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GEOHAZARD INFORMATION AND PERMAFROST CHARACTERIZATION SURVEYS ALONG THE YUKON-ALASKA HIGHWAY CORRIDOR

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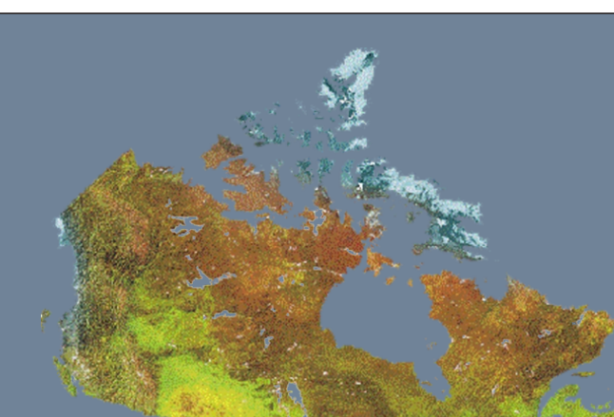


INTRODUCTION

This project addresses knowledge gaps related to permafrost conditions, landslides, and earthquake hazards along a potential pipeline route within the Alaska Highway Corridor in the Yukon Territory (YAHC). Essential and critical baseline geoscience information and knowledge is being generated, and techniques and models developed to support a) pipeline design, b) environmental assessment and regulatory processes, and c) development of environmental monitoring and management programs to ensure environmental effects are minimized. Reconnaissance fieldwork was carried out in summers 2011-12 in the study area (Fig. 1). The objectives of this poster presentation are to show results from 1) Permafrost characterization, 2) Landslide distribution, 3) Qualitative landslide susceptibility mapping in permafrost terrain, and 4) Denali fault investigations.

