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Structure of the western Brooks Range fold and thrust belt, Arctic Alaska

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Abstract: This study summarizes the structure of the western Brooks Range fold and thrust belt of Arctic Alaska. The fold and thrust exposes a series of NE-SW-trending, NW-transported and regionally folded thrust sheets. Emplacement of thrust sheets results from ophiolite obduction and telescoping of the ancient continental passive margin of Arctic Alaska in the Cretaceous. Integration of stratigraphic, structural and geophysical data suggests that the structure of the fold and thrust belt is controlled by inheritance of NW-SE-trending Paleozoic structures of the pre-existing continental margin.

Keywords: fold thrust belt, structure, Brooks Range, Alaska, Arctic, duplex, triangle zone.

The Brooks Range fold and thrust belt and the adjacent North Slope foreland basin have seen in recent years a growing interest in both petroleum and in mineral exploration. Recent petroleum assessments estimate that the foothills of the Brooks Range and the North Slope foreland basin contain as much as 32 TCF of gas (Bird and Houseknecht, 2002) while the fold and thrust belt hosts the world's largest zinc deposits (Young, 2004). Previous studies have mainly focused on the central and eastern Brooks Range. This study summarizes the structure of the western Brooks Range fold and thrust belt.

Plate tectonic setting and location of the study area

The Brooks Range, the northernmost orogenic belt of Alaska, is located approximately 1000 km north of the present-day convergent plate margin between the North American and Pacific plates (Fig. 1). The Brooks Range lies north of a series of terranes that were accreted during Mesozoic and Cenozoic time and were subsequently disrupted by Cenozoic to present-day continental-scale strike-slip fault systems (Fig. 1).

Regional framework

The Brooks Range is an E-W- to NE-SW-trending and N- to NW-verging, thin- to thick-skinned Late Jurassic to Tertiary arc-continent collision orogenic belt (Fig. 2), formed as a result of the obduction and collision of a continental passive margin (Arctic Alaska terrane) and an oceanic crust slab and island arc (Angayucham and Koyukuk terranes) (Mull, 1982; Moore *et al.*, 1994; Young, 2004).

The ancient continental margin of the Arctic Alaska terrane was telescoped and is now exposed in a series of NE-SW-trending and NW-transported, regionally-folded thrust sheets that have been historically referred to as allochthons (Fig. 2). The thrust sheets of the Arctic Alaska terrane are structurally overlain by the Angayucham terrane, interpreted as an ophiolite. A relatively undeformed foreland basin filled with deep to shallow marine strata lies ahead of the thrust front to the northwest (Fig. 2).

