# PROCEEDINGS OF THE TWENTY-SIXTH ANNUAL KECK RESEARCH SYMPOSIUM IN GEOLOGY

April 2013
Pomona College, Claremont, CA

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# KECK GEOLOGY CONSORTIUM
# PROCEEDINGS OF THE TWENTY-SIXTH ANNUAL KECK RESEARCH SYMPOSIUM IN GEOLOGY

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SHAWN A. MOORE, Smith College, Northampton MA
Research Advisor: Bosiljka Glumac

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# PROVENANCE ANALYSIS OF MEDIAL BASIN CHANNEL SANDS IN THE CHICKALOON FORMATION, MATANUSKA VALLEY, ALASKA

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**Research Advisor:** Bosiljka Glumac

## INTRODUCTION

The Chickaloon Formation, the main focus of this study, was deposited in a fault bounded terrestrial forearc basin known as the Matanuska Valley-Talkeetna Mountains Basin (Trop et al., 2003) located in south central Alaska. It overlies the Wrangellia composite terrain and is gradationally or unconformably overlain by the up to 1100 m thick Wishbone Formation conglomerate (Triplehorn et al., 1984). The Chickaloon Formation was deposited during a hothouse climate phase approximately 57 to 53 Ma during the late Paleocene to early Eocene at about the same latitude it is in today (Triplehorn et al., 1984; Sunderlin et al., 2011). The formation represents rapid deposition in a floodbasin environment and is dominated by lacustrine, floodplain, channel sandstone, crevasse lobe and channel, and alluvial strata. These deposits consist of interbedded sandstones, siltstones, mudstone, coal, carbonaceous shale, and ash fall tuff with an overall thickness of 1500m.

The focus of this study is the Chickaloon Formation channel sandstone facies, which is dominated by channel "approach and abandonment" sedimentary successions produced by migrating fluvial channels. Studies conducted by Neff et al. (2011) at the Evan Jones Mine exposure of the Chickaloon Formation suggest the presence of a continuous annual meandering trunk channel with many smaller seasonal channels. Also present were indicators of large tributary channels that possibly fed crevasse splay and lobe deposits (Neff et al., 2011).

Most of southern Alaska's modern Matanuska Valley lies north of the rocks in the Mesozoic Chugach accretionary wedge (MCAW) and south of mountainous exposures of the Jurassic Talkeetna Volcanic Formation (JTVC) in the Talkeetna Mountains (Fig. 1). The MCAW south of the Border Ranges Fault consists of blueschist, mesomelange (altered shale, interbedded sandstone and siltstone, red and black chert, basaltic lava, and recrystallized limestone), and greywacke-conglomerate (Clift et al., 2012). The metamorphic mélange of the Chugach Terrane was scraped off the subducting Kula and Farallon plates (Trop et al., 2003; Sunderlin et al., 2011). The uplifted JTVC north of the Castle Mountain fault consists mostly of basaltic and andesitic lavas and tuffs, as well as volcaniclastic rocks (Clift et al., 2005). It was previously suggested that the sedimentary provenance and paleocurrent indicators imply the facies of the Chickaloon Formation prograded into the center of the basin from both the MCAW and the JTVC (Trop et al., 2003). The current study seeks to describe the extent to which the MCAW and JTVC have contributed to the sediment within the medial channel sands of the Chickaloon Formation in order to better understand the development and evolution of this fluvial system in relationship to tectonism and climate of this part of Alaska during its deposition.

## FIELD AND ANALYTICAL METHODS

Twenty-seven samples of the channel-dominated lithofacies in the Chickaloon Formation were collected from the coarsest deposits at each of the ten study sites throughout the Matanuska Valley along the east-west basin axis (Fig. 1). Two of these localities had been studied previously in detail (Neff et al., 2011). Much of my time in the field was spent scouting out new sites to locate and document good exposures of the Chickaloon Formation channel sandstones. Four of the sampling localities were not studied in detail in the field because the nature of the outcrops made this impractical, or due to our time constrains related to working in such remote areas. For the remaining four localities, together with other Keck project participants, I created a detailed record of the stratigraphy through measuring and describing the section. Of those four localities, stratigraphic columns were made for outcrops referred to as the Coyote Lake and Elephant Foot exposures (Figs. 2 and 3 respectively in Williams and Sunderlin, this volume). For all ten sites I also recorded the GPS location of the samples collected and documented any sedimentary structures and any textural and compositional trends and gradients that could help determine sediment source and transport direction.