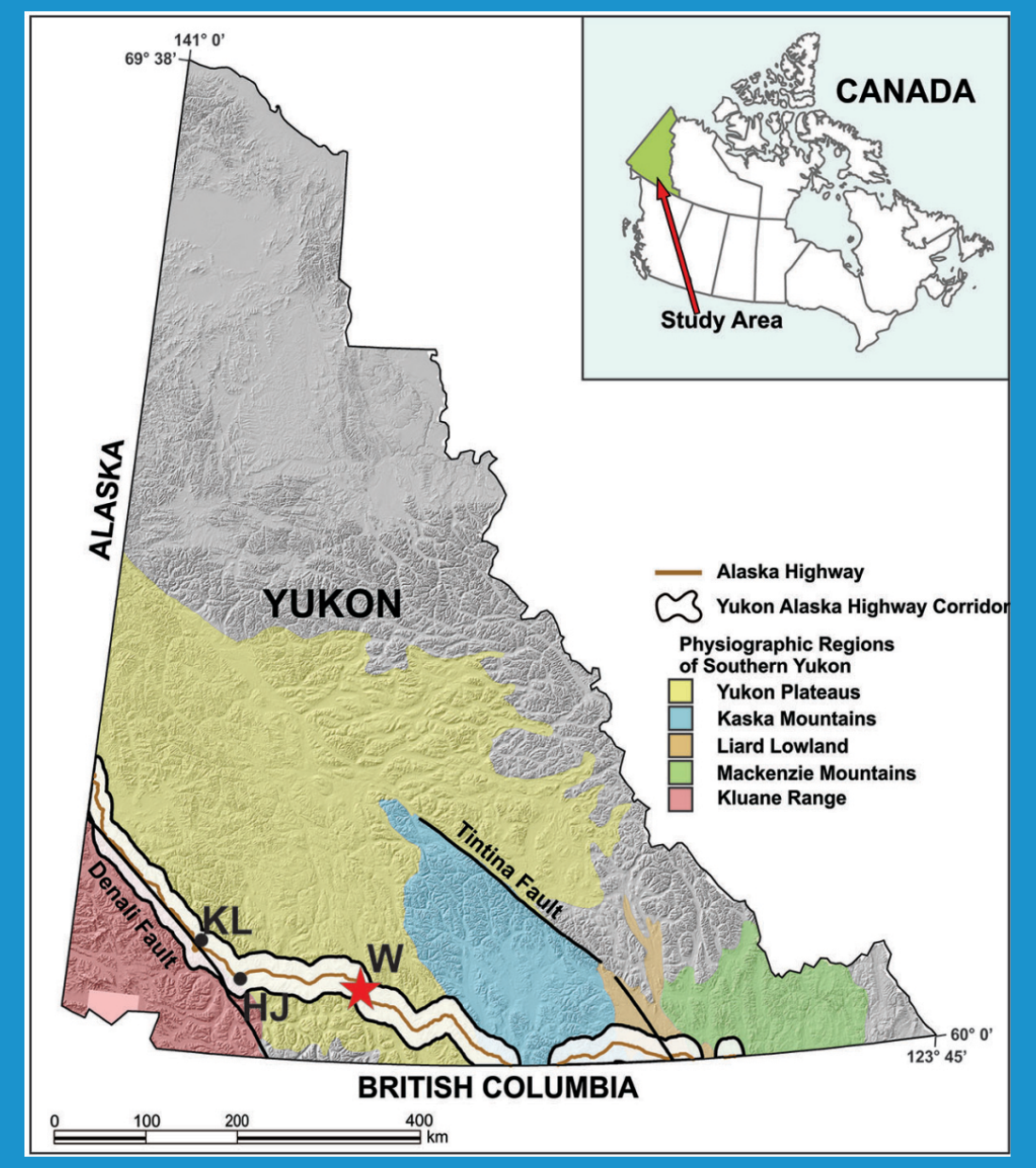


Figure 1. Location map of the Yukon Alaska Highway Corridor showing physiographic regions, faults, and geographic reference points (Huscroft et al., 2004). KL=Kluane Lake, HJ= Haines Junction, and W=Whitehorse.

METHODOLOGY

Below is a description of the methods used for the four activities

1) Permafrost characterization:

Most of the existing information on ground thermal conditions was collected over 30 years ago. Between 1978 and 1982, the Geological Survey of Canada measured ground temperatures in a suite of boreholes along the corridor. In summer 2011 efforts were made to find these boreholes and eight were instrumented with temperature cables and loggers to acquire information on current ground thermal conditions (Fig. 2). Temperature data were acquired from the loggers in summer 2012 and for most sites a data record of one year is now available to describe the ground thermal regime. Electrical Resistivity Tomography (ERT) was also utilized to characterize the spatial variation in permafrost conditions at the boreholes sites.

2) Landslide inventory and other ground hazards:

Landslides were identified and compiled from air-photo interpretation. Fifty-one inventory maps were produced at the 1:50,000 scale (Blais-Stevens et al., 2011a) as well as a landslide distribution map (Fig. 3). All data products are publicly available. In addition, high resolution satellite imagery is being investigated as a method to update and improve the landslide inventory.

3) Landslide susceptibility methods and models:

Landslide susceptibility maps were initially generated for debris flows and rock fall/rock slides along the YAHC (Blais-Stevens et al, 2011b; 2012). Qualitative heuristic landslide susceptibility models were developed and modified from Lyle (2006) for active layer detachment slides (ALD; Lewkowicz and Harris, 2005) and retrogressive thaw slumps (RTS) (Fig. 4.) through incorporation of an improved permafrost probability model (Bonnaventure et al., 2012).

Active Layer Detachment susceptibility equation:
$SI=0.25\,P + 0.10PISR + 0.25\,San + 0.15LC + 0.25\,SG$ (1)

Retrogressive Thaw Slump susceptibility equation:
$SI=0.25\,P + 0.05PISR +0.20\,San + 0.15LC + 0.25\,SG + 0.10DD$ (2)

Where P=Permafrost probability, PISR= Potential incoming solar radiation, San=Slope angle LC=Land cover SG=surficial geology, and DD=Distance to drainage.

Hence, each pixel (25 m x 25 m) represented a sum of all the weighted parameters and their rating in the form of a susceptibility index (SI). Validation of these models is on-going.

4) Denali fault investigations:

Field investigations were carried out at Quill Creek and Duke River to look for ground disturbances related to pas seismic activity and compare with previous findings (Sietz et al, 2008).

