# Using Drainage Area Power-Law Relationships as a Method to Test For Points of River Capture

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**Can the hydraulic geometry of a stream be used to pinpoint where a river capture event may have taken place within a region?**

## I. Background and Motivation

This past summer our research team conducted fieldwork in southwestern Norway. Collaborating with Dr. Tim Redfield, a geologist from the Norwegian Geological Survey, we explored the fluvial geomorphology in the area surrounding the Norwegian 'passive' margin. While out in the field, we made detailed observations, collected samples to undergo cosmogenic surface dating methods, and used ArcGIS to catalog and process our findings. We specifically focused on rivers and their drainage patterns, which led us to new hypotheses involving river capture and drainage reorganization. Several of the drainage networks in the region display prominent geomorphic evidence of river capture; however, we wanted to develop a way to quantitatively analyze the rivers for evidence of capture, and therefore accurately pinpoint where a capture event may have taken place.

**Figure 1**

*Figure 1* shows photos from fieldwork. 1a and 1b show sample collection for cosmogenic nuclide dating and 1c shows us taking observations.

## II. Field Site

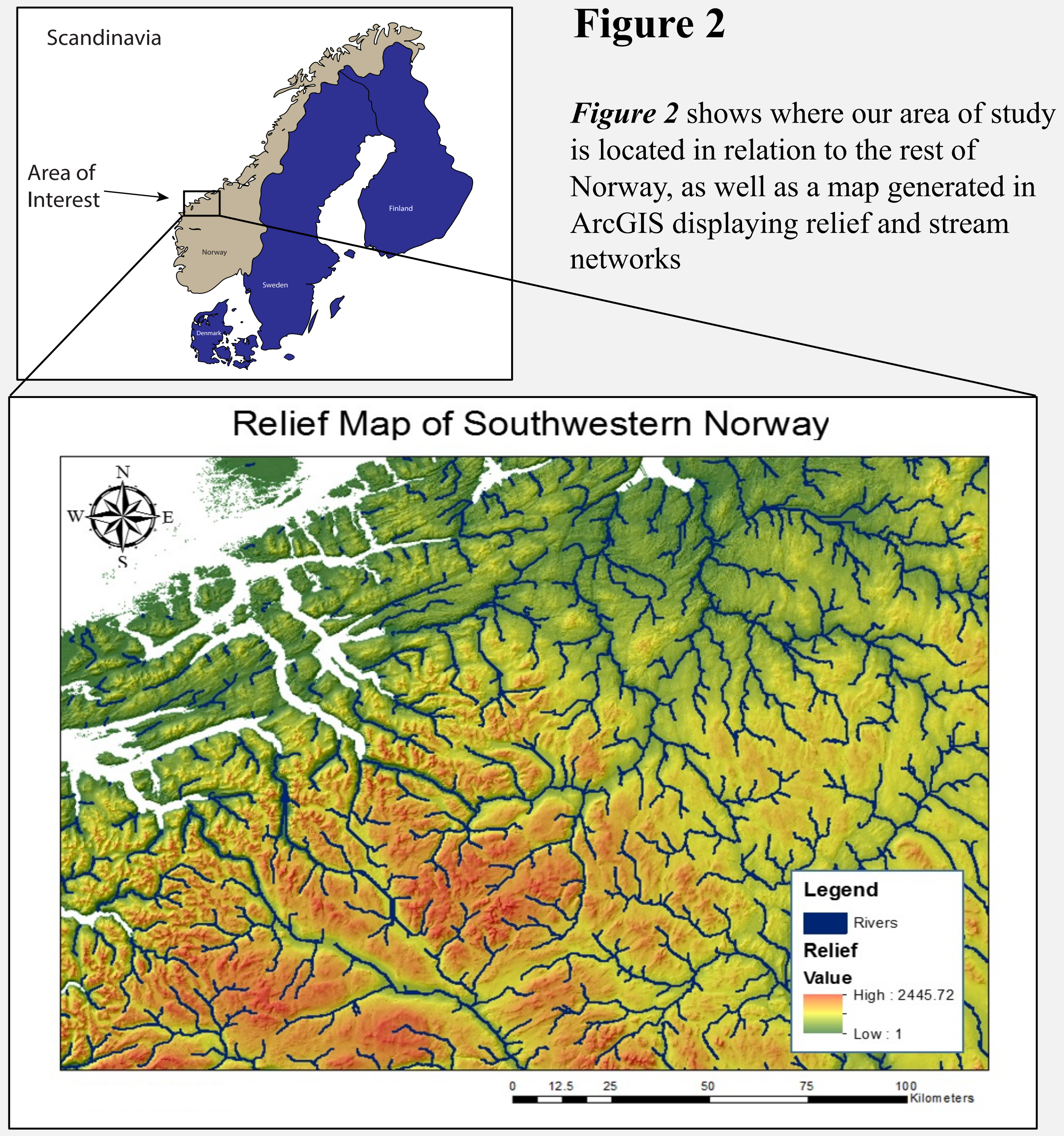


**Figure 2**

*Figure 2* shows where our area of study is located in relation to the rest of Norway, as well as a map generated in ArcGIS displaying relief and stream networks

## III. Hydraulic Geometry

The morphometric relationships that reveal how width, depth and velocity of flow increase as a power-law function of drainage area are termed the hydraulic geometry of a stream channel. These relationships provide important determinants in the progressive evolution of the channel downstream and are often expressed as power-law equations that show linear trends on log-log plots (Leopold and Maddock, 1953). Deviations from these established relationships may suggest non steady-state within a drainage system. One process that could be responsible for non-steady state within a system is river capture.

