DR BRIAN HAMPTON

Shedding light on the Farewell terrane

Currently leading pioneering research aimed at understanding some of the geologic and tectonic complexities of the Alaska Range, **Dr Brian Hampton** talks in detail about his project as well as the importance of, and his commitment to, educational outreach

Why is the origin and tectonic history of the many crustal fragments that make up the deepest parts of the Cordillera in the Alaska Range so elusive?

The Alaska Range is located in a remote region that can only be accessed by helicopter or small fixed-wing aircrafts such as bush planes. Although much of the geology of Alaska has been studied at a regional scale, the underdeveloped infrastructure, rugged topography and unpredictable mountain weather systems have limited the number of detailed, field-based studies conducted in the Alaska Range. The range is also part of a geologically-complex region that is referred to as a tectonic suture zone. While modern tectonic processes in suture zone settings can be easily monitored and studied, geologists know very little about the origin and tectonic history of crustal fragments that make up the older, deeper geologic basement of suture zones.

95 per cent of Alaska consists of accreted terranes. Can you outline some of the implications of this?

One of the most significant implications for regions that have undergone accretionary tectonic processes is the occurrence of large magnitude earthquakes along terrane suture boundaries. Accretionary events are marked by an intense period of tectonic activity including erosion, exhumation and sedimentation, where crustal material is added or sutured onto a continental margin. The latest stages of accretion are marked by the development of continent-scale strike-slip faults that initiate along the suture boundary. These sutures can represent weak zones in the upper crust, and many of the strike-slip faults that develop adjacent to accreted terranes can remain seismically active for millions of years after the accretionary event. For example, the Denali fault of southern Alaska which remains seismically active today developed over 90 million years ago on a Mesozoic suture that borders the southern margin of the Alaska Range.

What inspired this project and the decision to track the Siberian-Laurentian Detrital Transition in the Farewell terrane in southwestern Alaska?

The idea for this project originated after discussions with geoscientists at the U.S. Geological Survey (USGS) and the Alaska Division of Geological and Geophysical Survey (DGGS). For several decades, researchers at both agencies have been conducting regional geologic mapping projects throughout remote parts of southwest Alaska. My chief motivation for this project was to build on these contributions by conducting detailed field studies – and a sample collection campaign – at a number of key geologic localities within the Farewell terrane. The Farewell terrane is a crustal fragment that contains thick stratigraphic successions of clastic sedimentary rocks that are thought to record periods of erosion, exhumation, and sedimentation. By studying the provenance of these sedimentary rocks, we can better understand which source areas were eroding to supply sediment during the early- and late-stage tectonic history of Farewell terrane.

Tracking **detrital transitions**

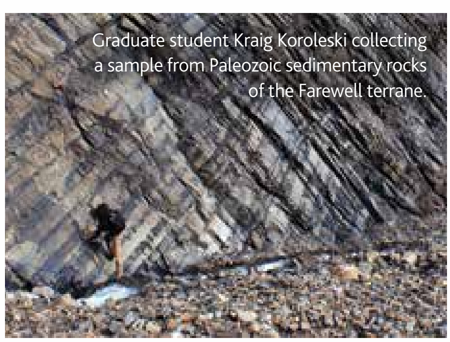
Ongoing studies at **Michigan State University** and **New Mexico State University** combining fieldwork with zircon geochronology are seeking to clarify both the Palaeozoic development of the North American Cordillera and the tectonic processes underpinning southern Alaska

THE AMERICAN CORDILLERA is a chain of mountain ranges extending from Antarctica in the south to Alaska in the north and running almost continuously along the Western edges of South America, Central America and North America en route. Whilst large stretches of the Cordillera have been studied extensively, the origin and tectonic history of many of the crustal fragments which constitute the deeper sections of the Alaska Range remain largely unknown. Responding to this gap in knowledge, a two year-long study based at Michigan State University in East Lansing, Michigan and New Mexico State University (NMSU) in Las Cruces, New Mexico, is seeking to develop understanding of the Farewell terrane of southwestern Alaska. Led by Dr Brian Hampton, an Assistant Professor in the Department of Geological Sciences at NMSU, and funded by the National Science Foundation (NSF), the groundbreaking research is expected to shed light on one of the Cordillera's most remote and poorly-understood mountain belts.