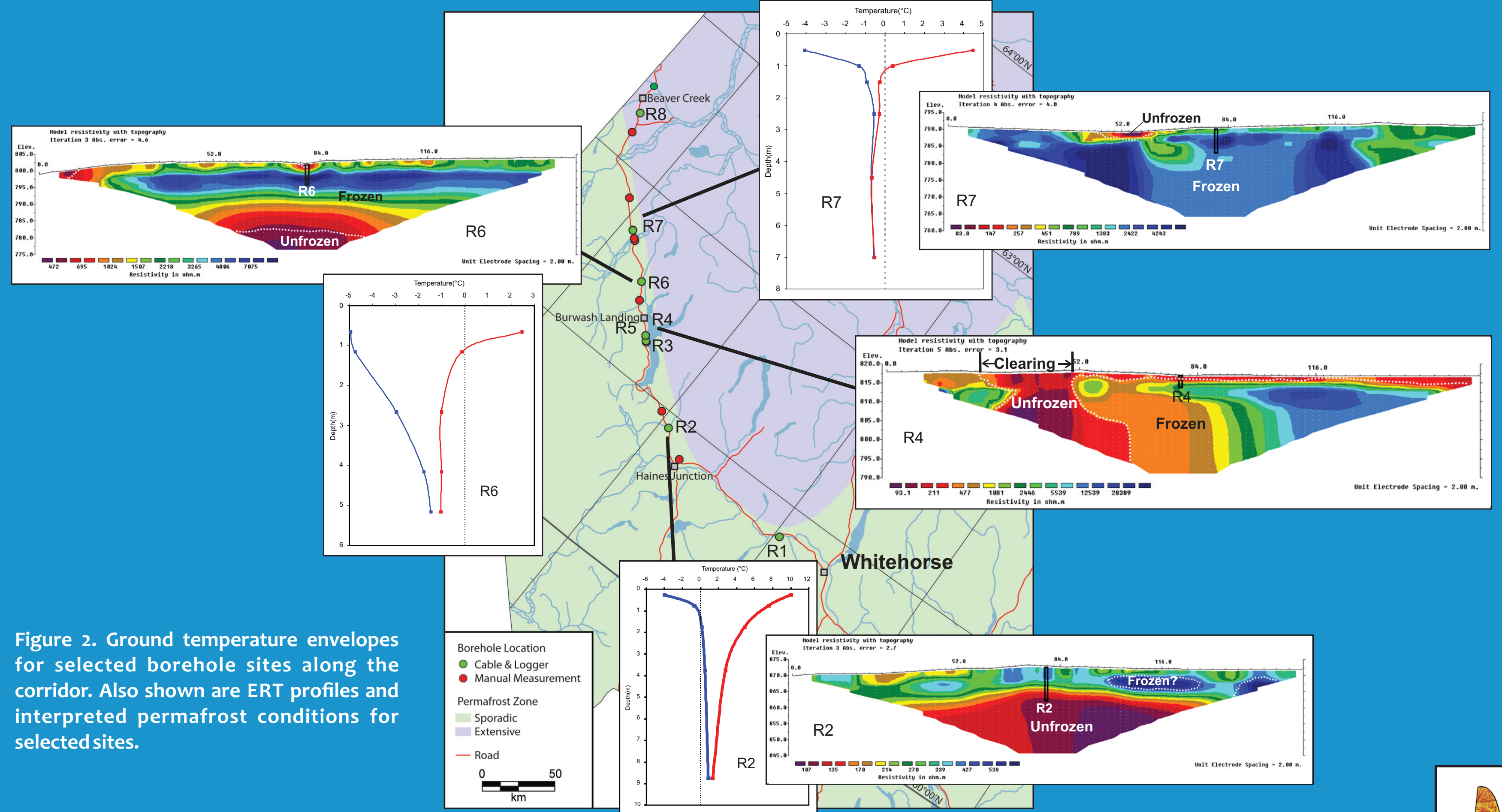


Figure 2. Ground temperature envelopes for selected borehole sites along the corridor. Also shown are ERT profiles and interpreted permafrost conditions for selected sites.