**Figure 3**

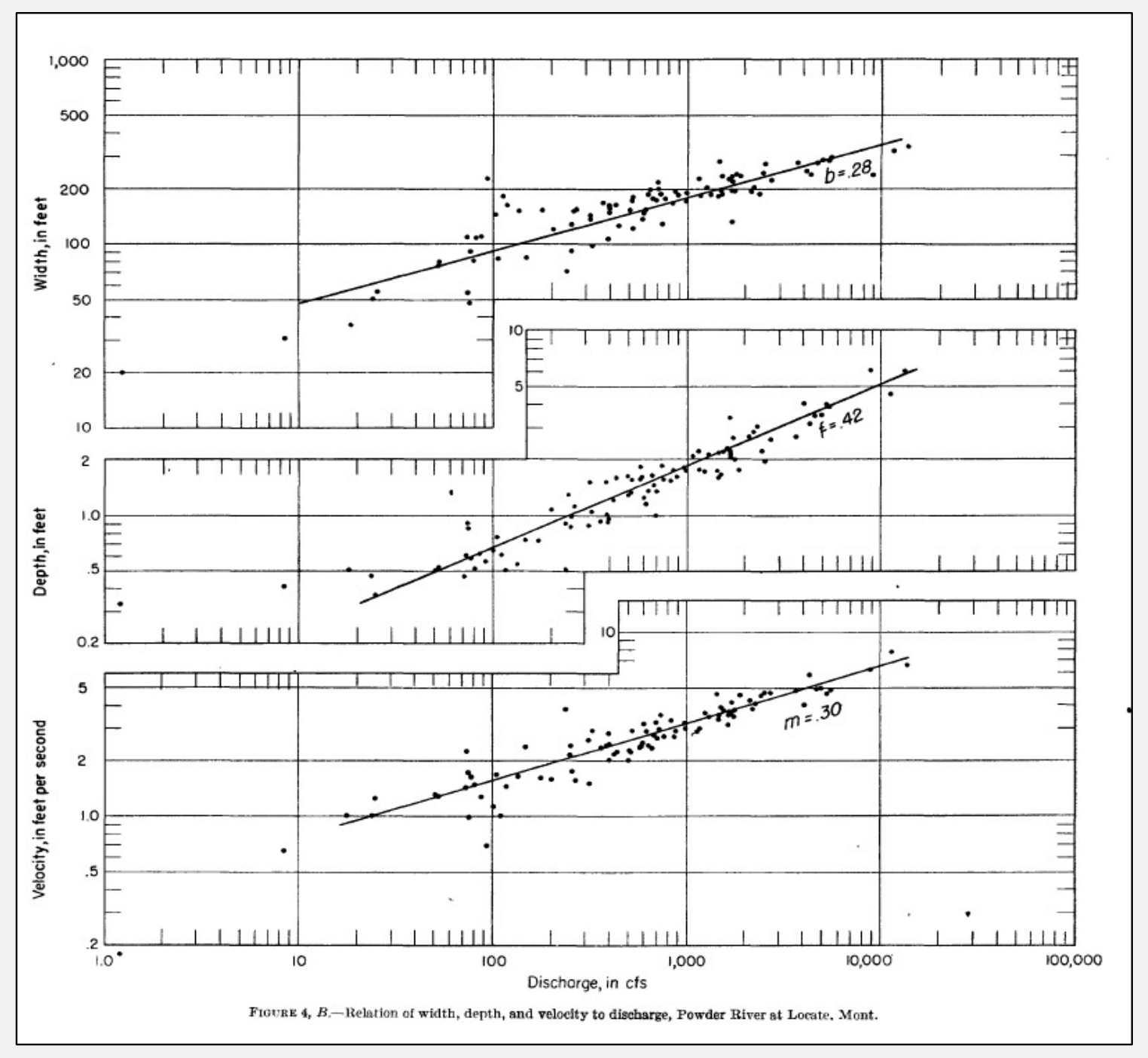


FIGURE 4, B.—Relation of width, depth, and velocity to discharge, Powder River at Locate, Mont.

*Figure 3* is from Leopold and Maddock (1953) and shows graphs plotted between various stream parameters. These graphs are based on the equations:

$$w = aQ^b$$
$$d = cQ^f$$
$$v = kQ^m$$

In these equations W is width, d is mean depth, v is mean velocity, Q is flow, and a, b, c, f, k, and m are numerical constants. These graphs reveal the linear power-law relationships between various stream characteristics.

## IV. River Capture

River capture takes place as a result of a base level change or a tilt in the landscape. This causes one river, termed the "pirate", to capture another river, termed the "victim". Geomorphic indicators such as knickpoints, bedrock terraces, underfit river channels, barbed tributaries, and other drainage anomalies can all be indicative of river capture (Clark et al., 2004).

**Figure 4**

*Figure 4* shows an example of a bedrock terrace.

