in height at the foot of the landslide. Significant offset across a stone wall (Figure 7) suggests a dextral displacement of up to 1 m has occurred in this location during the recent movement event. This feature indicates a transition zone in the landslide between extension (with subsidence within the landslide mass) and compression (uplift of the mass at the toe).
2. There were also newly formed 'sag ponds', with a notable absence of water-loving plants, adjacent to a series of small thrusts forming 'rucked-up' ground, indicating compression at the foot of the landslide (Figure 8).

Figure 7: Displaced stone wall as a result of landslide movement. The wall has moved c. 1 m in a dextral sense of motion and rotated slightly. Photo facing east.

Figure 8: Newly formed sag ponds and thrusts in the foot of the landslide. Springs issuing from the toe. Photo facing west.

3.5 REGION 5 – LANDWARD TOE OF LANDSLIDE

Region 5 is situated at the toe of the landslide, where the toe mass abuts against, and is laterally supported by, a moderately steep southward facing slope (interpreted as the degraded side scarp of an older post-Late Devensian landslide).

1. Where the landslide material (moving north) meets this southward facing slope, the margin of the landslide is marked by a thrust with c. 20 cm of vertical displacement (Figure 9).
2. Above the landward toe, on the pre-existing scarp slope, there are open tension cracks with a normal displacement, also facing southward.

Figure 9: Thrust at landward toe of landslide in Region 5 [NR 62696, 20112]. Photo facing westward.

3.6 REGION 6 – SEAWARD TOE OF LANDSLIDE

The toe of the landslide is exposed along a low coastal cliff, below which it rests on recent beach deposits. It should be noted that there is evidence of active coastal erosion at the toe of the landslide).

Observations

1. In the toe of the landslide, just above the low coastal cliff, there is evidence for slow creep within the landslide. The wall and a fence above the landslide has seen displacement of around 1 m in a dextral motion prior to the recent slip, and has no fresh scarps or indicators of very recent movement, suggesting creep or flow. The recent landslide movement has caused the wall to be displaced by 10 – 20 cm.
2. Immediately above the pebble beach, a cross section through part of the landslide's toe is revealed (Figure 10) exposing highly weathered loose gravel of CPV-BAROCM (Figure 11, which is unlike the debris near the main scarp (Figure 5d) - which is composed of sandy clay with large angular boulders of basalt.
3. Immediately above the toe, there are fresh tension cracks with 'normal' sense of vertical displacement towards the north. The cracks mark the landward extent of active incipient shallow rotational slump failures within the locally over-steepened sea cliff.

Figure 10: Toe of recent landslide, exposed on the coast. Note displaced grass and strandline and recent beach deposits buried by landslide debris. Photo facing south.

Figure 11: Detail of in-situ, weathered basalt (CPV-BAROCM), with wavy grey bands of highly weathered bedrock. This deposit is gravelly and very friable. Photo facing south east.

3.7 REGION 7 – WESTERN FLANK

The westward edge of the recent landslide is defined by a break-in-slope that forms a northward extension of the coastal cliff. Movement of the landslide mass towards the north and north-west has carried the slipped material over the break-in-slope, creating a zone of tension, forming multiple tension cracks and has caused rotation of a large boulder located within the slope. Groundwater was seen issuing from springs within the boulder-dominated deposits, approximately 5 m downslope of the main area of tension cracks associated with the margin of the slip deposit.

3.8 REGION 8 – COINCIDENT FLOW DEPOSIT

Where the landslide mass adjoins the cliffs to the south, a smaller boulder rich debris flow has occurred depositing debris. This flow occurred as landslide material slid to the north-west, meeting the cliff edge, before flowing down the steep slope below the cliffs (see Figure 12).

Figure 12: Left - view from the beach facing eastward. The mud flow is visible coming down the slope to the left of the lines of cliffs. The line of large boulders marks the down slope extent of several previous flows. Right - extent of debris flow material derived from the main landslide mass that has escaped over the coastal slope. Photo facing north east.

3.9 CLASSIFICATION

The movement style is composite, due to the presence of the main compound landslide and the subsidiary debris flow between the main landslide and the cliff (region 8). The type of movement is dominantly translational with minor rotational elements at the head. The maximum depth of movement is unclear, but likely to be deep-seated (with the slip surface >5 m) in the head and main body, becoming shallow (<5 m) in the foot region. The landslide lies within a degraded (and previously unrecognised) post-Late Devensian landslide complex, and the recent failure is therefore a reactivation of part of a dormant relict landslide. The recent landslide has been recorded in the National Landslide Database as Landslide ID19462/1.