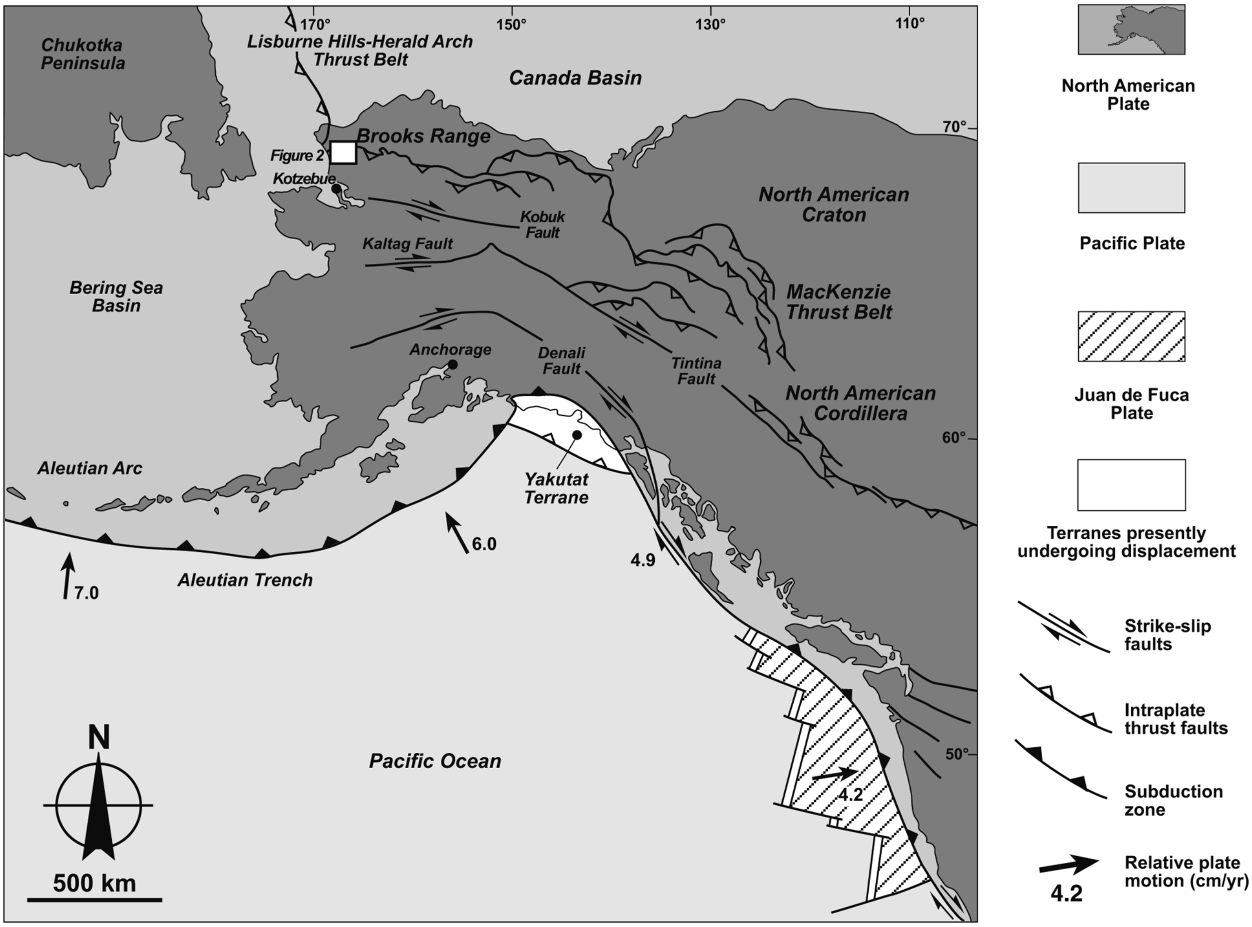

Figure 1. Plate tectonic setting of the Brooks Range and location of the study area (compiled from Plafker and Berg, 1994; Moore *et al.*, 1994).

Regional stratigraphy

The stratigraphy of the western Brooks Range consists of Late Devonian through Jurassic siliciclastic and calcareous strata that record continental to deep marine sedimentation on the ancient continental passive margin of Arctic Alaska (Fig. 3). These successions were telescoped in the Early Cretaceous and are now preserved in a series of regional thrusts sheets. The stratigraphy of the region can be subdivided into four depositional megasequences, here referred to as the syn-rift, post-rift, early and late syn-orogenic megasequences. The syn-rift megasequence consists predominantly of siliciclastic and carbonate strata of Late Devonian to Pennsylvanian age (Fig. 3). The post-rift megasequence is dominated by a condensed succession of shales and cherts that are unconformably overlain by turbidites and mass-transport complexes of the Early and Late syn-orogenic megasequences (Fig. 3).

Regional structure

The fold and thrust belt consists of seven tectonostratigraphically distinct thrust sheets or allochthons. The lowermost of these is the Endicott Mountains allochthon, which is overlain by the structurally higher Picnic Creek, Kelly River, Copter Peak and Misheguk Mountain allochthons (Figs. 3 and 4), each representing a distinct part of the ancient continental margin. These allochthons are regionally folded, forming a series of regional antiforms and synforms. Antiforms reflect the development of duplexes and antiformal stacks at the lower structural levels (e.g. Mount Raven and Husky Hills antiforms) (Fig. 4). Structural styles are dominated by low-angle thrust faults, duplexes and km-scale fault-related folds. Kinematic indicators show a dominant NW tectonic transport direction with localized transport to the NNE along lateral ramp structures.

