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Geological hazards off Cape Lazo, eastern Vancouver Island

J.V. Barrie, K. Douglas, and B. Molloy

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Canada

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Abstract:

Just offshore Cape Lazo, near Comox, British Columbia, a significant seabed geological hazard occurs that has been tentatively termed the Cape Lazo Fault. Nearshore the seabed has been ripped open to form a 25 m deep, 2 km long pit, as part of the possible active faulting process. A limited sub-surface survey undertaken by the Canadian Hydrographic Service in September 2020 reveals the nature of the scarp in the ocean floor and provides new insights into the possible hazard for the Department of National Defense Comox site just inshore of the Cape.

Introduction:

Located 4.0 km from Cape Lazo, Comox, British Columbia (Figures 1 and 2), there are several morphological features observed from multibeam swath bathymetry that may be related to marine hazards and, in particular, active crustal faulting. The main features are a northwest – southeast trending scarp, possibly the surface expression of an active crustal fault and a linear series of pockmarks or pockmark chain (gas escape features) that often reflect the trace of an active fault (Figure 2).

Initial interpretation of these features was undertaken based on Geological Survey of Canada archive data collected during regional surveys of this portion of the Strait of Georgia in 2000 and 2005. However, a focused sub-surface study with an objective to clarify if the morphogenic processes are related to crustal faulting was needed. Consequently, a preliminary seismic-reflection survey was designed to further explore stratigraphy for evidence of crustal active faulting and undertaken in September 2020. Our objective is to present an initial interpretation of these seabed features based on these two data sets. This will then contribute to the planning of a more extensive Geosphere Huntec seismic-reflection survey to be carried out in the near future by the Geological Survey of Canada.

To determine whether there is evidence for active faulting near Cape Lazo we adopted the following criteria. The criteria includes: 1) the juxtaposition of acoustic characteristics such as displaced well-layered reflections; 2) truncation of layered reflections against acoustically transparent or chaotic reflections; 3) deformed reflections along a vertical or slanting plane; and 4) hyperbolic diffractions associated with truncation of layers (i.e., a probable fault plane), or a combination of one or more of the above criteria.

