Topographic Development History of the Alaska Range

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Abstract: The overall goal of this project is to use variations in sediment source through time as a proxy for deciphering the uplift history of the Alaska Range (Fig. 1). In particular, we tracked variations in sediment provenance through time for the Oligocene to present Tanana Basin. The three main sediment source regions are north of the Alaska Range, south of the Alaska Range, and from the Alaska Range itself (Fig. 2). Furthermore, we will use the sediment source interpretation to test the hypothesis that the Nenana River changed direction during the Miocene (23 Ma to 5.3 Ma) (e.g. Brennan, 2012).

Figure 1. Regional Map with study area, bedrock, and modern river sample locations annotated. We sampled the uplifted Paleo-Tanana Basin at the Suntrana Type Section.

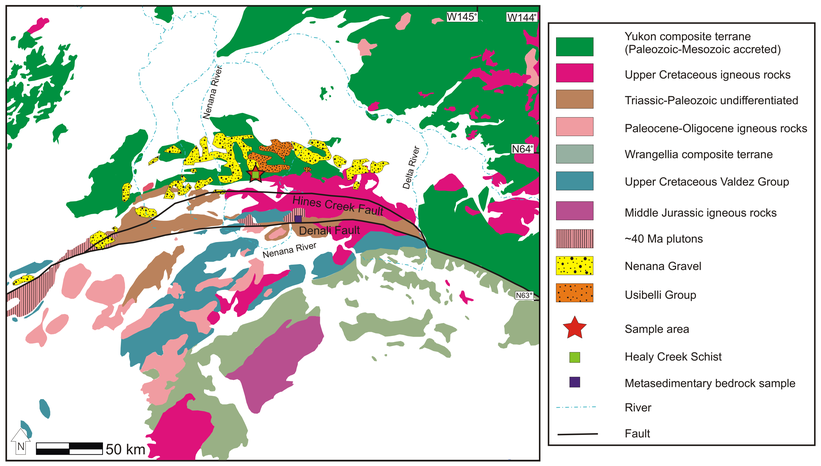

Figure 2. Geological Map. Triassic-aged rocks are present in the Alaska Range. The 201-153 Ma Talkeetna Arc lies south of the Alaska Range; ~140 Ma to ~120 Ma-aged sources lie north of the Alaska Range in the Yukon-Tanana Highlands. There are plutons and metasedimentary rocks within the Alaska Range that have the distinct age of ~40 Ma. Map modified from Trop and Ridgway, 2007.

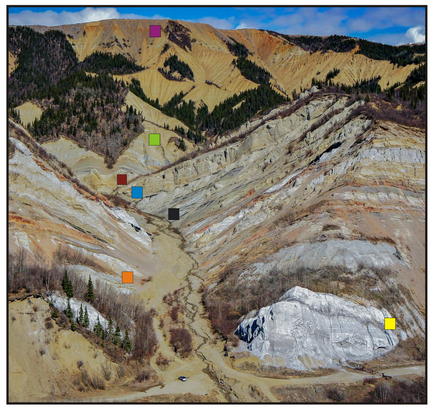

Figure 3. Photograph of the upper part of the Usibelli Group at the Suntrana Type Section. Samples were collected from Healy Creek, Sanctuary, Suntrana, Lignite Creek, and Grubstake Formations along with the Nenana Gravels. Note the car for scale in the lower center of the photo. Photo and text modified from Wartes et al., 2013.

Methods: We collected sandstone and sand samples from the Usibelli Group and Nenana Gravels at the Suntrana Type Section (Healy Creek site). We then separated out >~50 grains of muscovite from each sample and applied $^{40}Ar/^{39}Ar$ geochronology to deconvolve their original source region. In addition, we collected sand from the modern Nenana River both north and south of the Range, a schist bedrock sample at the Suntrana type section, and a metasedimentary rock from the headwaters of the Nenana River and applied $^{40}Ar/^{39}Ar$ muscovite geochronology to supplement existing regional river and bedrock $^{40}Ar/^{39}Ar$ geochronology data sets.

