Determining Uplift In the Surnadal River Valley through Cosmogenic Nuclide Dating and the Stream Power Model

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Is it possible to use cosmogenic nuclide dating as well as the stream power model in order to explain why this seemingly 'passive' margin in southwestern Norway displays features commonly associated with active rifting?

I. Background/Motivation:

Southwestern Norway is a topographically diverse area shaped by both glacial and tectonic forces. The Surnadal valley is a river valley that displays low relief topography on one side of the river while the other side displays dramatic river gorges, similar to that typically displayed in areas of active uplift. However, the Norwegian margin is a passive plate boundary thought to no longer have active faulting (Osmundsen and Redfield 2011). Located within our area of study is the Møre-Trøndelag Fault Complex (MTFC) (Figure 1) which is a system of known faults spanning across the southwestern corner of Norway. One hypotheses suggests the MTFC has been reactivated thus causing the high relief, high elevation topography seen within the area (Redfield and Osmundsen 2009).

However other hypotheses about the region suggest the topography could be a result of differential glacial carving or possible isostatic rebound as a result of post-rifting erosional processes (Steer et al., 2012). These conflicting hypotheses have caused a lot of disagreement among researchers and raised the question of whether or not this continental margin can truly be considered a 'passive' margin. My research will address the topic of whether or not uplift, which induces erosion, is higher on one side of the valley versus the other. If this hypothesis is supported, I will then focus on whether or not this higher uplift is a result of uplift on the fault itself or if it can be contributed to other.