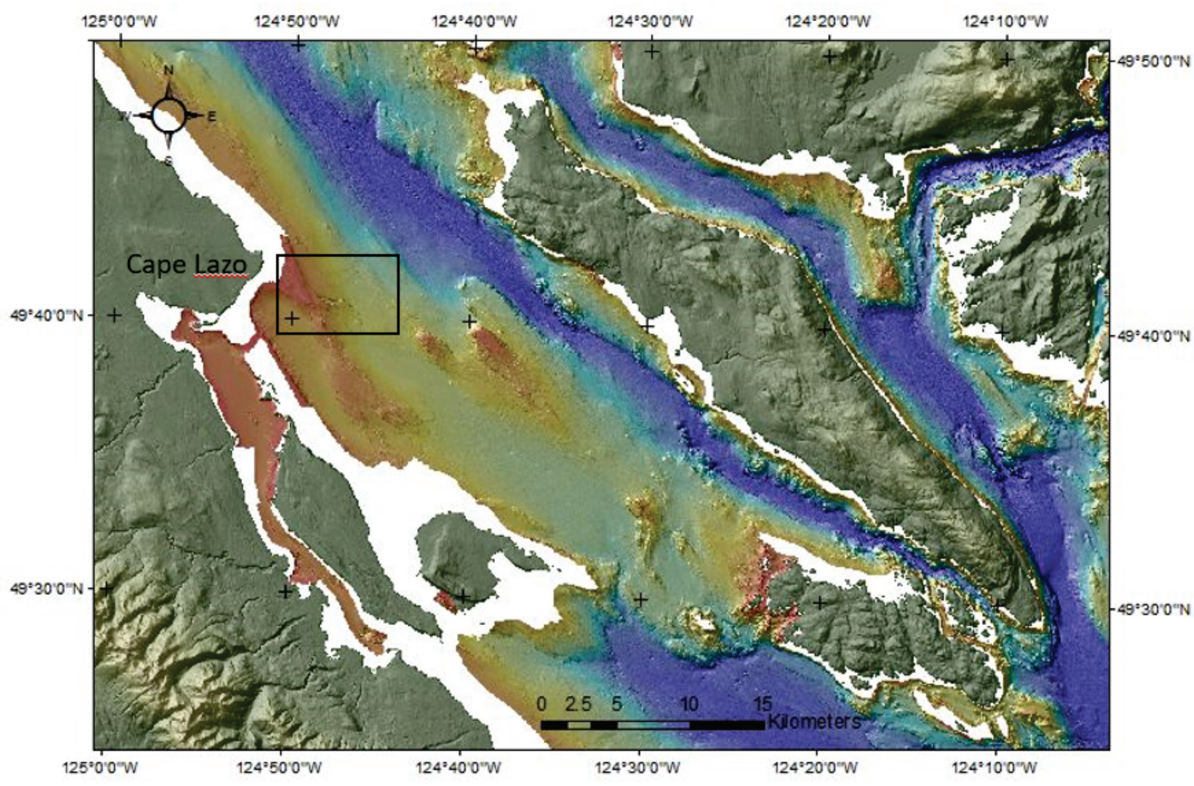

Figure 1. Location of the area of interest off Cape Lazo, within the west-central Strait of Georgia. Seafloor imagery based on multibeam swath bathymetry.