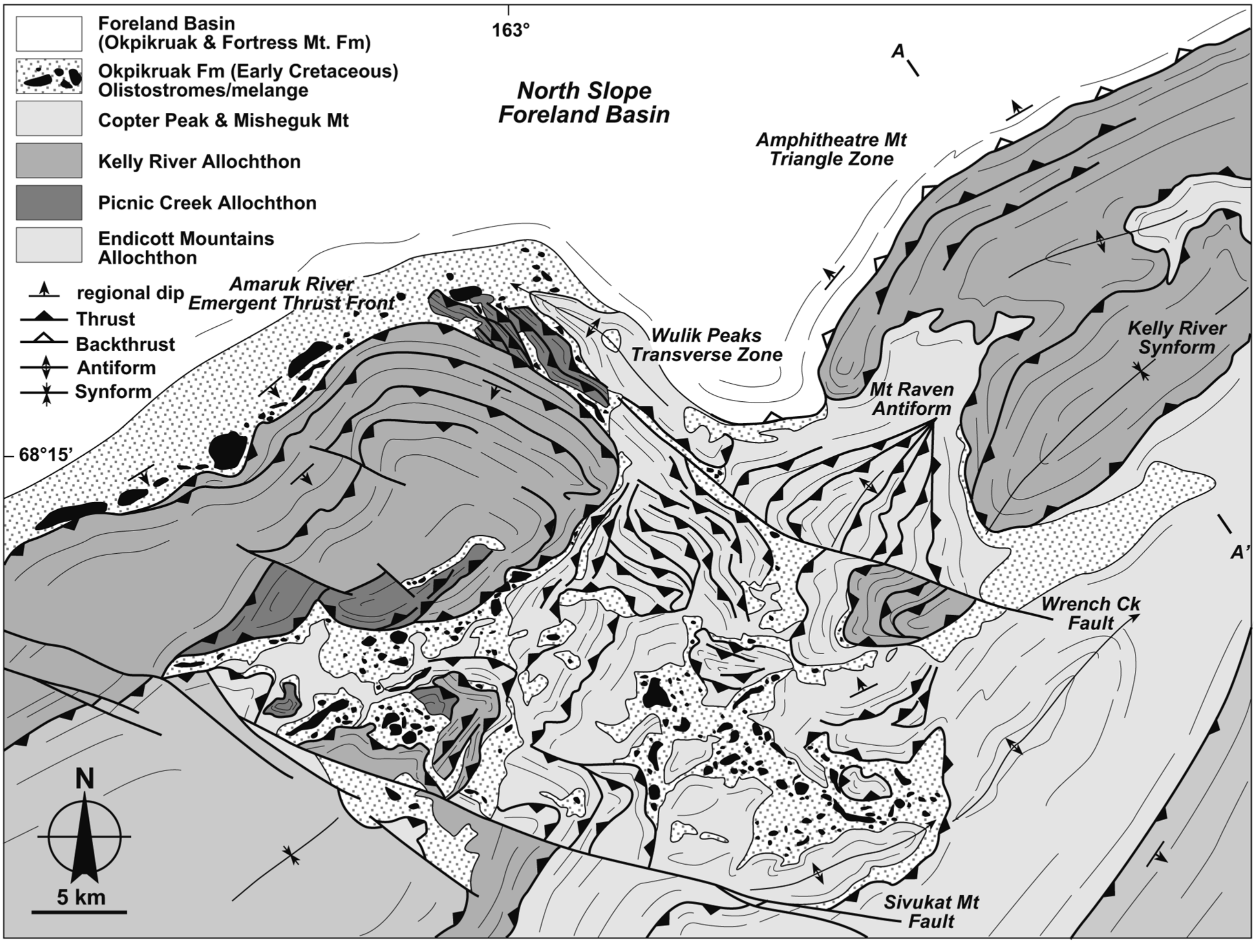

Figure 2. Regional geological map of the western Brooks Range.

Structure of the thrust front

The thrust sheets of the western Brooks Range are separated from relatively undeformed strata of the North Slope foreland basin by a well-developed thrust front, whose position, orientation, vergence and structural styles vary significantly along-strike (Fig. 2). These changes are best represented by the Wulik Peaks transverse zone, a regional-scale feature along which the thrust front trends at a high angle to the dominant NE-SW-trending structural grain of the fold and thrust belt (Fig. 2). NE of the Wulik Peaks transverse zone the thrust front is defined by the Amphitheatre Mountain triangle zone and to the SW by the Amaruk River emergent thrust front (Figs. 3 and 4).

Wrench creek and Sivukat mountain faults

The dominant NE-SW-trending structural grain defined by the thrust sheets of the western Brooks Range is offset by a series of WNW-ESE-trending and dominantly SE-dipping high angle faults. These features are best represented by the Wrench Creek and Sivukat Mountain faults (Fig. 2). These two faults exert a control on the topography and show km-scale extensional throws. The spatial relationship between the Wrench Creek fault and the Wulik Peaks transverse zone suggests that these faults might have originated as tear faults that were subsequently extensionally reactivated in the Tertiary.

Discussion and conclusions

The Brooks Range is a premier example of a telescoped continental passive margin. Structural, stratigraphic, and geophysical data suggest that the along-strike changes in the geometry and position of the thrust front and the development of the Wulik Peaks transverse zone resulted from the inheritance in the Early Cretaceous of Late Devonian to Jurassic WNW-ESE- to NW-SE-