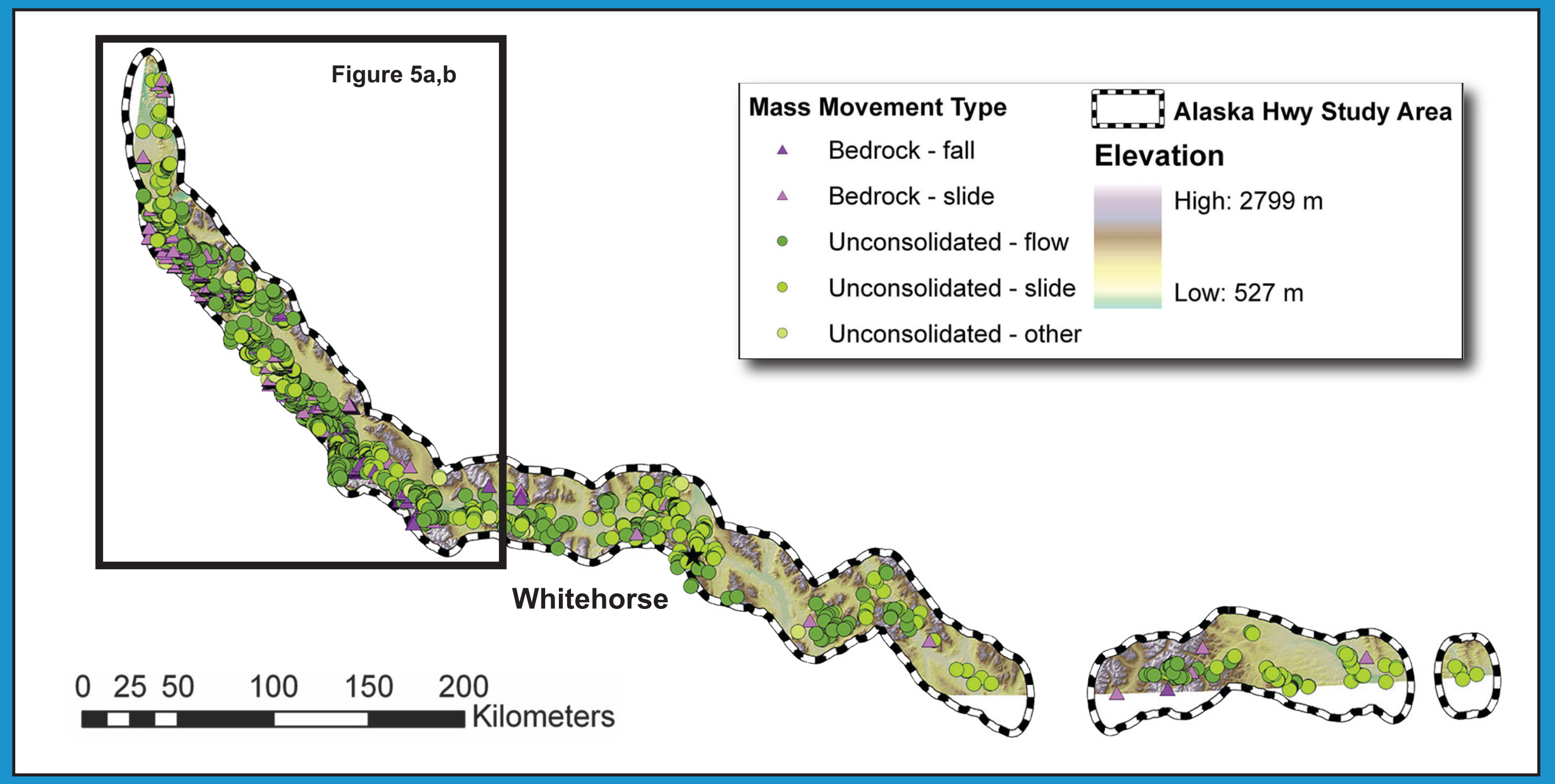


Figure 3. Map of landslide distribution displaying landslides triggered in bedrock (purple triangles) and those triggered in sediment (green circles). A total of 1743 landslides were identified. Black star indicates location of Whitehorse. Rectangle indicates location of Figures 5a and b.