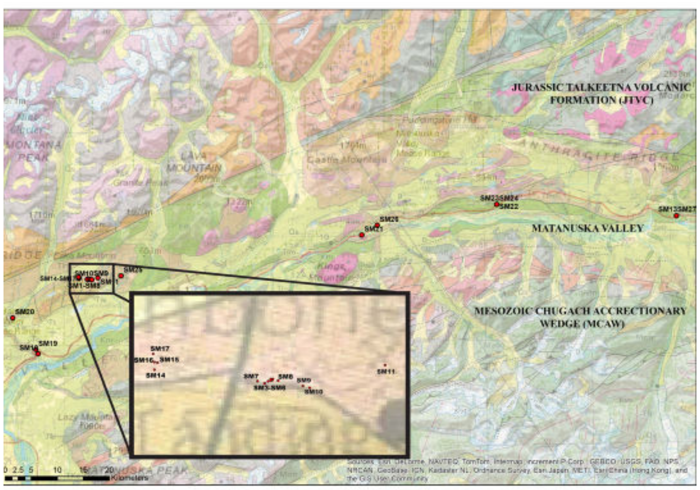


*Figure 1. Map of the Matanuska Valley sampling area in south-central Alaska and its surrounding geology. Sample collection locations marked with red dots and labeled with sample names. Adapted from a geologic map by Winkler (1992).*

Channel sandstones were selected for this provenance analysis to determine if lithics within the samples could be identified as being of metamorphic or volcanic origin. The southern border range of the Chugach Terrane is composed of accretionary metamorphic rocks, and the northern border range of the Talkeetna Mountains represents a volcanic arc (Fig. 1; Sunderlin et al., 2011). Therefore, classification of lithic fragments within the Chickaloon sandstones as metamorphic or volcanic is useful in determining their provenance and how dominance of MCAW versus JTVC sourcing may vary across the sampled Chickaloon strata in the basin.

Twenty-two of the samples collected in the field were prepared for petrographic analysis and point counting analysis was conducted on ten thin sections representing one sample from each of the major sampling locations. The analysis was conducted following the Glagolev-Chayes method, which involves identifying and recording the type of grains or matrix present in the intersection of the microscope cross hairs at evenly spaced intervals along multiple transects of the thin section (Carver, 1971). A mechanical stage with an interval of 0.5 mm was used to count 500 points from each thin section.

## PETROGRAPHIC AND POINT COUNTING RESULTS

Petrographic analysis revealed that the dominant lithic component of the sand-size fraction in all samples was polycrystalline quartz of metamorphic origin or chert, with schist and fine grained siliciclastic rock fragments making up the bulk of additional lithics present. Volcanic lithic fragments did occur in some samples, but not in significant amounts (Fig. 2).

The results of the point counting analysis were plotted as pie charts showing the percentage of each component as well as the relative proportions of lithic fragments in the sand fraction. Point counting analysis supported the results of petrographic analysis regarding the dominance of metamorphic lithics in all samples and revealed that the most abundant lithic present in all samples was polycrystalline quartz except in SM# in which it was chert (Fig. 2). The samples that contained the highest percent of volcanic lithics (samples SM14 and SM21), still only around 5% of the entire sample, were collected from the southeastern section of the sampling area, but were approximately 60 km apart and separated by samples that did not show this increase is the amount of volcanic lithics (Fig. 1).