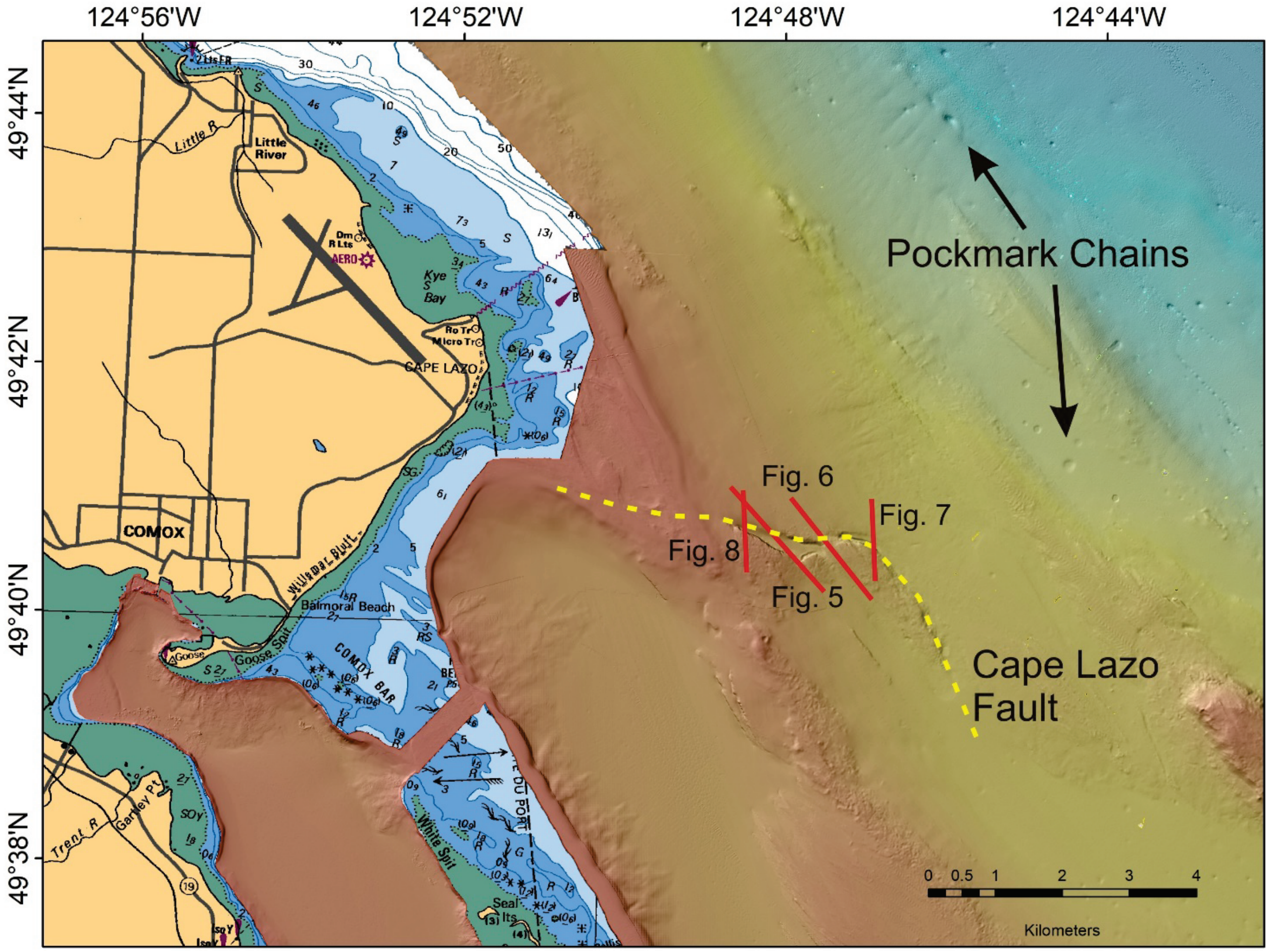

Figure 2. Multibeam swath bathymetry image from Cape Lazo region that illustrates morphology related to potential geohazards including the Cape Lazo Fault and linear northwest – southeast trending pockmark chains. Location of Figures 5, 6, 7, and 8 are shown.

2020 Survey:

A limited CHIRP 3.5 kHz seismic-reflection survey was designed (Figure 3) to further explore stratigraphy for evidence of crustal active faulting. The survey was completed in September 2020 by the Canadian Hydrographic Service for the Geological Survey of Canada, using the survey vessel *Otter Bay*. Though the CHIRP system is not ideal for identification of active faults, due to its limitation in penetration, the preliminary survey provides high-resolution profiles that are correctly orientated to the structural features.

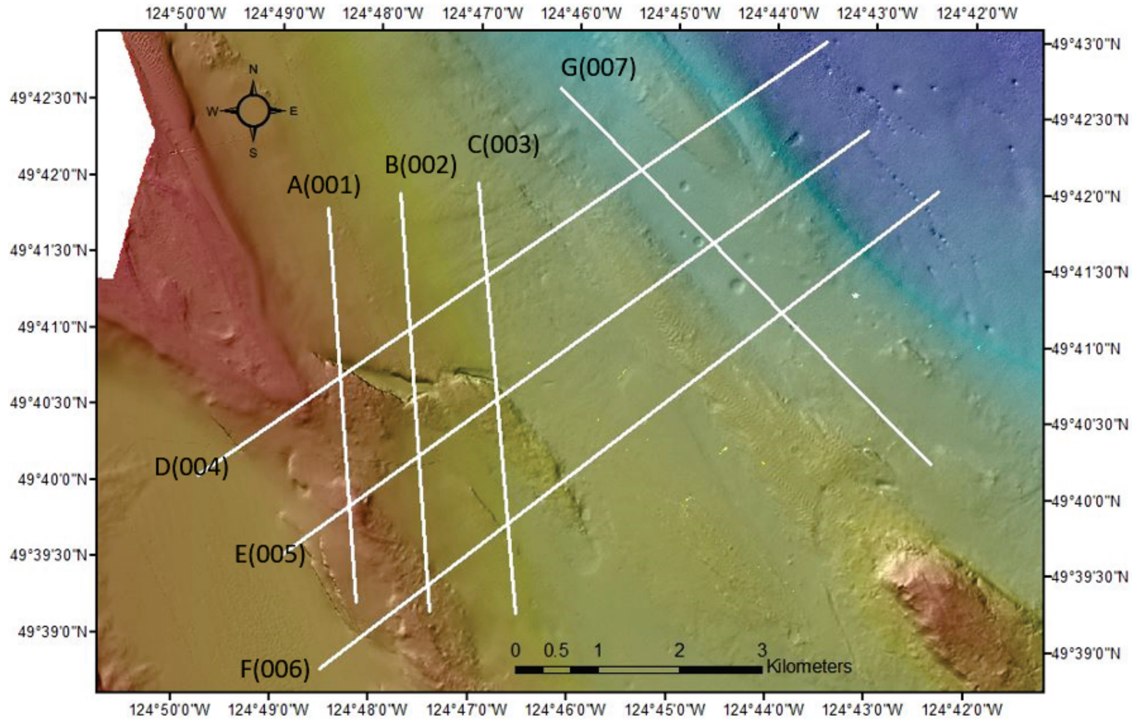

Figure 3. CHIRP 3.5 kHz seismic-reflection survey undertaken in September 2020 by the Canadian Hydrographic Service.