RESULTS

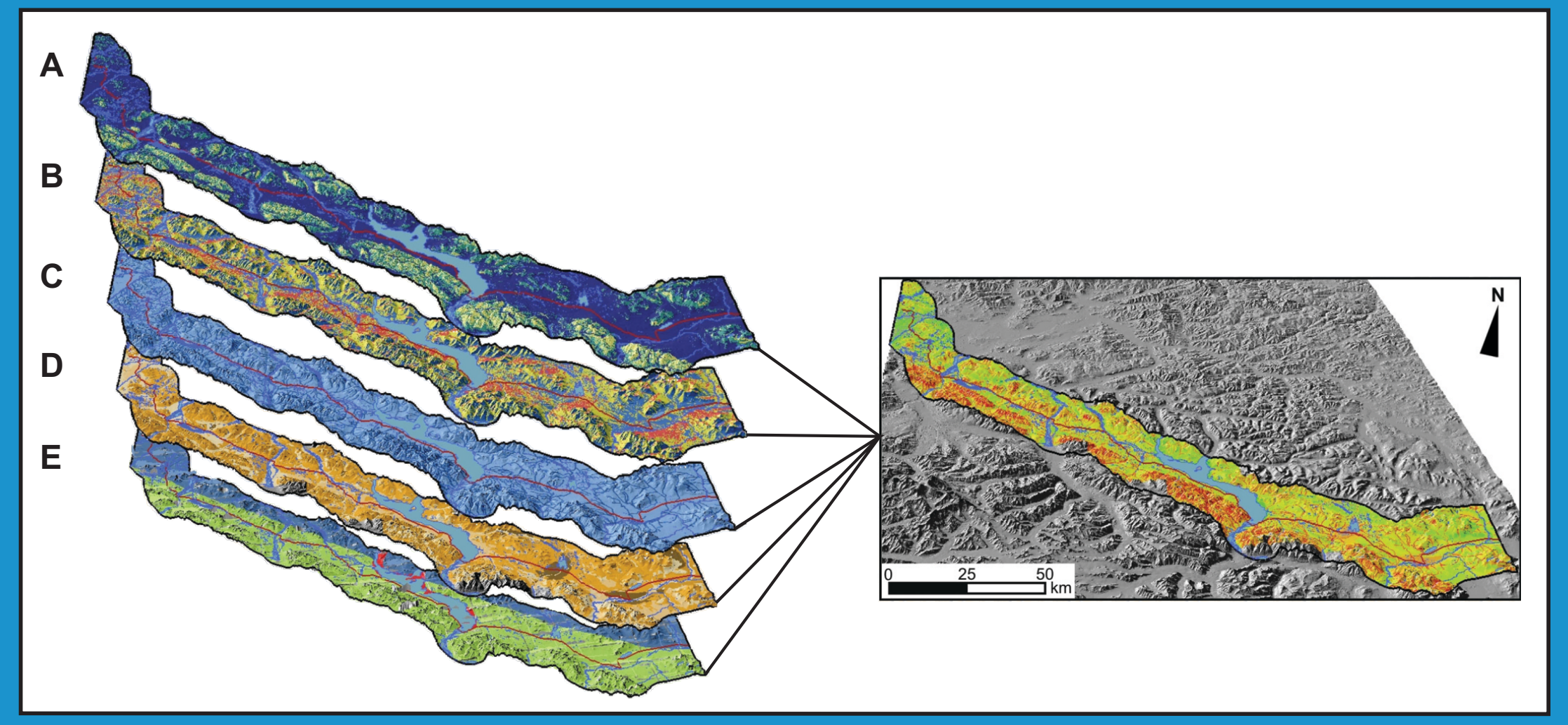