II. Area of Study

Figure 1

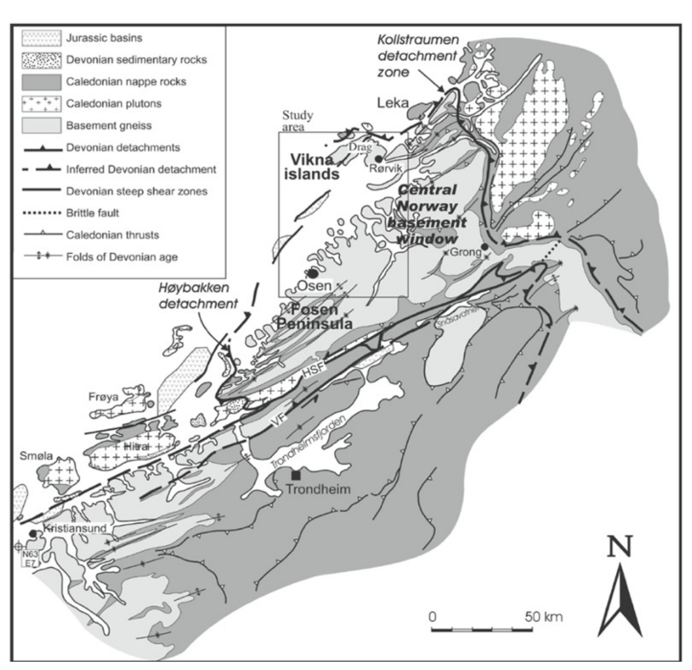


Figure 2

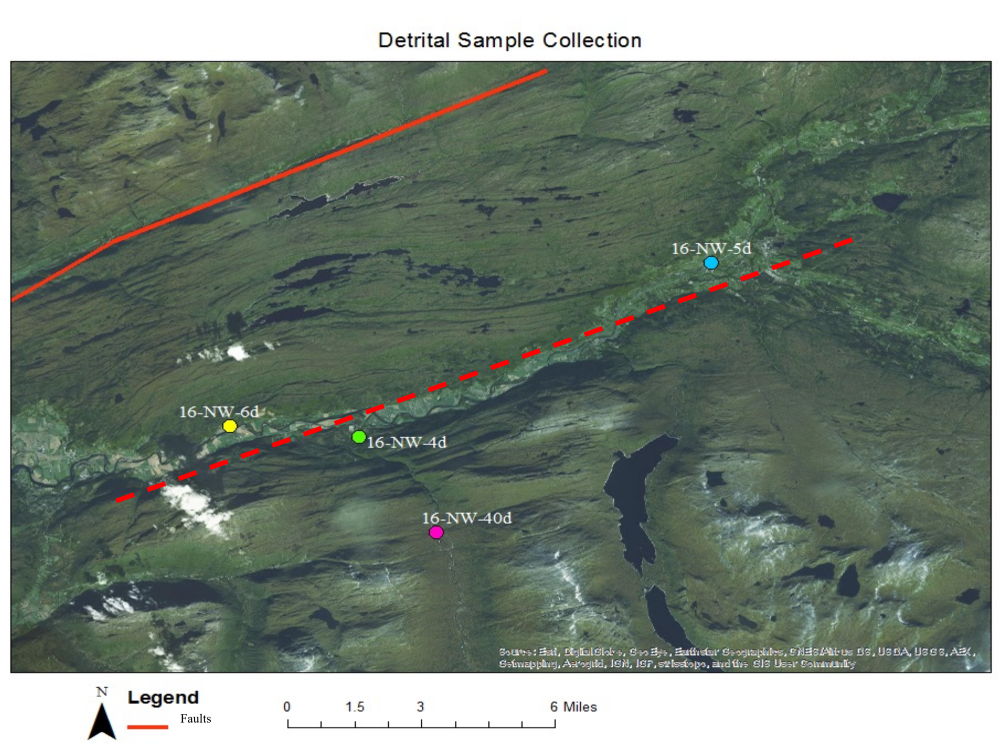


Figure 1 on the left shows the Møre-Trøndelag Fault Complex in detail.

Figure 2 on the right shows a map created in ArcGIS showing the Surnadal valley along with the locations of where different detrital samples were taken. The dashed red line indicates a possible fault running between the samples

III. Research Plan

This upcoming summer our team will conduct fieldwork in southwestern Norway. In preparation, I've been preparing geomorphic maps and cross sections of the region in order to highlight potential areas of interest. I have also employed the river profile methodology highlighted in Wobus et al. (2006) within the Surnadal river valley and through the use of ArcGIS and MatLab located a correlation of knickpoints found in incised areas within the Surnadal river valley. While in Norway, we plan to collect more samples and make detailed maps of the incision and knickpoints within the Surnadal valley as well as in other topographically varied drainage basins within the area around the MTFC that are contrary to the typical passive margin topography. We will collect more samples within these areas and upon returning process them using radiometric dating methods such as the process of ^{10}Be and ^{26}Al cosmogenic nuclide dating which uses cosmogenic nuclides created from cosmic rays to date when a certain rock was at or near the surface of the earth. The data collected from this process can then be applied to a serious of mathematical equations in order to determine erosion rates. Once we have processed all the samples we will compare our data across the region and note any varied erosional rates and how they correlate with each other. I will also employ the stream power model, which allows us to express the erosion rate of a network in terms of drainage area and slope and apply that to the integral method.

Figure 3

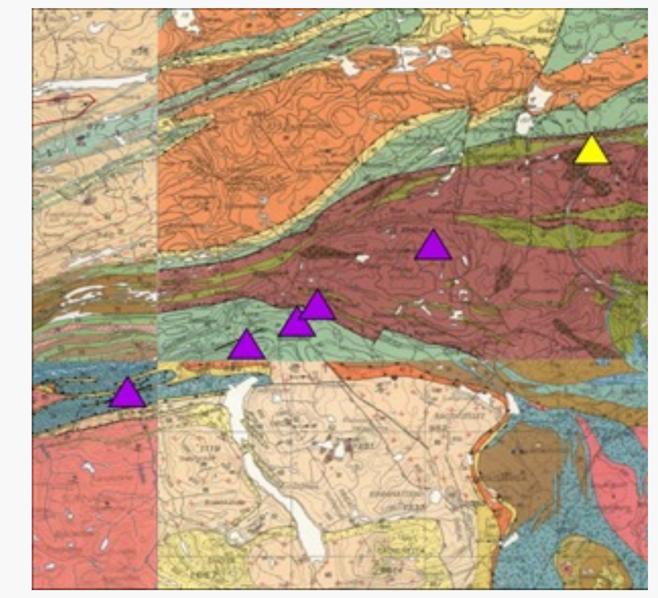


Figure 3 shows a correlation of knickpoints plotted out on a geologic map of the Surnadal valley (Image courtesy of Dr. Tim Redfield)