Results:

The surface expression of the scarp feature is ~2 km long with a near vertical north facing wall, and 15 to 25 m of relief between the top of the scarp and its base. Visuals collected during an ROV dive in 2005 reveal bedrock outcrop on a clean scarp wall (Figure 4). Multibeam bathymetry also shows an adjacent surface depression north of the scarp wall, a steeply dipping south facing wall, all giving the appearance of a rift (seabed pull-apart). Video data from the ROV dive clearly display fissures in the sea floor within the base of the scarp feature (Figure 4).

Figure 4. Images collected near scarp feature during an ROV dive in 2005 (2005011PGC ROV Station 1, Photos 1 and 2, National Expedition Database ((https://ed.gdr.nrcan.gc.ca/index_e.php)). Left image shows seafloor with fine grained sedimentation - note the presence of fissure. Right image shows bedrock outcrop on wall of scarp.

Sub-bottom seismic-reflection survey lines from previous marine surveys in the region by the Geological Survey of Canada in 2000 and 2005 are shown in Figures 5 and 6. Deformation can be observed in Figure 5 within both the south facing and north facing walls. In both Figures 5 and 6 sediment fill is draped within the depression between both walls.

Pockmarks are circular depressions within the seafloor, usually formed by escaping gas, that are often associated with active faults (Barrie and Hill, 2004). Consequently, the surface expression of pockmark features located 3 km east of the Cape Lazo scarp feature is also of interest (Figure 2). Multibeam bathymetry shows a linear northwest - southeast alignment of 6 pockmarks over 3 km. The largest of these pockmarks are roughly 100 - 150 m in diameter, with relief of ~3 m between pockmark depression and seafloor. Archived sub-bottom seismic collected near the pockmarks have poor resolution of the sub-surface and does not show any sequence stratigraphy as a basis for interpretation of their origin.

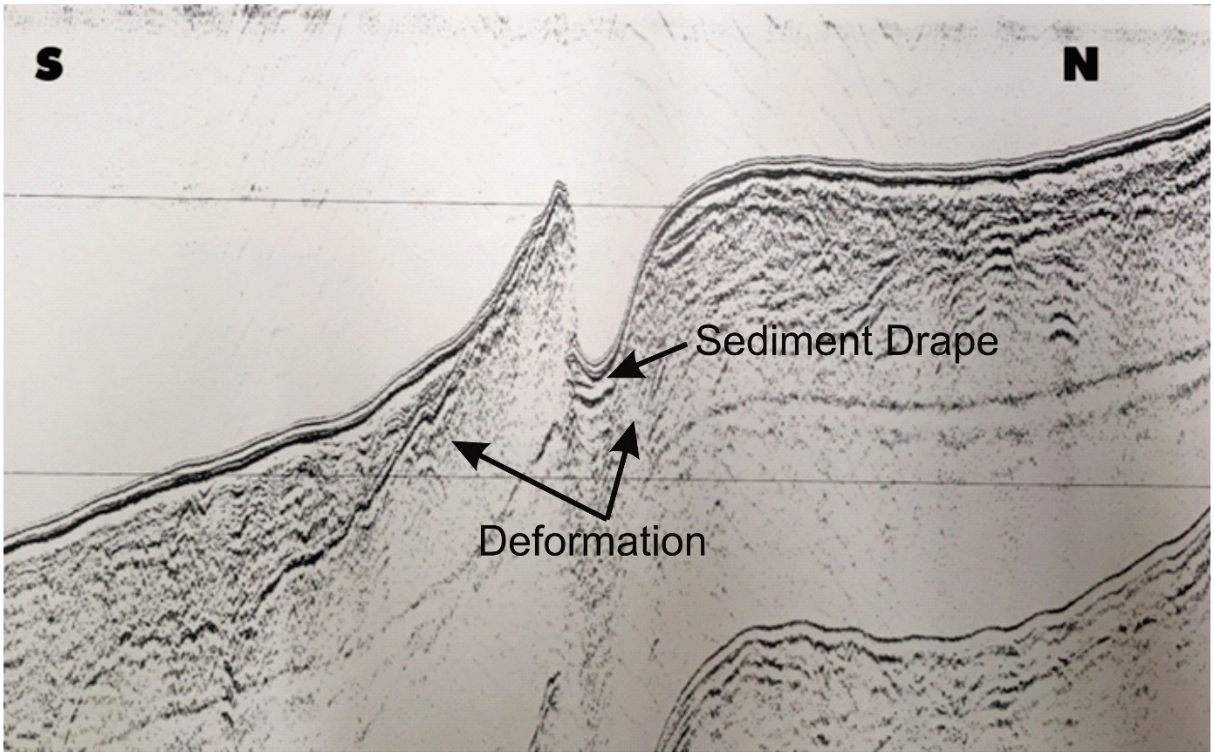

Figure 5. Sub-bottom seismic-reflection profile collected in 2000 over scarp feature. Note deformation associated with north facing and south facing walls, as well as sediment draped in depression. Profile location shown in Figure 2.