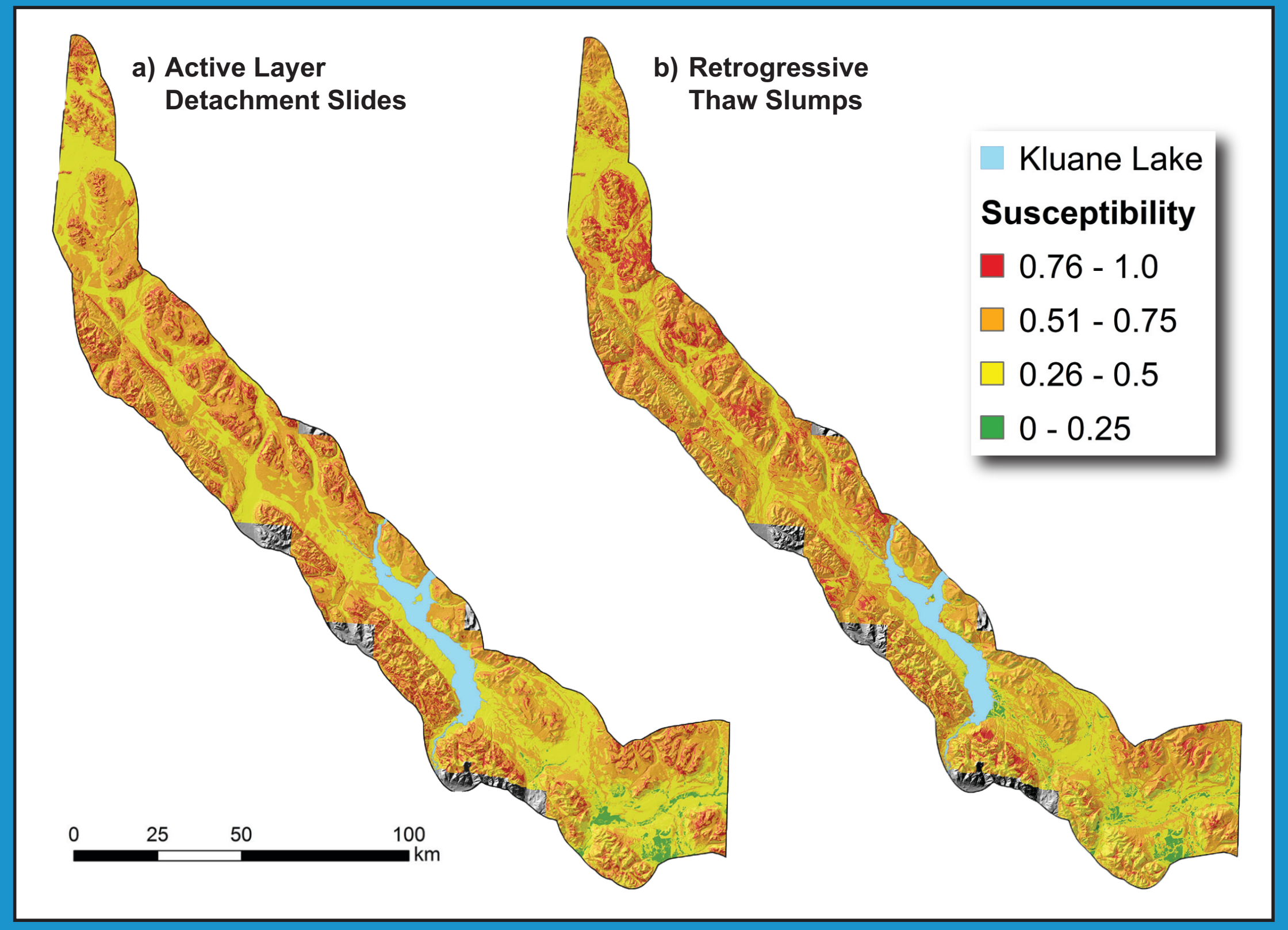


