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Detrital Zircon Geochronology of Proterozoic to Devonian Rocks in Interior Alaska

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This newsletter promotes the January luncheon talk of the Alaska Geological Society to be held Thursday, January 17th at the BP Energy Center, Anchorage.

Alaska Geological Society Luncheon

Date & Time: **Thursday, Jan. 17th, 11:30 am - 1 pm**

Program: **Detrital Zircon Geoch**

Speaker: **Dwight Bradley, USGS**

Place: **BP Energy Center**

Reservations: **Please make your reservation before noon Tuesday, Jan. 15th , 2008.**

Cost:

Seminar only, no meal:		**free**
Reserve a hot lunch*:		
	Members:	**$20**
	Nonmembers:	**$22**
Reserve a box lunch:		
	Member:	**$13**
	Nonmember:	**$15**
No Reservation: (on an "as-available" basis only)		**$25 hot / $18 box**

***If there are not enough hot lunch requests to reach catering minimum, a box lunch reservation will be substituted.**

E-mail reservations: **peterags@acsalaska.net Or phone (907) 334-5329**

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Abstract:

Background: Detrital zircon geochronology is a rapidly growing field that can yield several types of information bearing on problems of stratigraphy, regional geology, tectonic evolution, and geodynamics. Detrital zircons—especially in active tectonic settings—often provide new age constraints on the depositional age of the host sandstone or metasandstone, which can be no older than the youngest zircons. This is especially important in strata that are devoid of fossils. Detrital zircons can be linked to possible bedrock source regions by their age and this, in turn, can bear on the timing of tectonic events such as juxtaposition of terranes. Detrital zircon age distributions (commonly referred to as "barcodes"; see Figure 1) can be used to evaluate possible stratigraphic correlations between sandstone- or metasandstone-bearing units. This information has applications in geologic mapping at the quadrangle scale (making decisions about problematic rocks), and on a regional scale (matching displaced parts of an originally continuous sedimentary or metasedimentary succession). Finally, detrital zircons may be the only surviving record of rocks that have since been removed from the geologic record or are now on the other side of the world.

Most sandstones and metasandstones contain detrital zircons. In sampling, compositionally mature sandstones are preferred because they tend to yield more zircons than immature sandstones. In addition, very coarse to medium-grained sandstones are preferred over finer- or coarser-grained rocks, which yield zircons so small that they present analytical problems. A 5 kg sample will generally yield hundreds to thousands of zircons. Like igneous zircons, detrital zircons are extracted by crushing the rock and then using a combination of density and magnetic separation techniques (detrital zircons are quite sturdy and generally survive the process unbroken). Zircons are dated by the U-Pb method. Two analytical procedures are in common use today, each with its pros and

cons. The ion microprobe (e.g., SHRIMP) features a narrow ion beam that analyzes the U and Pb from a very shallow depression that the beam excavates in the polished surface of the zircon crystal, allowing analyses of only the most favorable zones. The other common technique is laser-ablation inductively coupled mass spectrometry (LAICPMS), which employs a much wider beam that burns a deep hole into or even through each zircon crystal, including any bad parts. Analytical costs being comparable, the tradeoffs are between spatial resolution (better on the SHRIMP), sample destruction (no on SHRIMP, yes on LAICPMS), and speed (five times faster on the LAICPMS). Sixty zircons per sandstone are generally analyzed by SHRIMP, compared to 100 grains by the faster LAICPMS.

Results. Detrital zircon populations have now been analyzed for all major terranes in interior Alaska that are thought to include Precambrian rocks (Figs. 1 and 2).