FIELDWORK

Tectonostratigraphic terranes, or terranes for short, are fragments of crustal material which have broken away from a tectonic plate and become accreted or sutured onto another, retaining a distinct geology from the plate of which they detached. The Farewell terrane is both geologically essential and geographically central to Alaska's terrane system, yet its origins are poorly understood. Hampton's study is one of the first to examine the clastic sedimentary basin deposits which constitute the terrane's middle and upper Palaeozoic sections, and is beginning with some basic fieldwork in the region. "These field components will involve two summer seasons, each consisting of between four and six weeks of backcountry fieldwork in a number of remote localities in the western Alaska Range," he explains.

One of the key aims of these expeditions is to conduct geological mapping at a variety of important locations within the Farewell terrane, with a specific focus on documenting geological contacts between the oldest, middle and youngest parts of the terrane. Hampton and his collaborators will also be focusing on describing, measuring and collecting samples from Palaeozoic stratigraphic intervals from both the middle and youngest parts of the terrane. Following the initial field drop – which, due to the rugged and remote nature of the Alaska Range, is performed either by helicopter or fixed-wing plane – the researchers must first locate a safe and advantageous location to set up their tents and camp. Once this has been completed, the itinerary for such a trip usually consists of around one or two weeks spent in a given field locality to carry out mapping, stratigraphic measuring and sample collection, before the researchers are picked up and taken back to civilisation to restock, wash clothes and mend or replace any lost or damaged gear. This type of fieldwork is an essential component of Hampton's work, and he is confident that the results will be essential to deciphering the terrane's origins.



Graduate student Kraig Koroleski collecting a sample from Paleozoic sedimentary rocks of the Farewell terrane.

DETRITAL ZIRCON GEOCHRONOLOGY

In order to garner a clearer understanding of the origin of sand grains which they collect from sedimentary basins, many geologists are increasingly relying on the analysis of detrital zircon grains, and Hampton is no different. "Zircon crystals," he elucidates, "originate in magmatic systems and the uranium-lead (U-Pb) age of an individual zircon reflects the age of crystallisation, ultimately helping to determine the age of a magmatic source area". One of the biggest advantages of this approach is that zircon is highly resistant to erosion, meaning it can be found throughout the stratigraphic record in very old Precambrian rocks as well as modern sediments. Ages determined by U-Pb dating of zircon grains in sedimentary rocks can effectively be used as a form of geological fingerprint, revealing the age of magmatic sources that were being eroded during tectonic events.

Hampton and his students have relied on the experience of researchers from the Arizona LaserChron Center in the Geoscience Department at the University of Arizona. The LaserChron Center is an NSF multi-user facility that is equipped with a specialised laser that can ablate parts of the zircon grains, and a mass spectrometer to measure the atomic ratios of uranium, thorium and lead, to determine the ages of individual zircon sand grains. Fascinatingly, Hampton and his students collect anywhere from 15-20 samples in any one field season which, once analysed, can consist of more than 1500-2000 U-Pb ages from the Farewell

Can you detail the project's core objectives?

The primary goal of this project is to characterise the provenance of Palaeozoic sedimentary rocks in the Farewell terrane in order to better understand both where the terrane originated from and where it has travelled. There are several competing hypotheses for the origin and paleogeographic transport history of the Farewell terrane. The first suggests that it originated somewhere further south along the western margin of North America and has since been tectonically transported up the margin to Alaska. A second suggests that the Farewell originated in Siberia and was tectonically transported from Siberia to North America through a Palaeozoic ocean passageway known as the Uralian Seaway. One of the main aims of this project is to test these hypotheses by comparing the provenance trends from the Farewell terrane with potential magmatic source areas throughout western North America and Siberia.

What does the project's education outreach component provide?

We have been involved with meeting and holding a series of short courses with local primary and secondary teachers, introducing them to some of the basic geologic themes of this project. Short-course sessions are aimed at helping teachers to use Alaska as a near-modern analogue for many of the same processes that they can observe where they live. The ultimate goal is to work with teachers to find an effective way of introducing very basic tectonic themes to students who are in the early stages of their primary or secondary education.