**Figure 5**

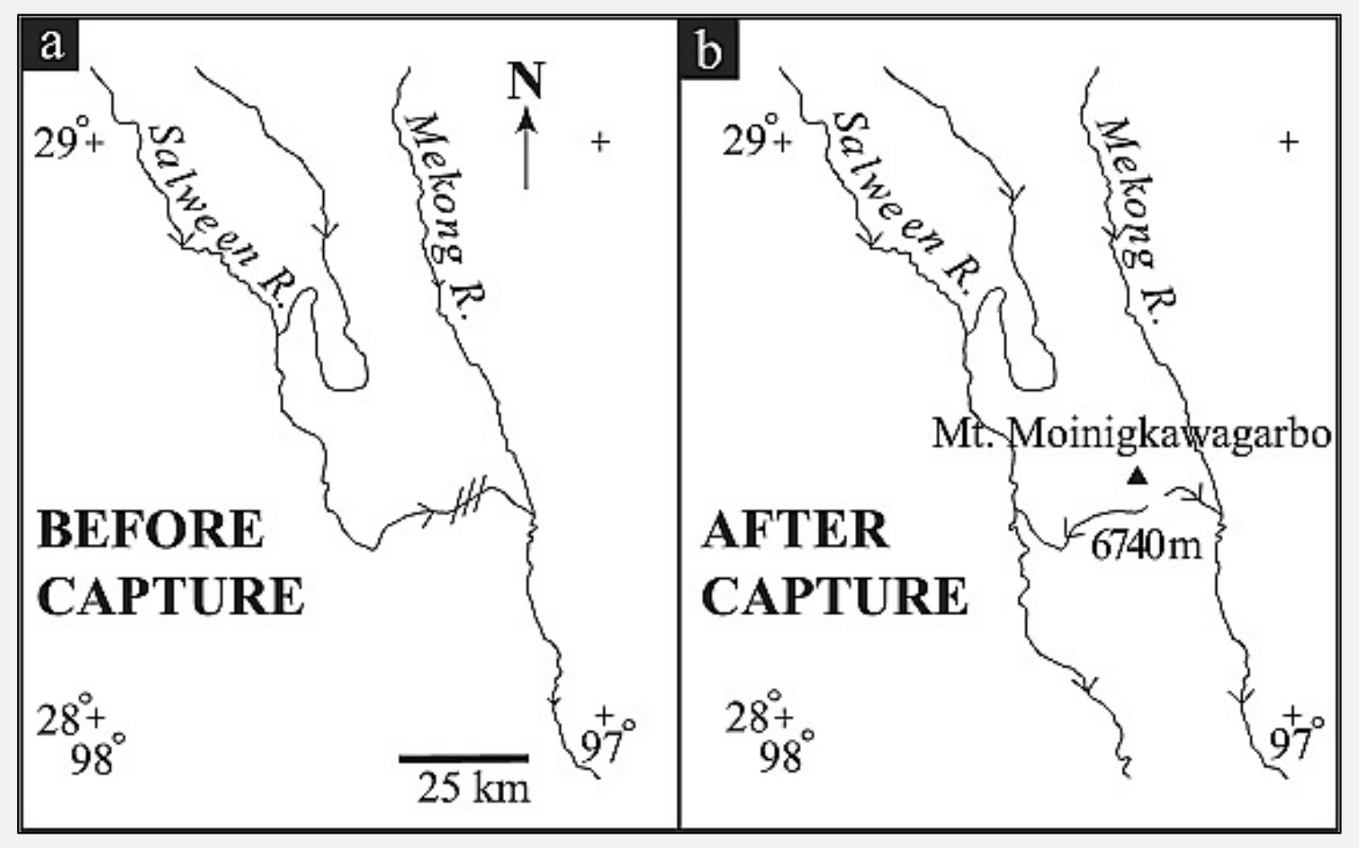


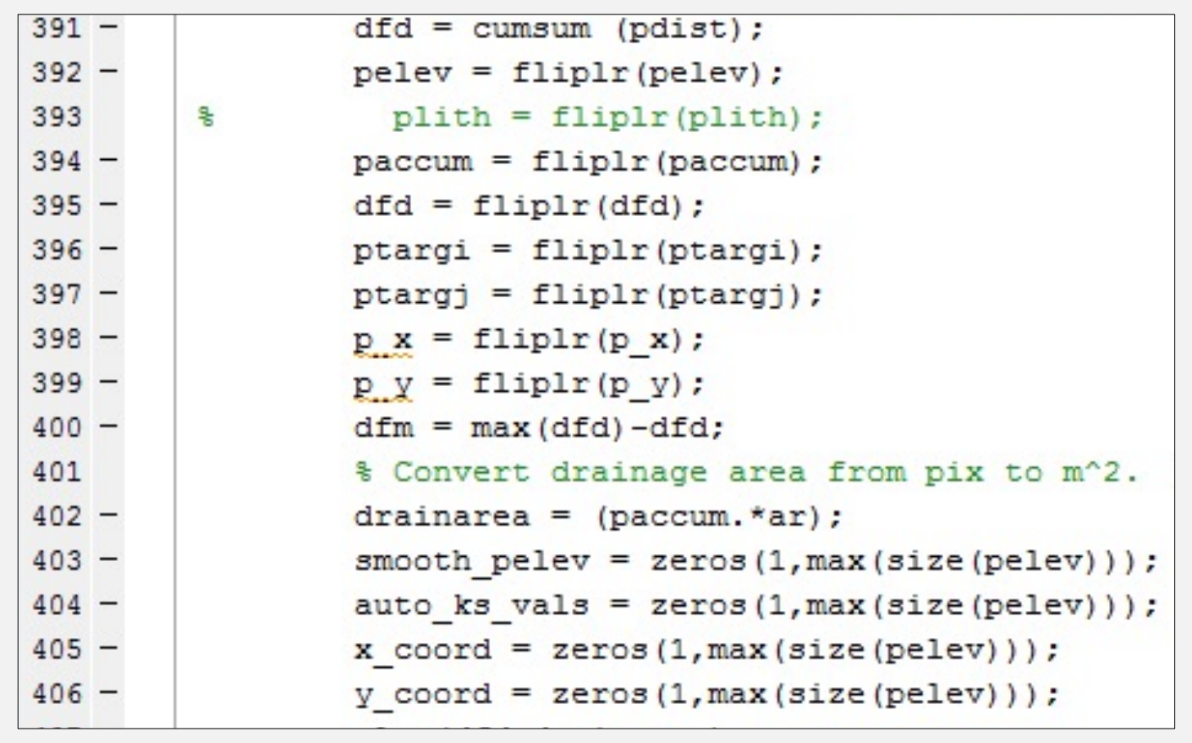
*Figure 5* is from Clark et al., 2004 and shows an illustration of a river before and after a river capture event took place