Heavy mineral zircon U-Pb ages more often reflect magmatic ages, whereas light mineral muscovite $^{40}Ar/^{39}Ar$ ages reflect metamorphic ages. For our purposes, muscovite was the mineral of choice because of its stability during transportation and deposition, low specific density, and because the potential source regions have bedrock lithologies that are abundant in muscovite with distinct age populations from north and south of the Alaska Range and from within the Alaska Range itself.

A muscovite sample from the Grubstake Formation and the Nenana River headwaters has yet to be dated, and we are currently in the process of dating more samples of the Sanctuary Formation and Lignite Formation,

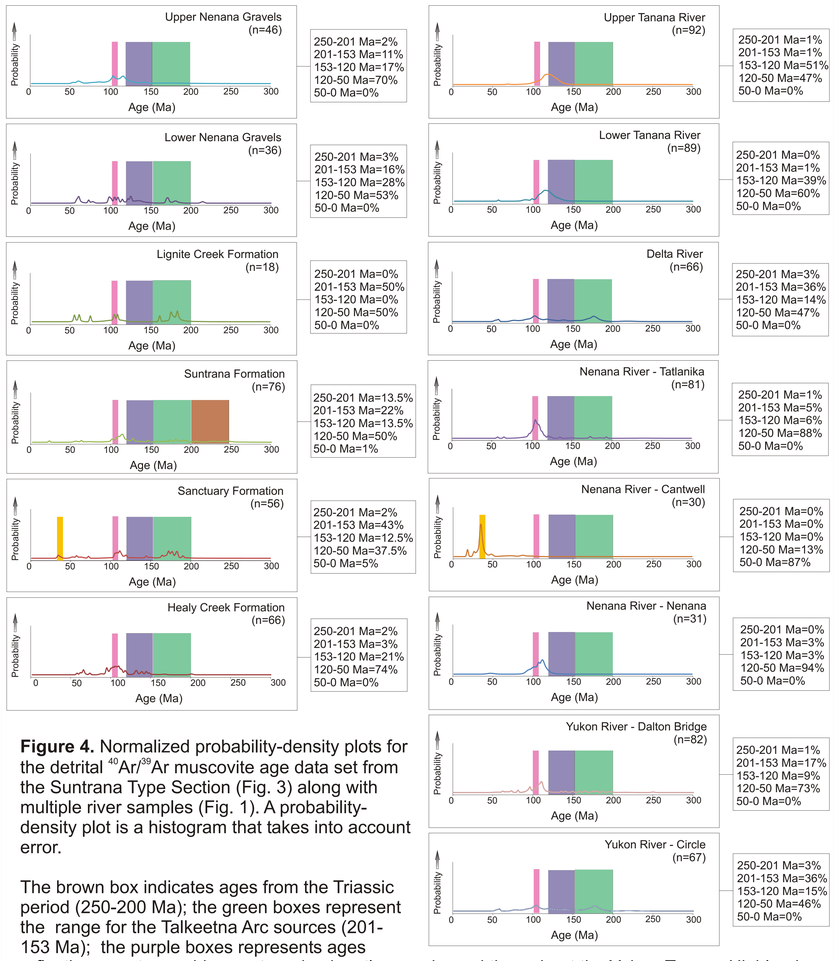

Figure 4. Normalized probability-density plots for the detrital $^{40}Ar/^{39}Ar$ muscovite age data set from the Suntrana Type Section (Fig. 3) along with multiple river samples (Fig. 1). A probability-density plot is a histogram that takes into account error.

The brown box indicates ages from the Triassic period (250-200 Ma); the green boxes represent the range for the Talkeetna Arc sources (201-153 Ma); the purple boxes represents ages reflecting a metamorphic event predominantly experienced throughout the Yukon-Tanana Highlands (153-120 Ma); the pink lines indicate ages similar to the Healy Schist bedrock (104.3 ± 1.1 Ma); the yellow lines represents bedrock sources from within the Alaska Range (36.7 ± 0.3 Ma); and 120-50 Ma ages are non-unique throughout the data sets. Graphs inspired by Brennan, 2012.