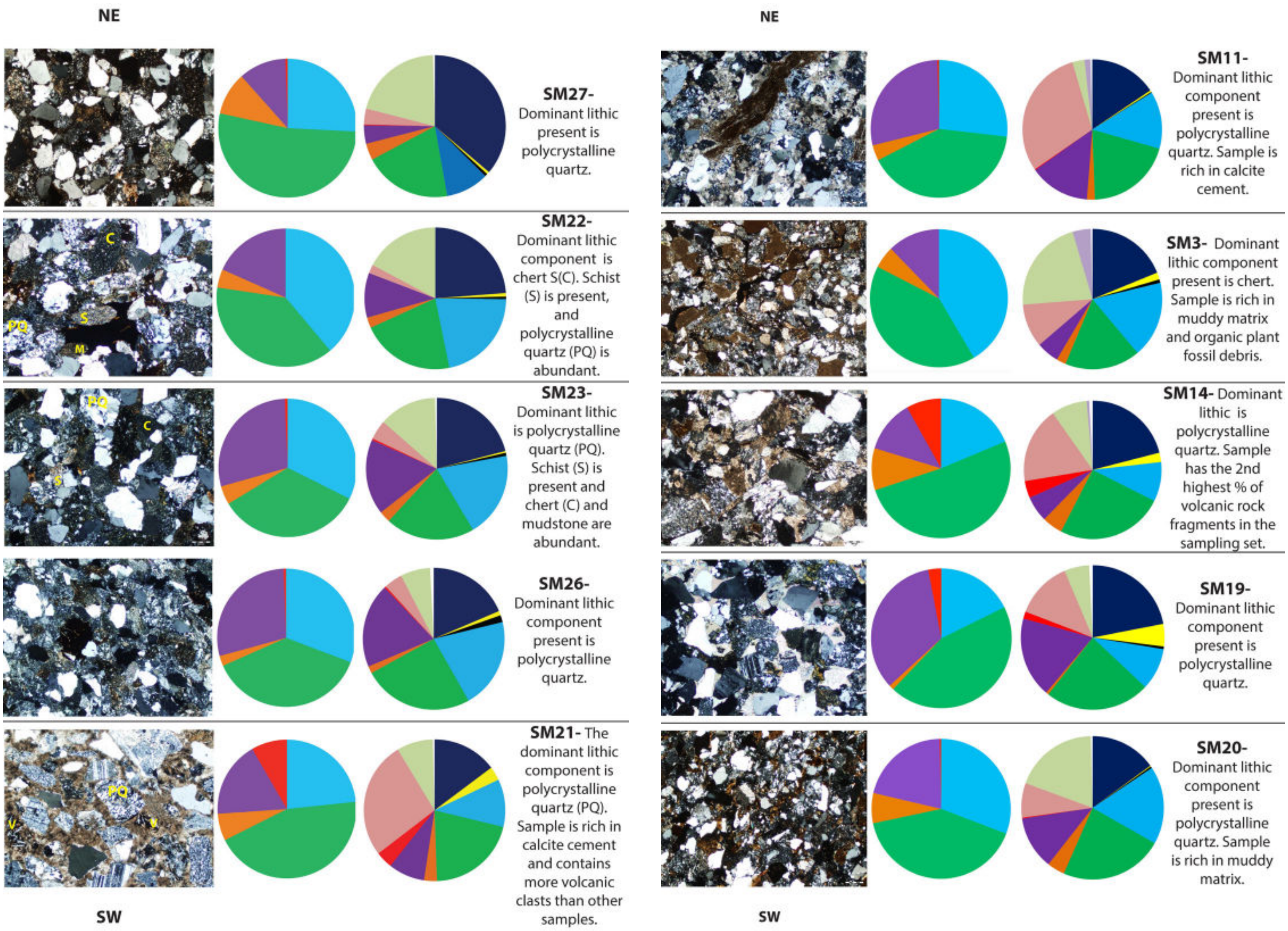


*Figure 2. Samples used in the point counting analysis of the Chickaloon sandstones arranged in order of their position along the northeast-southwest transect through the Matanuska valley basin. To the left are cross-polarized light photomicrographs of each sample, in the center are charts showing the percentages of lithic types present in each sample, and to the right are charts showing the percentage of all components present in the sample. Scale for all photomicrographs is 200 μm.*

## DISCUSSION

The finding that metamorphic and metasedimentary rock particles are the dominant lithics present in the sand fraction of the majority of the samples of the Chickaloon Formation collected across its east-west basin axis suggests that the Mesozoic Chugach accretionary complex was the dominant sediment source for the sampled Chickaloon Formation channel sandstones. This information provides useful knowledge for reconstructing the evolution of fluvial systems of the Chickaloon Formation.

One possible explanation for the dominance of southern MCAW sediment input could be that this uplifted coastal terrane received more coastal precipitation than the northern Talkeetna Mountains highlands, leading to a higher rate of water-driven erosion from the south. In response to a regional orographic effect, moist air that blew in off the North Pacific Ocean from the south would have dropped most of its water once it hit the high topography of the Chugach uplift. Due to the rain shadow effect, as the air continued across the Paleogene Matanuska basin and over to the Talkeetna Mountains it no longer contained as much water and the amount of precipitation and sediment contribution to the basin would have been greatly diminished.