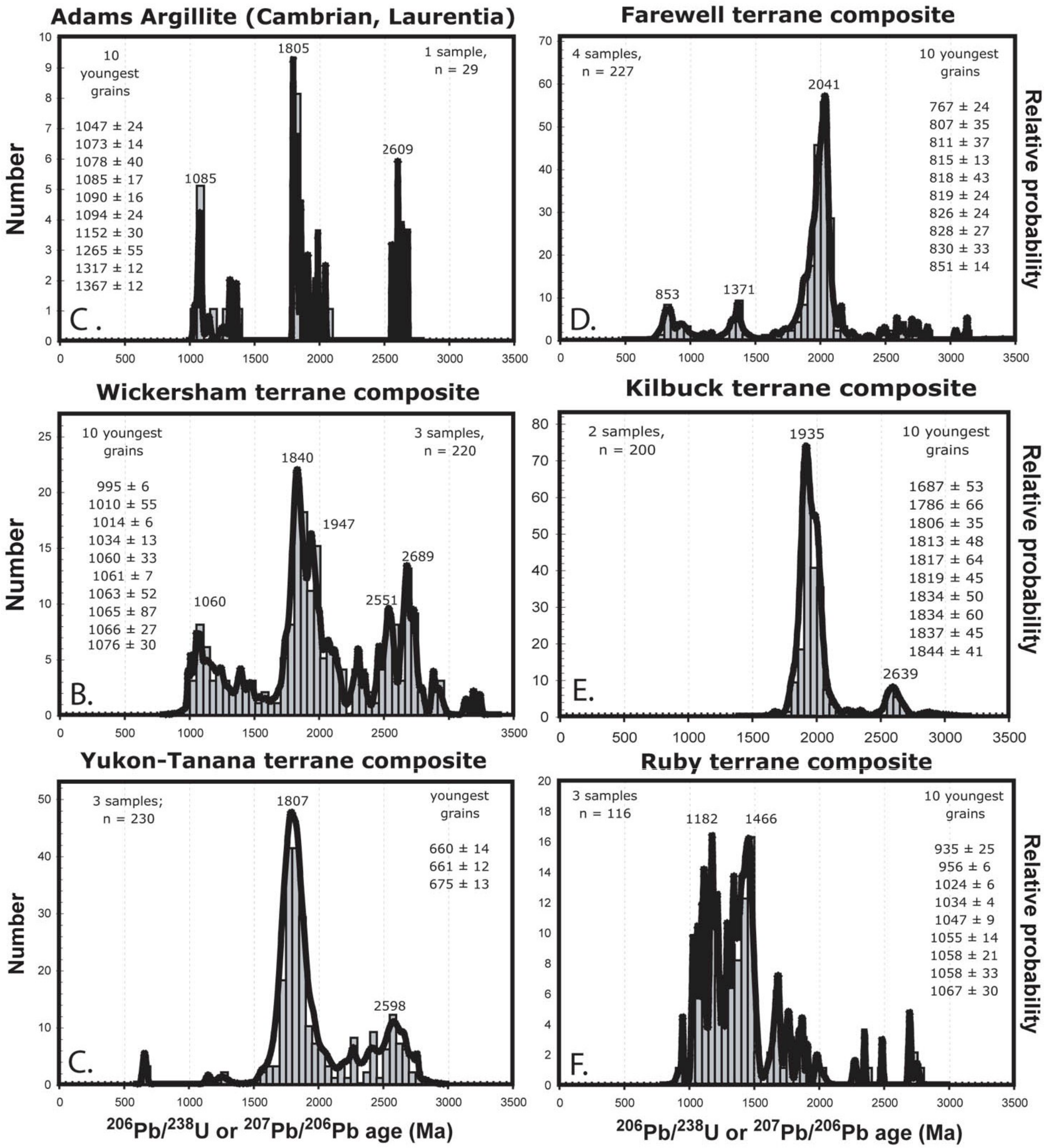
Laurentia. The term Laurentia refers to the Precambrian nucleus of North America plus Greenland. The only Neoproterozoic to early Paleozoic rocks in Alaska that are of undisputed Laurentian origin crop out north of the Yukon River in easternmost Alaska (Fig. 2). Detrital zircon data have been reported from Cambrian and Devonian strata by Gehrels et al. (1999); detrital zircons from Neoproterozoic strata have not yet been dated. The Cambrian Adams Argillite has distinctive triple zircon peaks at 1085, 1805, and 2609 Ma (Fig. 1a), all traceable to Laurentian sources. The Devonian Nation River Formation has similar peaks at 1838, 1922 and 2740 Ma, as well as a peak at 431 Ma. A Silurian zircon source is not known from western Laurentia, which was the site of a passive margin at that time, nor from exotic terranes in interior Alaska; the ca. 430-Ma zircons must have been derived from an outboard source that is no longer nearby.