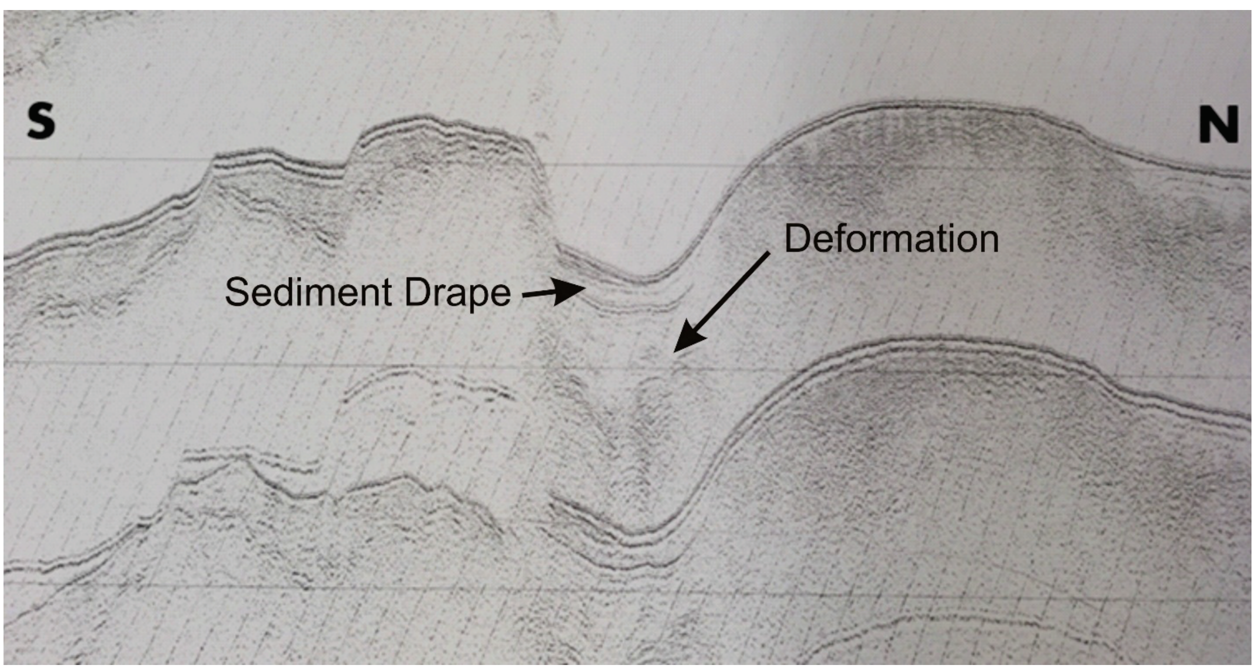

Figure 6. Sub-bottom seismic-reflection profile collected in 2005 over scarp feature (see location Figure 2). Note deformation in north facing wall and sediment draped in depression

Though the September survey was limited, there is a strong indication of active fault deformation along the northwest – southeast trending scarp. For example, a survey line running normal to the structure shows both displaced reflectors and deformation along a steeply dipping fault plane (Figure 7). Another cross-section normal to the scarp displays an almost vertical face with deformation and displacement of reflectors (Figure 8), all strong indications of an active fault.