Figure 4

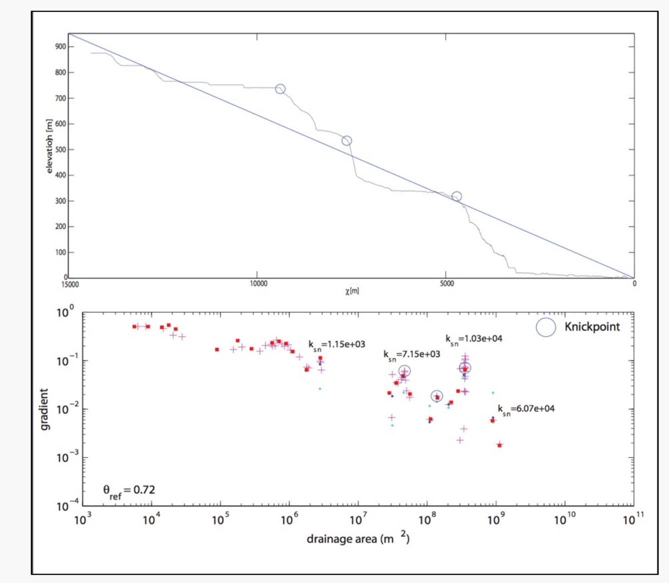


Figure 4 shows the longitudinal profile of the Follda River (located in the Surnadal valley) with various knickpoints identified.

IV. Chi Plots

The integral method, termed chi plots by Perron and Royden 2013, uses the computer program MatLab in order to take the steady-state longitudinal profile of a stream and transform it into a straight line by standardizing distance as the spatial integral of a drainage area, which serves as a proxy for integrated water discharge. A network in steady-state equilibrium will display a linear chi plot with channels parallel to the trunk stream. Thus, discrepancies found within the chi plot will help us to support the hypothesis the system is not in steady state and there is a possibility for active uplift.

Figure 5

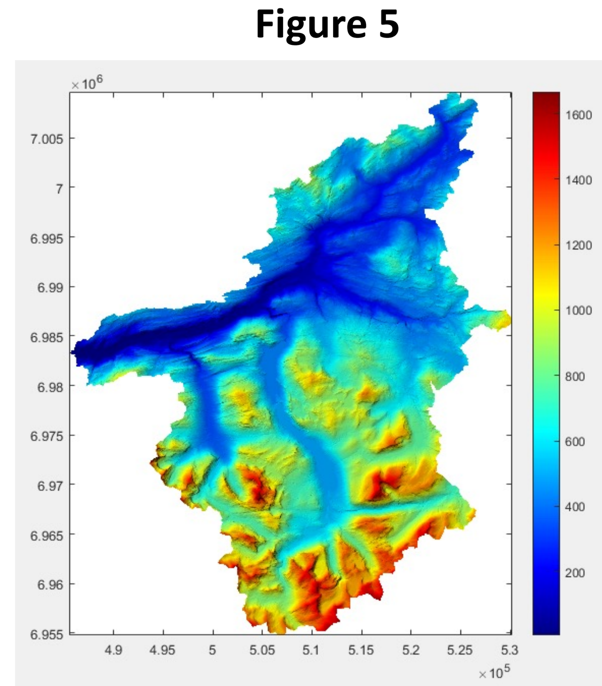
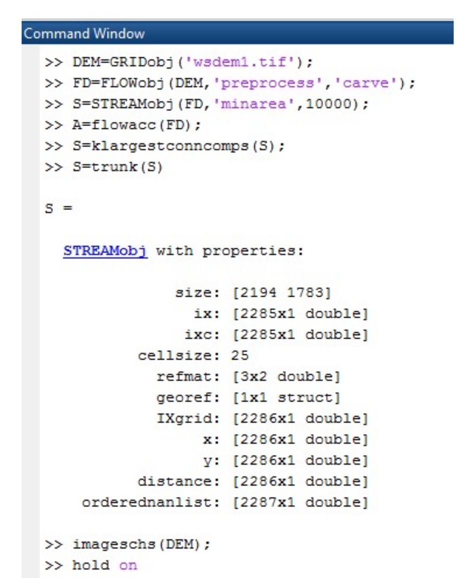