Wickersham terrane. The Wickersham terrane, which consists of coarse sandstone ("grit"), red and green mudstone, and minor limestone of inferred late Neoproterozoic to Cambrian age, is mapped in Livengood and Tanana quadrangles (Weber et al., 1992; Chapman et al., 1982) (Fig. 2). These rocks show signs of low-grade metamorphism. A composite Wickersham barcode, based on 3 samples, has peaks at 1060, 1091, 1840, 1947, 2551, and 2689 Ma (Fig. 1b). This is quite similar to the barcode of the roughly coeval Adams Argillite and thus a Laurentian provenance is inferred

Yukon-Tanana terrane. The Wickersham is bounded to the southeast by higher-grade metasedimentary and metaigneous rocks that are assigned to the vast Yukon-Tanana terrane (Fig. 2). The Yukon-Tanana underlies much of east-central Alaska and has been traced as far southeast as the Alaskan panhandle, and as far southwest as the western Alaska Range. In addition to protoliths that seem to correlate with the Wickersham grit (Weber et al., 1985), the Yukon-Tanana terrane also includes a metamorphosed Devonian-Mississippian continental-margin magmatic belt (Dusel-Bacon et al., 2004). Detrital zircon data support a connection between the Wickersham and Yukon-Tanana terranes. A composite Yukon-Tanana barcode, based on 3 samples, shows peaks at 1807 and 2598 Ma and mainly differs from the composite Wickersham barcode in the absence of a so-called "Grenville" peak at about 1 Ga (Fig. 1c). The zircons are traceable to the Laurentian craton. A tuffaceous metasandstone in the Yukon-Tanana schist in the central Alaska Range (Unit Pzp-Cs of Csejtey et al., 1994) yielded mainly detrital zircons along with a few apparently pyroclastic zircons that define a young peak at about 670 Ma, suggesting a Neoproterozoic depositional age for these previously undated rocks.

Farewell terrane. The Farewell terrane is a microcontinental fragment in the western Alaska Range and Kuskokwim Mountains (Fig. 2) that includes both 850-980 Ma basement (McClelland et al., 1999; Bradley et al. 2003) and an overlying passive margin platform sequence (Nixon Fork subterrane) of late Neoproterozoic to Devonian age. Cambrian to Devonian fossils from the Nixon Fork subterrane are a mix of Siberian and North American faunas (Blodgett et al., 2002; Dumoulin et al., 2002) that rule out the once popular view of the Farewell as a displaced piece of the passive margin of western Canada (where Siberian faunas are lacking). A composite detrital zircon barcode of the Farewell terrane, based on 4 samples of late Neoproterozoic(?) and Cambrian quartzites, shows a dominant peak at 2051 Ma, suggesting derivation either from the Kilbuck terrane (see below), or basement rocks of the same age that are somewhere other than Alaska. A ca. 2050-Ma peak is seen in the detrital zircon barcode of the Paleoproterozoic to Mesoproterozoic (ca. 1650 to 1350 Ma) Uy Group along the eastern margin of the Siberia Craton (Khudoley et al., 2001). A Laurentian source is unlikely because of the absence of peaks at ca. 2.6, 1.8, and 1.0 Ga, which are the hallmark of sandstones of known Laurentian provenance.

Kilbuck terrane. The Kilbuck terrane and a displaced fragment of it called the Idono Complex (Fig. 2) contain the oldest known rocks in Alaska—granitic gneisses dated at 2050 to 2084 Ma. The Kilbuck terrane is now known to include at least one younger granite dated at 849 Ma (Bradley et al., 2007), strongly suggesting commonality with parts of the Farewell terrane. Detrital zircon data (Figs. 1d and 1e) also suggest a link. A composite detrital zircon barcode of the Kilbuck terrane, based on 2 samples of Mesoproterozoic(?) quartzite, shows a dominant peak at 1935 Ma. The main peaks of the Kilbuck and Farewell composites show substantial statistical overlap, and the Kilbuck composite is almost identical to one of the Farewell samples in particular. A ca. 1950-Ma peak is seen in the detrital zircon barcode of the Mesoproterozoic (ca. 1350 to 1000 Ma) Kerpyl Group along the eastern margin of the Siberia Craton (Khudoley et al., 2001), providing further support for a Siberian connection. Detrital zircons and a crosscutting