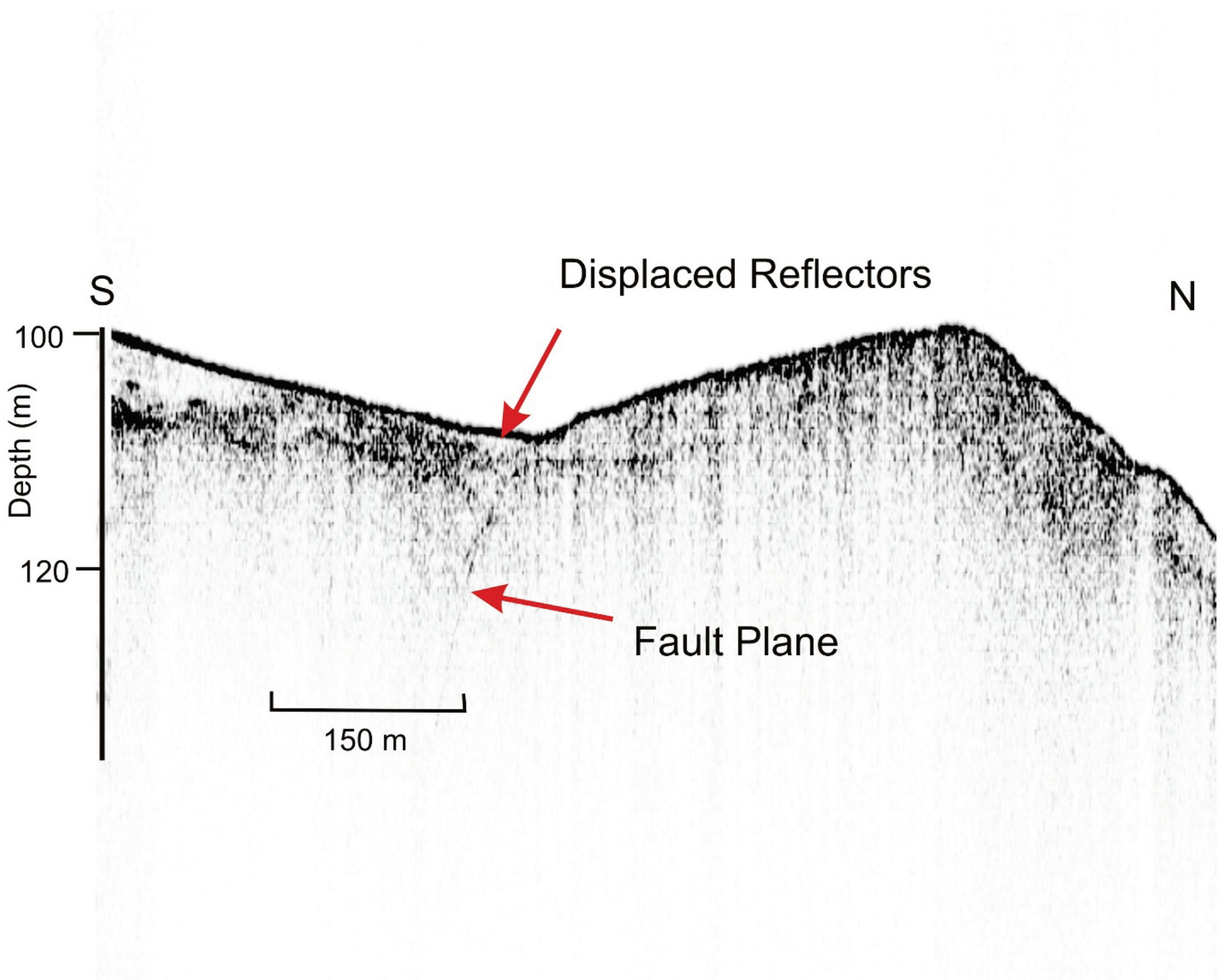

Figure 7. CHIRP seismic-reflection profile across the Cape Lazo Fault showing the near surface deformation and the steeply dipping fault plane. Profile location shown in Figure 2.