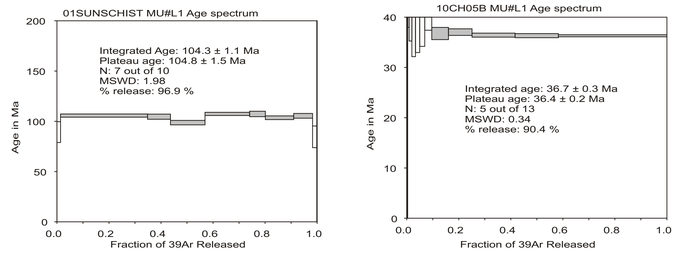

Figure 5. Age spectra for the Healy Creek Schist (bedrock formerly known as Birch Creek Schist) and the Alaska Range showing integrated ages of 104.3 ± 1.1 Ma and 36.7 ± 0.3 Ma respectively.

Alaska Range: When did these mountains arise to become sediment source topographic highs and change drainage patterns?

Conclusions: During the deposition of the Healy Creek Formation in the paleo-Tanana Basin, the paleo-Nenana River likely flowed south to Cook Inlet draining the Yukon-Tanana Highlands (21% of muscovite grains) (Fig. 6a). By the time of the deposition of the early-Miocene Sanctuary Formation, the paleo-Nenana River was both sourcing the uplifted Alaska Range (5% of muscovite grains) and the Talkeetna Arc (43% of muscovite) and flowing north (Fig. 6b). The mid-Miocene Suntrana formation had a large contribution from Triassic rocks (13% of muscovite grains) implying a spatially variable history of drainage patterns and rock uplift in the Alaska Range. During the deposition of the Nenana Gravels, there is a large population of muscovite grains sourced from the Yukon-Tanana Highlands (28%) implying sediment recycling as the southern extent of the Healy Creek formation was uplifted and eroded. The modern Nenana River near Cantwell has an 87% contribution of muscovite grains from the Alaska Range and no Talkeetna Arc-aged grains, implying continued drainage reorganization after the deposition of the Nenana Gravels (see modern Nenana River Figs. 1 and 2). This is supported by the Broad Pass Fault likely being active during the Pliocene (Haeussler et al., 2008). These results are in general agreement with past work in which Brennan (2012) applied a U-Pb geochronology source-to-sink approach to the paleo-Tanana Basin. In summary, the Alaska Range was uplifted by the early Miocene, the Nenana River drainage changed direction by this time period, and continued drainage reorganization has occurred to the recent past.

Continued Work: Our next step in this project is to complete the muscovite $^{40}Ar/^{39}Ar$ dating for the Grubstake Formation, Nenana Glacier headwaters, and additional Lignite and Sanctuary Formations sample analysis. To further expand and support our preliminary conclusions, we also plan on applying the same radiometric dating approach to different paleo-Tanana Basin outcrops outside the Suntrana Type Section.

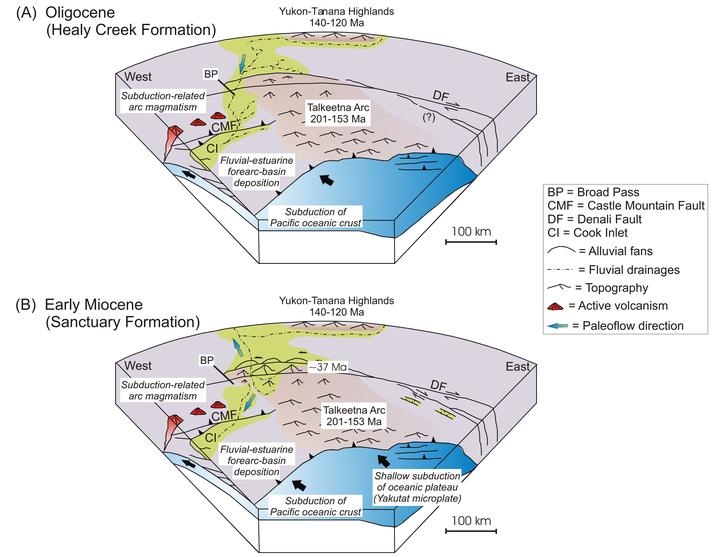

Figure 6 (A,B). Tectonic baseball diagrams of the paleodrainage patterns of the region of study both during the Oligocene and the Early Miocene. Modifed from Ridgway et al., 2012.

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