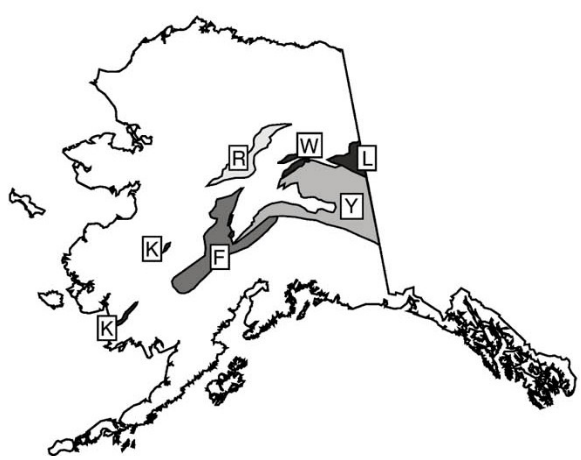


Figure 1 (above). Detrital zircon age distributions ("barcodes") for six rock units in interior Alaska. In each plot, the data are represented by histograms with 50-m.y. bins (gray rectangles) and by a probability density curve (heavy black line). The composite plots were made by combining data from all samples from each terrane, except, as noted in text, for omission of one Ruby terrane sample.

Figure 2 (left). Map of Alaska showing terranes discussed in text. L—Laurentia; W—Wickersham terrane; Y—Yukon-Tanana terrane; F— Farewell terrane; K-Kilbuck terrane; R—Ruby terrane. From Silberman et al. (1994).

pluton together provide the first age constraint on the depositional age of the Kilbuck terrane's supracrustal sequence, which must be between ca. 1800 and 850 Ma. Correlative strata might be sought in the upper Mesoproterozoic to Neoproterozoic (Riphean) succession of eastern Siberia.

Ruby terrane. The Ruby terrane is a belt of Neoproterozoic(?) and Paleozoic metasedimentary rocks located between the Yukon River and Brooks Range (Fig. 2). These rocks are of presumed continental margin affinity, and are intruded by Devonian orthogneiss and Early Cretaceous granites (Patton et al., 1994). A composite detrital barcode, based on 3 samples that have similar zircon populations, shows peaks at 1180 and 1470 Ma superimposed on a broad Mesoproterozoic high (Fig. 1f). The barcode is similar to that seen in Proterozoic Sequence B of the Canadian Northwest Territories (Rainbird et al., 1997) but also to the detrital zircon barcode of the ca. 1-Ga Uy Group of the eastern margin of the Siberia Craton (Khudoley et al., 2001). The detrital zircon barcode from a fourth sample from a thrust belt in the Ruby terrane is completely different from the other three, and was excluded from the Ruby composite shown in Figure 1. It is similar to Yukon-Tanana and Wickersham barcodes and hints at complexities that cannot be resolved with available data.

Summary. Detrital zircon geochronology is a powerful tool with many applications in regional geology and tectonics. At this early stage in Alaskan detrital zircon studies, the primary goal is to characterize all the major sandstone- and metasandstone-bearing rock units. The samples discussed here pertain to the early history of the older terranes and also provide a necessary foundation for understanding the post-Devonian assembly of the various terranes. Detrital zircon data support previously proposed but debatable connections between the Wickersham terrane, the Yukon-Tanana terrane, and the triangle of Laurentia in easternmost Alaska. The Farewell and Kilbuck terranes appear to be parts of the same microcontinent, and the zircon data are consistent with the paleontological evidence for a Siberian link. The distinctive detrital zircon barcode of the Ruby terrane raises two intriguing possibilities: that the Ruby might include strata as old as 1 Ga, and that the terrane could have a Siberian origin. Given the time elapsed and typical rates of plate motion, interpretations of detrital zircon data from Devonian and older rocks require a world view, supported by global databases of both igneous and detrital zircon geochronology.

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Speaker's Biography:

Dwight Bradley is a researcher in tectonics with the U.S. Geological Survey in Alaska. He grew up in Red Sox country. Dwight got his bachelor's degree in Geology at University of Vermont, and his Ph.D. in 1984 at the State University of New York at Albany. He was a postdoctoral fellow at Johns Hopkins and a Research Scientist at Lamont-Doherty before joining the USGS in Anchorage in 1987. Dwight has researched strike-slip and foreland basins in the Appalachians, the Devonian time scale, tectonic settings of carbonate-hosted lead-zinc deposits, passive margins through Earth history, and the geology of Mauritania. In Alaska, Dwight has worked on regional geologic mapping in south-central and southwestern Alaska, the tectonics of ridge subduction, and— the topic of today's talk— detrital zircon geochronology.