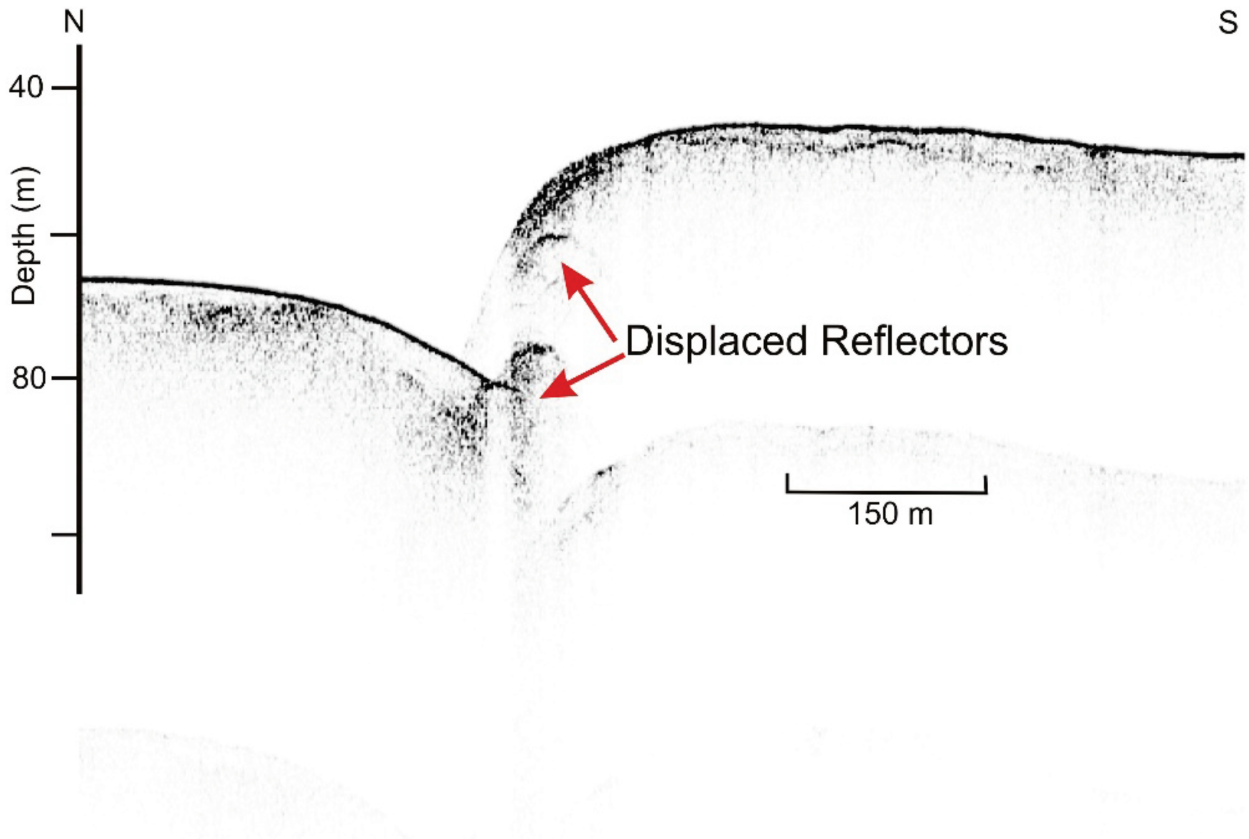

Figure 8. CHIRP seismic-reflection profile across the scarp that forms part of the Cape Lazo Fault, displaying the near surface deformation and near vertical south wall. Profile location shown in Figure 2.

Discussion:

At present, we do not have the sedimentological data to date displaced beds, but all reflectors have been deformed, suggesting movement in the recent geological past.

Whether this fault, which we tentatively name the Cape Lazo Fault, is a major fault, or more likely a splay or conjugate fault off a fault zone further into the Strait of Georgia cannot be determined with this limited data set. The structural trends with pockmarks seen in the multibeam swath bathymetry, just to the east of the Cape into the Strait of Georgia, may be part of a significant fault zone that trends with the axis of the Strait. Regardless, the data does clearly define a significant geological hazard that is adjacent to or even underlies the present Department of National Defense Comox facility.

Summary and Recommendations:

Clearly, a pattern of seabed deformation strongly indicates active faulting just offshore the region of Cape Lazo. To assess seismic risk a detailed survey using modern seismic-reflection techniques along with core sampling and age determination is required to understand the structural framework of this part of the central Strait of Georgia. In 2021, a *CCGS Vector* marine survey is planned, using a stronger seismic-reflection system than could be achieved with the CHIRP 2020 survey. The proposed Geosphere Huntec system will provide significantly greater penetration into the seabed, with the aim of producing a clearer picture of fault deformation at depth. We plan to undertake several lines over a larger area to understand the full extent of the fault system. Spatial extent is an indicator of seismic potential, as longer faults tend to be associated with higher magnitude seismic activity. The *CCGS Vector* is also equipped with a high-resolution multibeam echosounder that includes water column capability. If the pockmarks are actively venting, we should be able to image and quantify this activity.

Reference:

Barrie, J.V. and Hill, P.R., 2004. Holocene faulting on a tectonic margin: Georgia Basin, British Columbia, Canada. Geo-Marine Letters, 24, 86-96.