Figure 4. Diagram showing method of incorporating weighted data layers (left) into one susceptibility map (right).



Figures 5. Northern portion of the Active layer detachment susceptibility map (a) and Retrogressive thaw slumps susceptibility map (b) draped over the relief. The maps include Kluane Lake as a reference point and display low to high susceptibility indices. These were divided using defined equal breaks. Figures 7 and 8 show active layer detachment slides and retrogressive thaw slump, respectively.

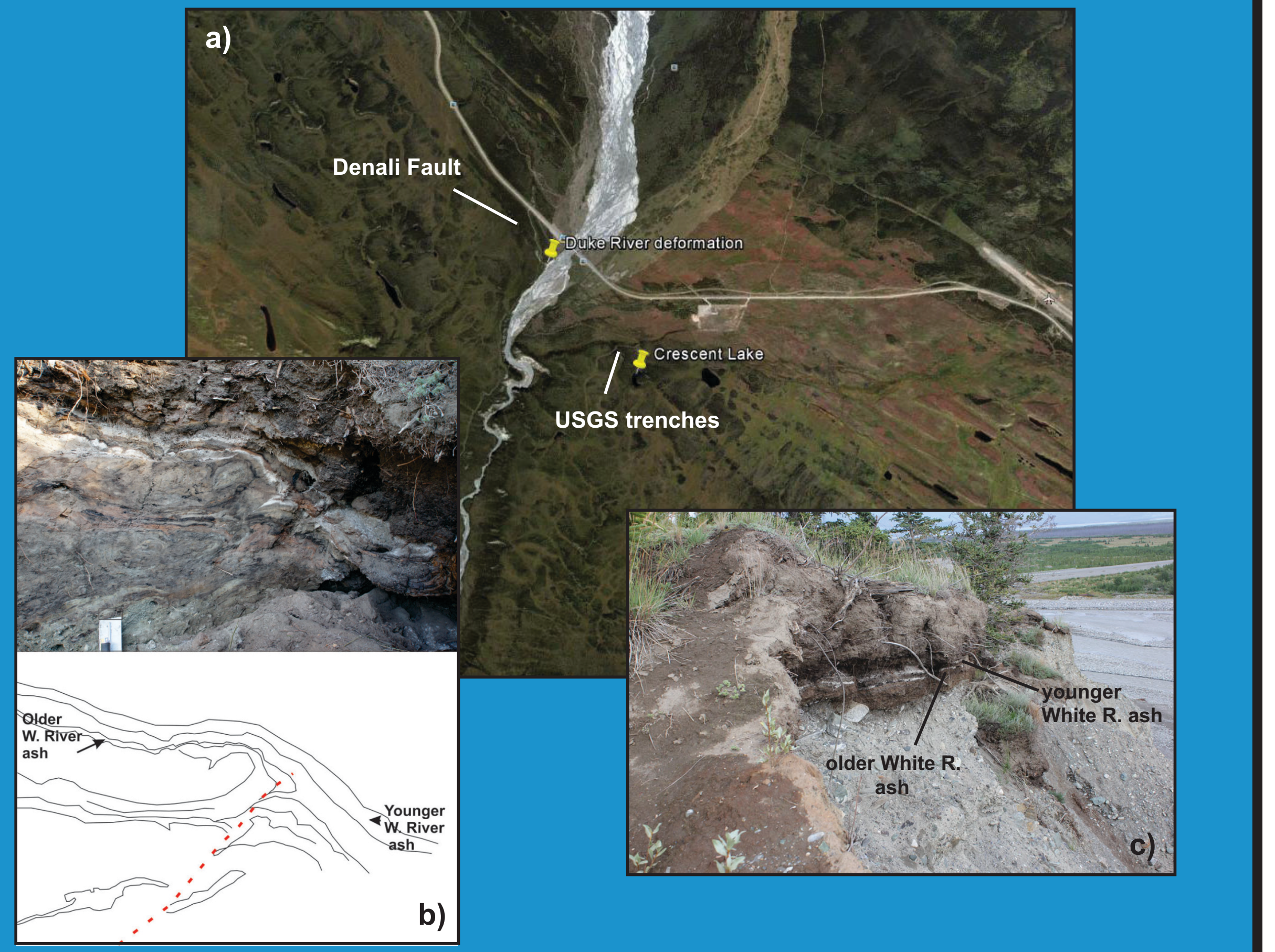


Figure 6. a: Google earth image displaying Duke River deformation site and USGS trenching sites located a few metres from Crescent Lake (Seitz et al., 2008). b: Photo taken right underneath the fault trace at the north bank of Duke River. The upper younger White River tuff is undisturbed and drapes the topography. The older White River tuff is disturbed and faulted. Red dashed line indicates interpreted fault trace. c: Photo taken standing on top of the fault trace on the north bank looking towards Duke River. It is showing both younger and older undisturbed volcanic tuffs.

Figure 7. Active Layer detachment slides (spring/summer 2012) taken north of Quill Creek, south of Donjek River on the eastern slope of the Kluane Ranges. Photo by Joe Koch.