TRACKING THE SIBERIAN-LAURENTIAN DETRITAL TRANSITION IN THE FAREWELL TERRANE, SOUTHWESTERN ALASKA

OBJECTIVES

To determine the provenance (source) of Paleozoic sedimentary rocks of the Farewell terrane in southwest Alaska and use results to constrain the origin and tectonic transport history of the Farewell.

KEY COLLABORATORS

Arizona LaserChron Center, University of Arizona, USA

U.S. Geological Survey, Alaska Science Center, USA

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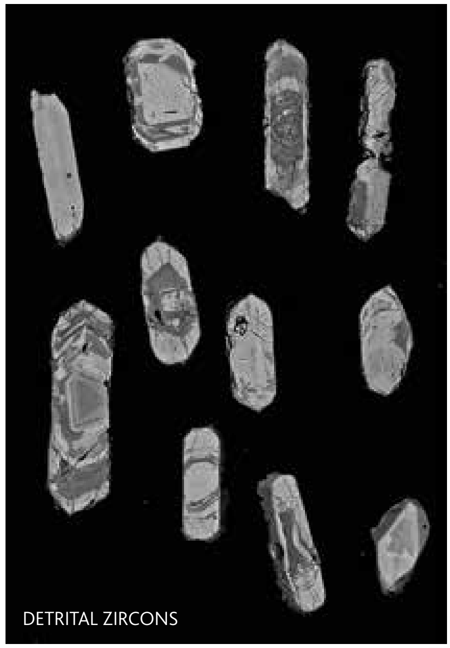
BRIAN HAMPTON received his graduate degrees from Louisiana State University and Purdue University. His research focus is on ancient and active tectonic settings with specific emphasis on the stratigraphic history of erosion and sedimentation associated with mountain building processes. He has conducted tectonic- and basin-scale research projects throughout southern Alaska, the central Andes and parts of eastern Russia.


DETRITAL ZIRCONS

terrane. These data are some of the first of their kind from the Farewell terrane and, together with new mapping and measured stratigraphic sections, are proving to be very useful to understanding the tectonic evolution of southwest Alaska.

PRELIMINARY FINDINGS

Although the research is ongoing, Hampton and his collaborators have so far produced some fascinating preliminary findings. Extrapolating provenance data from some of the older sedimentary rock they collected, the researchers have been able to identify a significant overlap with magmatic source areas located along continental margins of the Uralian Seaway, suggesting sections of the Farewell terrane are likely to have originated from Siberian or Baltic regions in the East, rather than from the Cordillera. Additionally, preliminary provenance trends from younger sections of the terrane appear to demonstrate a strong association with areas in the northwestern parts of the Cordillera. "At present we are analysing additional data from these younger stratigraphic intervals to determine when the Farewell terrane was in close proximity to its present location in the North American Cordillera," Hampton summarises. He is confident that the findings will have significant and widespread implications, elucidating not only the Palaeozoic development of the Farewell terrane but also the tectonic development of southwestern Alaska.

THE NEXT GENERATION OF GEOLOGISTS

Throughout his pioneering research into the Alaska Range, Hampton has provided both graduate and undergraduate students with the opportunity to become involved in this cutting-edge practice. To this end, a number of students have participated in field work and laboratory analysis. Hampton enthuses that "students have the chance to work in some of the more remote, exposed and tectonically complex regions of southern Alaska in which context they are privy to the basics of responsible backcountry camping and the challenges and rewards of living and conducting research in delicate alpine tundra environments". Students have also been involved in laboratory sample preparation and U-Pb dating with Hampton and researchers at the Arizona LaserChron Center. Hampton has ensured that each and every participating student has been involved at a research level, carrying out either graduate or undergraduate projects and formally presenting their findings at the university and national conferences. Only through initiatives such as this is it possible for academics such as Hampton to both break new ground in an influential and important field and have a hand in helping the next generation of geologists to learn the skills and techniques necessary to conduct worldclass research.

Fieldwork has formed both a fulfilling and essential component of Hampton's research