The entire process of river capture drastically alters the fluvial pattern of a drainage system and thus, disrupts the stream parameters and relationships that make up the hydraulic geometry of a stream. We specifically focus on the relationship between drainage area and channel length throughout different drainage basins located in our area of study. If a capture event has taken place, the addition of a captured river and its associated drainage basin should result in an abrupt jump in drainage area at the point of capture as well as correspond to geomorphic evidence of capture on the landscape.

## IV. Methodology

The program MatLab is often used in conjunction with ArcGIS by geomorphologists in order to generate the longitudinal profile of a river. My goal is to take the profile51 code that was generated by researchers at MIT to explicitly create longitudinal profiles and alter it so that it calculates and displays channel length versus drainage area of a river network. This involves taking apart the profile51 code and teasing out all the variables and functions necessary for this process and discarding the commands that are not required. I will then have to alter the code so that it plots channel length versus drainage area with the axes in a log-log format. This code will then be used in combination with ArcGIS to analyze various drainage networks within southwestern Norway and allow us to generate a channel length versus drainage area plot for each one.

**Figure 6**



```
            dfd = cumsum (pdist);
            pelev = fliplr(pelev);
%             plith = fliplr(plith);
            paccum = fliplr(paccum);
            dfd = fliplr(dfd);
            ptargi = fliplr(ptargi);
            ptargj = fliplr(ptargj);
            p_x = fliplr(p_x);
            p_y = fliplr(p_y);
            dfm = max(dfd)-dfd;
            % Convert drainage area from pix to m^2.
            drainarea = (paccum.*ar);
            smooth_pelev = zeros(1,max(size(pelev)));
            auto_ks_vals = zeros(1,max(size(pelev)));
            x_coord = zeros(1,max(size(pelev)));
            y_coord = zeros(1,max(size(pelev)));
```

*Figure 6* shows a sample of the profile51 code with some of the necessary variables displayed. This is the code that my code will be altered from.