Average annual precipitation data collected in Alaska from the year 1951- 1980 (Winkler, 1992) indicates a modern rain shadow effect in the present Matanuska Valley. Reconstructions of the Paleocene Matanuska Valley-Talkeetna Mountains Basin geometry in Trop et al. (2003) resemble the present physiography in broad terms and this region may have had a similar regional orographic effect. Paleoclimate data from the time the Chickaloon Formation was deposited indicates that there was clearly a lot of available precipitation in the basin (Sunderlin et al., 2011). Additional components of an erosional cause for the predominance of southern sediment sourcing could be fundamental differences in the way the MCAW and JTVC weather, and the role of physical and or chemical weathering in each source area.

The MCAW may have remained at such a high topography after such prolonged erosion in this area because of continued plate convergence and isostatic uplift, which would generate even more rock to be eroded. Another possible reason for enhanced erosion to the south would be that the fault on the MCAW side of the basin was more active than that on the JTVC side. The movement could be attributed to a northwestward shift in the Kula Plate that occurred around 54 Ma, and the resulting dextral oblique plate convergence. This convergence may have caused northward displacement of the basin and accretionary prism along orogen-parallel dextral faults, namely the boarder ranges fault (Trop et al., 2003). If the Border Ranges Fault to the south was undergoing more displacement at the time of deposition of the Chickaloon Formation than the Castle Mountain Fault to the north, more deformation and sediment creation would be occurring in the south leading to a higher rate of sediment input from this area.

## CONCLUSION

The medial channel sandstones of the Chickaloon Formation originated almost entirely from the southern Mesozoic Chugach accretionary wedge. Understanding the provenance of these sediments has implications for the development and evolution of the Matanuska Valley fluvial system. Primary sedimentary sourcing from the south could reflect climate of the area, namely a precipitation gradient from abundant moisture in the southern coastal region to much drier conditions in the north due to an orographic rain shadow effect, as well as tectonic and structural processes, such as enhanced uplift and faulting to the south of the Matanuska Valley.

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## REFERENCES


Carver, R.E., 1971, Procedures in Sedimentary Petrology. *Wiley-Interscience*, New York, 653 p. 385

Clift, P.D., Draut, A.E., Kelemen, P.B., Blusztajn, J., and Greene, A., 2005, Stratigraphic and geochemical evolution of an arc upper crustal section; the Jurassic Talkeetna Volcanic Formation, south central Alaska. *Geological Society of America Bulletin*, v. 117, p. 902-925.

Clift, P.D., Wares, N.M., Amato, J.M., Pavlis, T.L., Hole, M.J., Worthman, C., and Day, E., 2012, Evolving heavy mineral assemblages reveal changing exhumation and trench tectonics in the Mesozoic Chugach accretionary complex, south-central Alaska. *Geological Society of America Bulletin*, v. 124, p. 989-1006.

Neff, J.L., Hagadorn, J.W., Sunderlin, D., and Williams C.J., 2011, Sedimentology, facies architechture and chemostratigraphy of a continental high-latitude Paleocene-Eocene succession-The Chickaloon Formation, Alaska. *Sedimentary Geology*, v. 240, p. 14-29. (doi: 10.1016/j.sedgeo.2011.07.002)

Sunderlin, D., Loope, G., Parker, N.E., and Williams, C.J., 2011, Paleoclimate and paleoecology implications of a Paleocene-Eocene fossil leaf assemblage, Chickaloon Formation, Alaska. *Palaios*, v. 26(6), p. 335-345.

Triplehorn, D.M., Turner, D.L., and Naeser, C.W., 1984, Radiometric age of the Chickaloon Formation of south-central Alaska. Location of the Paleocene-Eocene boundary. *Geological Society of America Bulletin*, v. 95, p. 740-742.

Trop, J.M., Ridgway, K.D., and Spell, T.L., 2003, Sedimentary record of transpressional tectonics and ridge subduction in the Tertiary Matanuska Valley-Talkeetna Mountain forearc basin, south Alaska, *in* Sisson, V.B., Reoske, S.M., and Pavlis, T.L., eds., Geology of Transpressional Orogen Developed During Ridge-Trench Interaction Along the North Pacific Margin. *Geological Society of America Special Paper*, v. 371, p. 89-118.

Winkler G. R., 1992, Geologic Map and Summary Geochronology of the Anchorage 1º x 3º Quadrangle, Southern Alaska. *U.S. Geologic Survey*, scale 1: 250 000, 1 sheet.