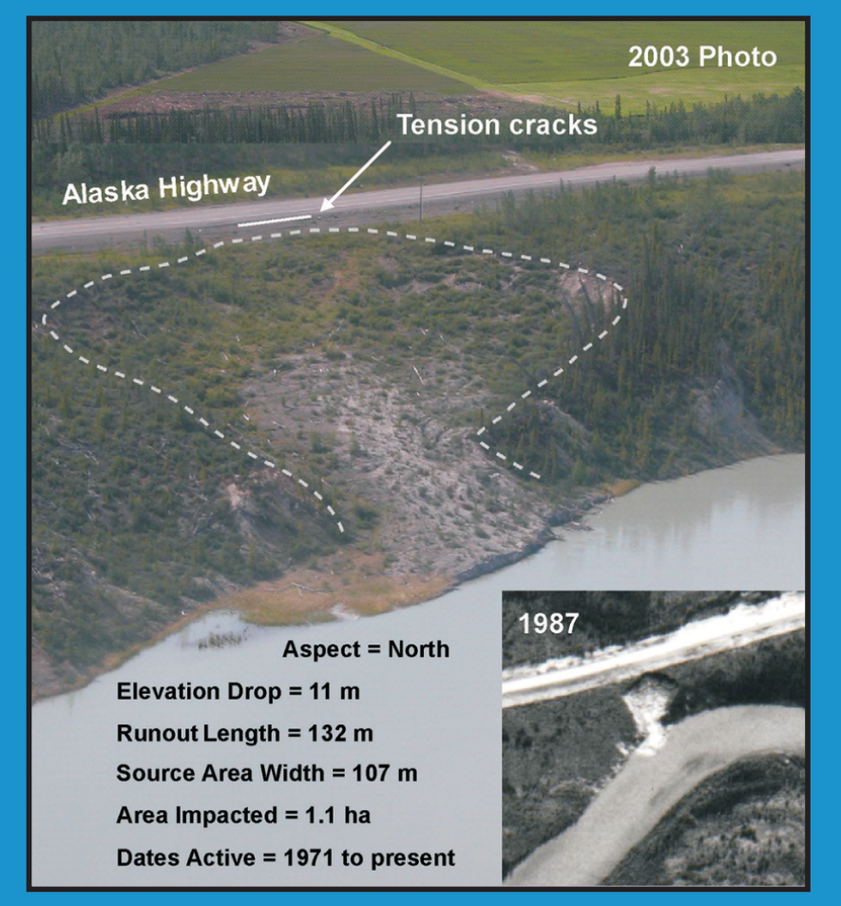


Figure 8. Retrogressive thaw slump near the Alaska Highway on the banks of the Takini River. Slump has been active since the early 1970s. Photo by Panya Lipovsky.

DISCUSSION and CONCLUSIONS

The initial information from the temperature cables (Fig. 2) indicates that ground temperatures are generally warmer than about -1.5°C with unfrozen conditions existing at the two sites closest to Whitehorse. An initial comparison of the 2012 ground temperatures with those measured in the late 1970s indicates that some warming may have taken place in response to increases in air temperature. More detailed analysis and modelling is in progress to better quantify the change in ground thermal regime.

Results from ERT surveys (Fig. 2) indicate that permafrost is generally less than 10 m thick or absent at most sites. However, closer to the Alaska border, permafrost can be >20 m thick. The surveys also indicate that where areas were previously cleared, permafrost has degraded.

The main landslide types from the inventory were: debris flows and slides, earth slides/flows, rock slides, rock falls, retrogressive thaw flows and active layer detachments. Landslide distribution reflects dominant landslide activity in unconsolidated sediments (Fig. 3). The use of recent high resolution satellite imagery is currently being assessed to update the landslide inventory.

The qualitative heuristic method used (Fig. 4) has provided preliminary regional assessment of active layer detachment slide and retrogressive thaw slump susceptibility (Figs. 5a, b) Validation of the models is on-going.

Preliminary investigations of Denali fault along Duke River (Fig. 6a) indicate that faulting took place between deposition of the older White River volcanic ash (1900 yrs BP) and the younger upper ash (1200 yrs BP; Lerbekmo, 2008). This is shown in photo taken (Fig. 6b) right underneath the fault trace and corroborates with some of the findings by Seitz et al. (2008). Everywhere else along the river section, the volcanic lash layers are undisturbed (Fig. 6c). Moreover, trenching further north along Quill Creek shows no disturbance in both volcanic ash units. If the disturbance is caused by paleoseismic activity, it would indicate that paleoseismic movement/disturbance along the Denali fault is not uniform.

In this proposed pipeline corridor, slope failures are prominent and landslide susceptibility maps indicate the potential for more landslide activity. Most landslides that could affect the pipeline corridor have been initiated in steep bedrock terrain. However, landslides triggered in terrain underlain by warm permafrost should also be considered during development of pipelines.

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