4 Interpretations

A record of the instability of the slope caused by the recent landslide has been preserved by several physical features. These features include morphological evidence and damage to man-made structures, described in the previous section. The interpretation of this evidence within the context of the existing mapped landslide enables the following conclusions to be made:

- The landslide event of 4th February is the reactivation of part of a larger relict landslide mass.
- The post Late Devensian landslide possibly formed as a rock slope failure, with evidence for this being large boulders of basalt found within the recent landslide, and also the presence of multiple large boulders on the beach.
- The main component of deformation has been accommodated at the head of the landslide by a mixture of synthetic and antithetic tension scarps, suggesting a rotational type landslide extending down slope as a translational slide.
- The rotational failure occurred in the upper portion of the slip, and then shunted soil and debris downslope, loading the mid-section of the slope, destabilising it.
- The offset of various displacement markers within the field (boulders, stone walls, areas of vegetation, scarp displacement) indicates movement of material in a northerly direction, with north-west and westerly movement along the western margin of the slip.

- The maximum northerly vertical displacement measured at the head of the landslide was 2 – 3 m (measured in displaced scarp material, with a dextral motion), and 1 m at the foot (measured in offset stone wall, also dextral in motion).
- There is a natural supply of water into the crown of the landslide area (behind the main scarp), which, during intense rainfall is likely to have rapidly increased pore water pressure in the slope, causing a significant reduction in effective shear stress. It is likely that this in turn destabilised the thick veneer of slope debris leading to progressive slope failure.
- The occurrence of newly formed springs at the toe of the landslide, and newly formed sag ponds in the foot of the landslide, suggest that the landslide has significantly affected the hydrology of the farmer's field.
- Deep weathering of the CPV_BAROCM basalt, which has weathered down to a gravelly regolith with clay, is likely to have gradually weakened the bedrock material in the lead up to failure. The toe of the landslide is predominantly made up of this gravelly basalt material, and evidence for minor previous movement of this material was seen in the form of old areas of displacement of stone walls and subsurface displacement of old land drains in the beach cliff at the toe.
- The most likely cause of the recent landslide can be attributed to intense heavy rainfall (failure in whole or part due to increase in pore water pressure from a high magnitude rainfall event), but conditioned by the steep nature of the slope, the low residual strength of the pre-existing landslip material, and deep weathering of basaltic volcanic bedrock to gravel with clay seams. Coastal erosion may continue to drive movement through loss of toe weight.

5 Conclusions

A walk over survey of a landslide at High Lossit, Mull of Kintyre [NR 62655, 19980] was conducted following reports of a landslide on the night of the 4th February 2014. The landslide has caused extensive ground deformation in an area of 12 000 sq m of rough grazing land, and occurred after a period of heavy rainfall.

The rural nature of the site means that damage to built structures was minimal, restricted to displacement and local collapse of stone walls. There are no habitable buildings within 500 m of the site and no roads within 300 m of the site. The landslip resulted in deformation of a hillside and degradation of pasture through the formation of scarps, tension cracks, and thrusts within a pre-existing landslide deposit. Changes to drainage resulting from the movement may also locally affect the quality of the grazing land. The displacement and rotation of large boulders in parts of the slip may render them potentially unstable.

5.1 RESEARCH POTENTIAL

This report has established that the 4th February landslide at High Lossit was a reactivation of a much larger and pre-existing landslide system, the movement of which is linked to a combination of high pore water pressure from heavy rainfall and weathering of one of the dominant rock units in the area. The weathering of the CPV-BAROCM basalt produces clayey gravels, which are more likely to be unstable than the angular solid rock boulders of CPV-BAOM found elsewhere in the system.

It is therefore suggested that a more detailed geological and geotechnical investigation could be carried out to identify the causal nature and extent of weathering of the CPV_BAROCM basalt and the landslide deposit and its effect on soil strength and stability elsewhere in the region. A hydrogeological study of the landslide would also be beneficial to better understand the ground water regime within the slope. Analysis of rainfall data from the antecedent period to the failure could also be undertaken to better understand trigger thresholds in this landslide domain. A slope stability model could also be developed to assess the residual stability of the slope and back-analyse the recent failure.