Figure 6



```
Command Window
>> DEM=GRIDobj('wsdem1.tif');
>> FD=FLOWobj(DEM,'preprocess','carve');
>> S=STREAMobj(FD,'minarea',10000);
>> A=flowacc(FD);
>> S=klargestconncomps(S);
>> S=trunk(S)

S =

  STREAMobj with properties:

            size: [2194 1783]
              ix: [2285x1 double]
             ixc: [2285x1 double]
        cellsize: 25
          refmat: [3x2 double]
          georef: [1x1 struct]
          IXgrid: [2286x1 double]
               x: [2286x1 double]
               y: [2286x1 double]
        distance: [2286x1 double]
 orderednanlist: [2287x1 double]

>> imageschs(DEM);
>> hold on
>> plot(S)
```

Figure 7

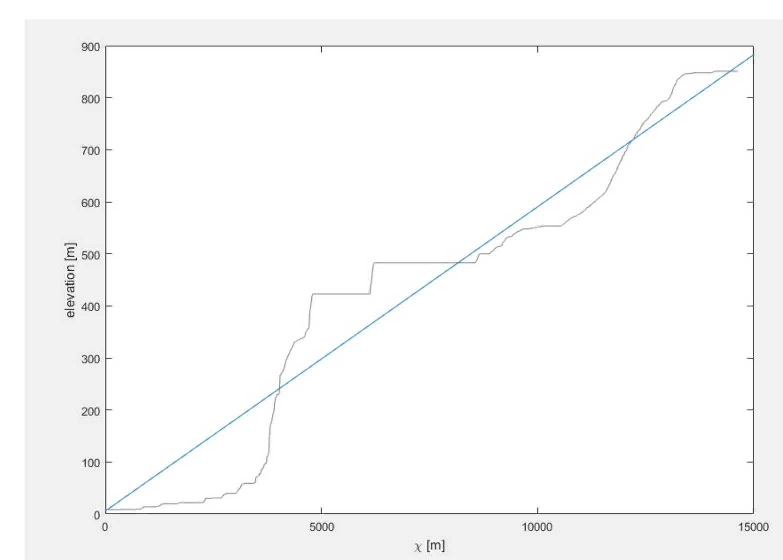


Figure 8

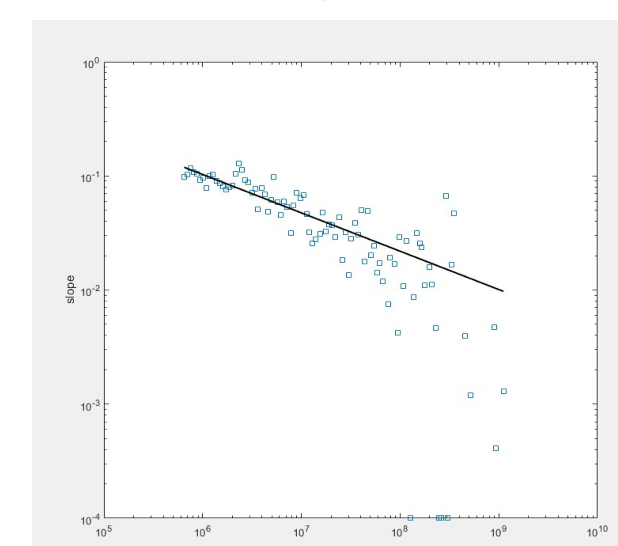


Figure 5 shows a DEM created in MatLab of the Surnadal drainage area and **figure 6** shows the codes used to generate that image. **Figure 7** shows a chi plot of the trunk stream within the Surnadal drainage while **Figure 8** shows a slope area plot of the same trunk stream.

References

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Osmundsen, P. T., & Redfield, T. F. (2011). Crustal taper and topography at passive continental margins. *Terra Nova, 23*(6), 349-361. doi:10.1111/j.1365- 3121.2011.01014.x
Phillippe Steer, Ritske S. Huismans, Pierre G. Valla, Sevastien Gac and Frederic Herman. (2012). Bimodal plio-quaternary glacial erosion of fjords and low- relief surfaces in scandinavia.(Nature Geoscience), 653.
T.F. Redfield, P. T. O. (2009). The tjellefonna fault system of western norway: Linking late-caledonian extension, post-caledonian normal faulting, and tertiary rock column uplift with the landslide-generated tsunami event of 1756.
Wobus, C., Whipple, K. X., Kirby, E., Snyder, N., Johnson, J., Spyropolou, K., . . . Sheehan, D. (2006). Tectonics from topography: Procedures, promise, and pitfalls. *Geological Society of America Special Papers, 398*, 55-74. doi:10.1130/2006.2398(04)