**Figure 7**

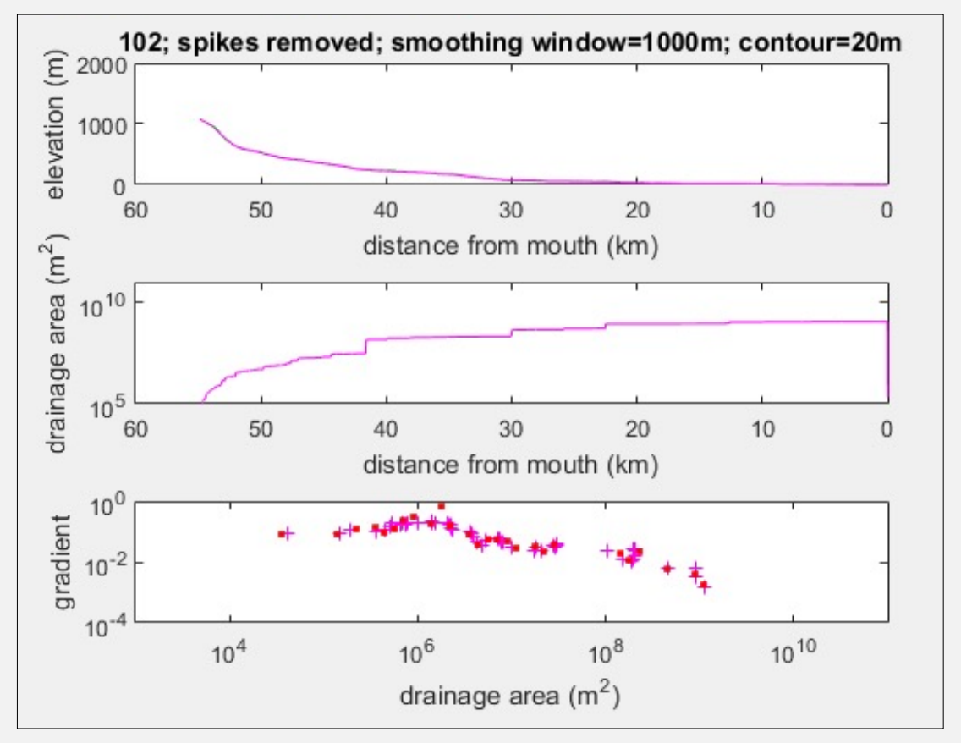


*Figure 7* shows an example of the longitudinal profiles that the profile51 code already gives us.

## V. Results and Next Steps

As of right now, I am still in the process of altering the profile51 code. Once I have successfully altered it, I will be able to develop channel length versus drainage area plots for various drainage networks within our area of study.

**Figure 8**

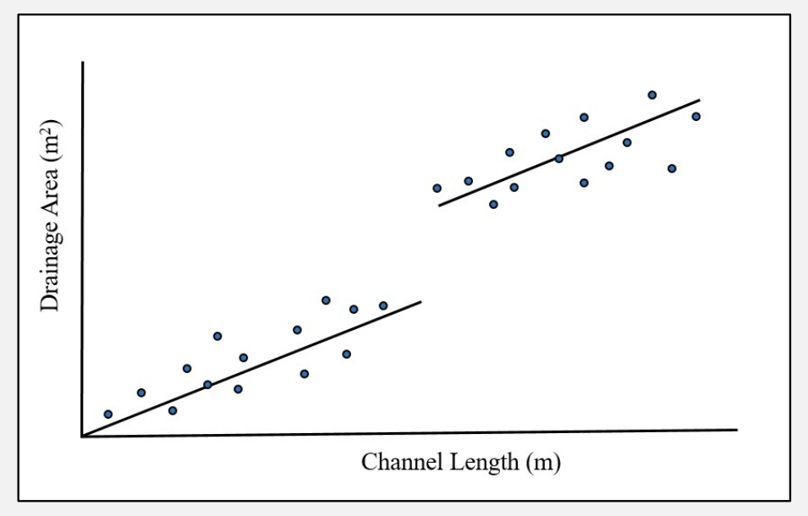


*Figure 8* shows what a jump in drainage area may look like

These plots will then be analyzed for any jumps in drainage area that could possibly be indicative of river capture. Each anomalous jump in drainage area is then analyzed for geomorphic evidence in order to determine if that area is in fact a capture point, effectively utilizing the hydraulic geometry of a stream, as expressed by the power law equations, to pinpoint locations of river capture event. This method will help us to inevitably determine what mechanism is causing the river capture in this region and whether or not it relates to the evolution of southwestern Norway's 'passive' margin.

## Acknowledgements and References

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Leopold, L. B. and Maddock, T. J., 1953, Hydraulic geometry of stream channels and some physiographic implications. U. S. Geological Survey Professional Paper 252, 55 p