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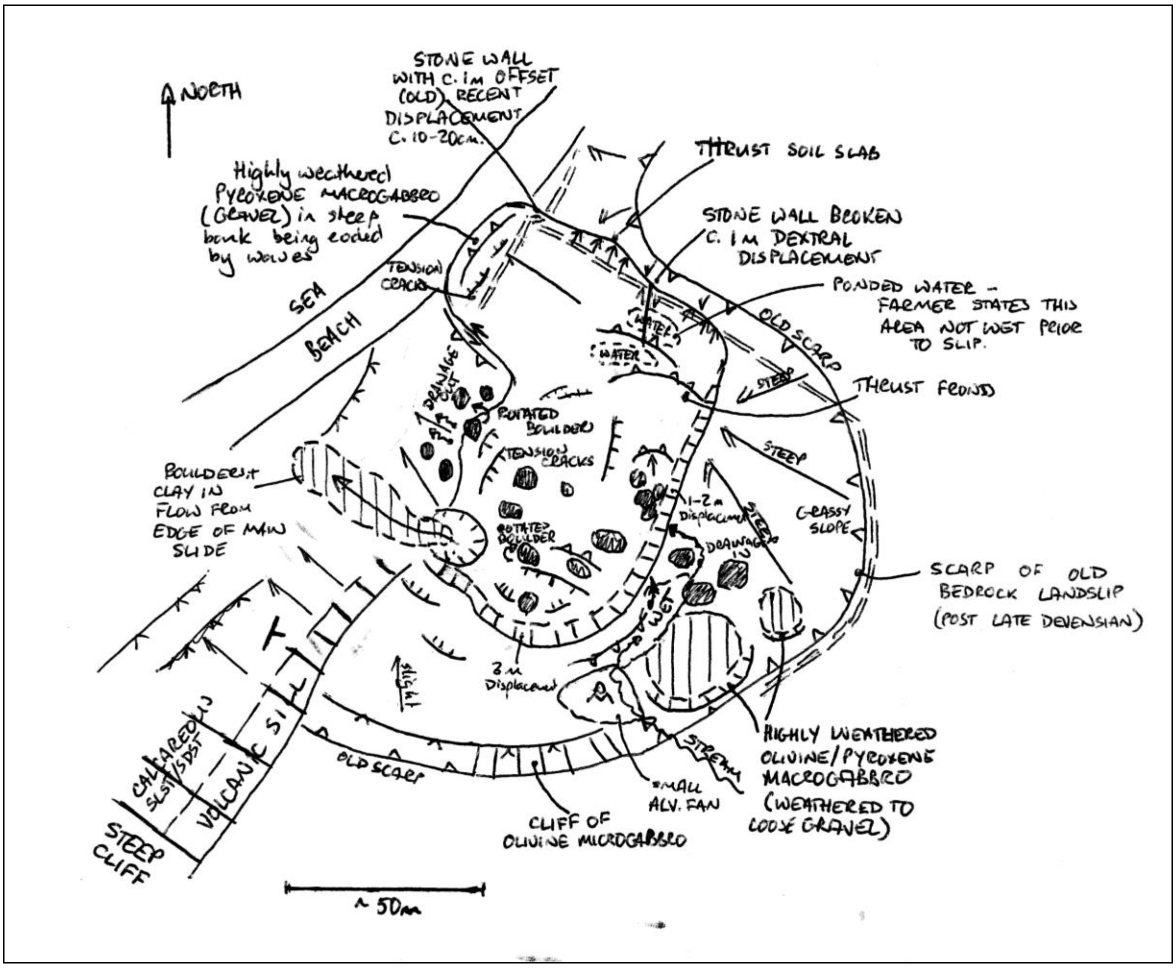
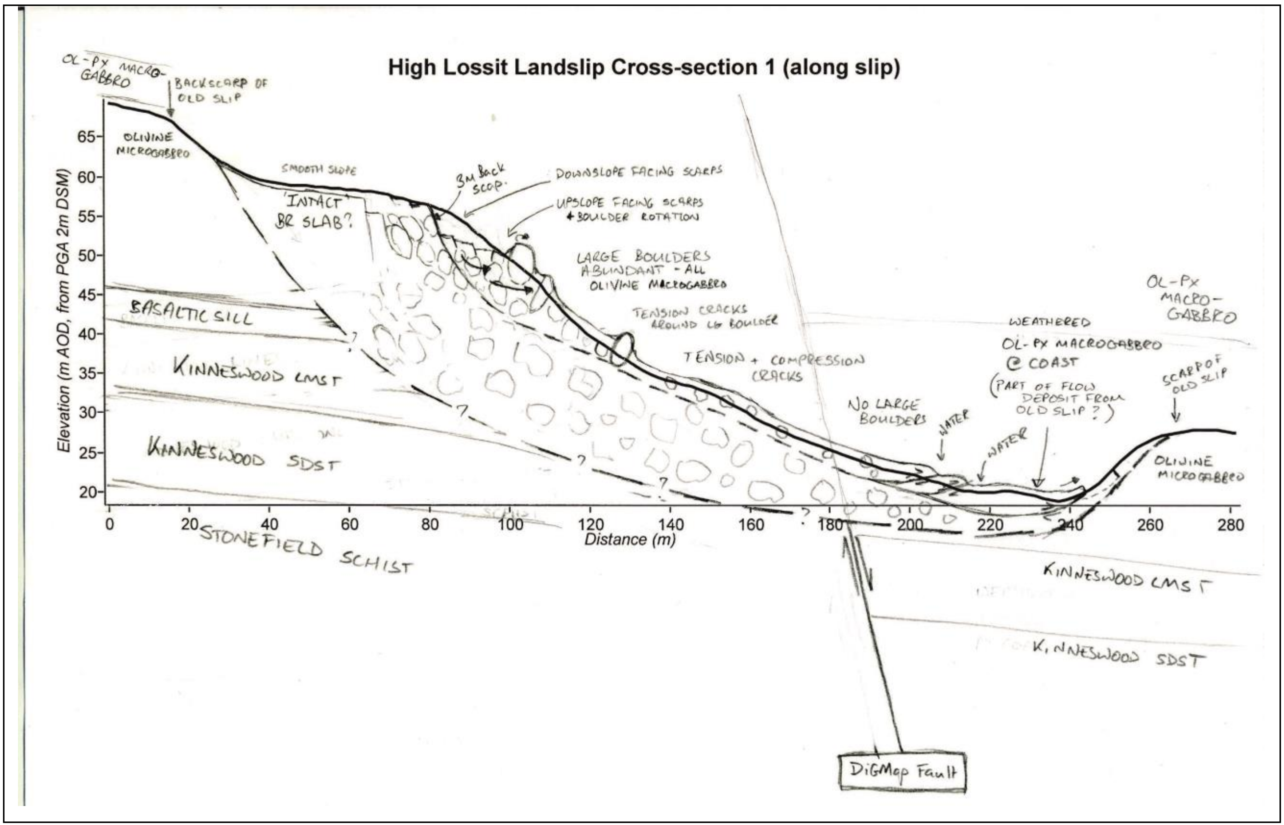
7 Appendix 1

The following figures provide a conceptual sketch map (plan view) and sketch cross section overview of the key components of the 4th February landslide at High Lossit Farm.




High Lossit Landslip Cross-section 1 (along slip)
Elevation (m AOD, from PGA 2m DSM)
Distance (m)
OL-PX MACRO-GABBRO
BACKSCARP OF OLD SLIP
OLIVINE MICROGABBRO
SMOOTH SLOPE
'INTACT' BR SLAB?
3M BACK SCARP
DOWNSLOPE FACING SCARPS
UPSLOPE FACING SCARPS + BOULDER ROTATION
LARGE BOULDERS ABUNDANT - ALL OLIVINE MACROGABBRO
TENSION CRACKS AROUND LG BOULDER
TENSION + COMPRESSION CRACKS
BASALTIC SILL
KINNESWOOD LMST
KINNESWOOD SDST
STONEFIELD SCHIST
NO LARGE BOULDERS
WATER
WATER
WEATHERED OL-PX MACROGABBRO @ COAST
(PART OF FLOW DEPOSIT FROM OLD SLIP?)
OL-PX MACRO-GABBRO
SCARP OF OLD SLIP
OLIVINE MICROGABBRO
KINNESWOOD LMST
KINNESWOOD SDST
DiGMap Fault