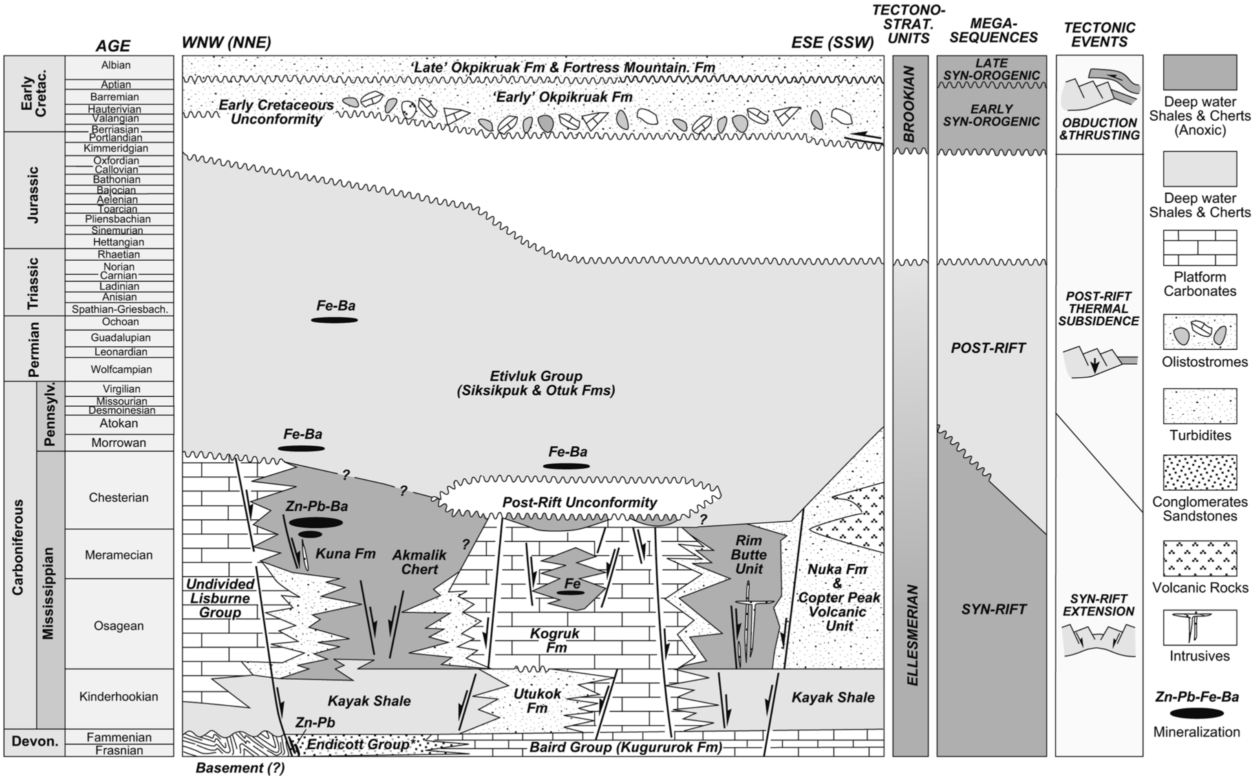

Figure 3. Regional chronostratigraphy of the western Brooks Range.

trending extensional faults of the ancient continental margin (Sooner River arch) (Fig. 5). WNW-ESE-trending Tertiary (Eocene) to present-day extensional faults record extensional reactivation of the Wulik Peaks transverse zone and close a remarkable cycle of Late Devonian to Present Day inheritance of WNW-ESE- to NW-SE-trending fault systems.

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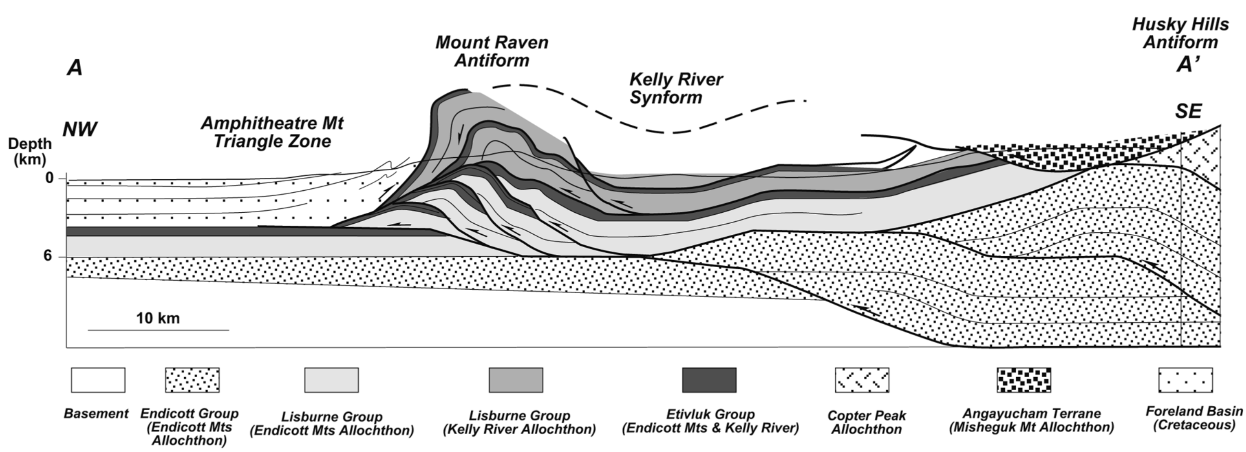

Figure 4. Schematic cross section illustrating the structural styles of the western Brooks Range. Refer to figure 2 for approximate location of the section.

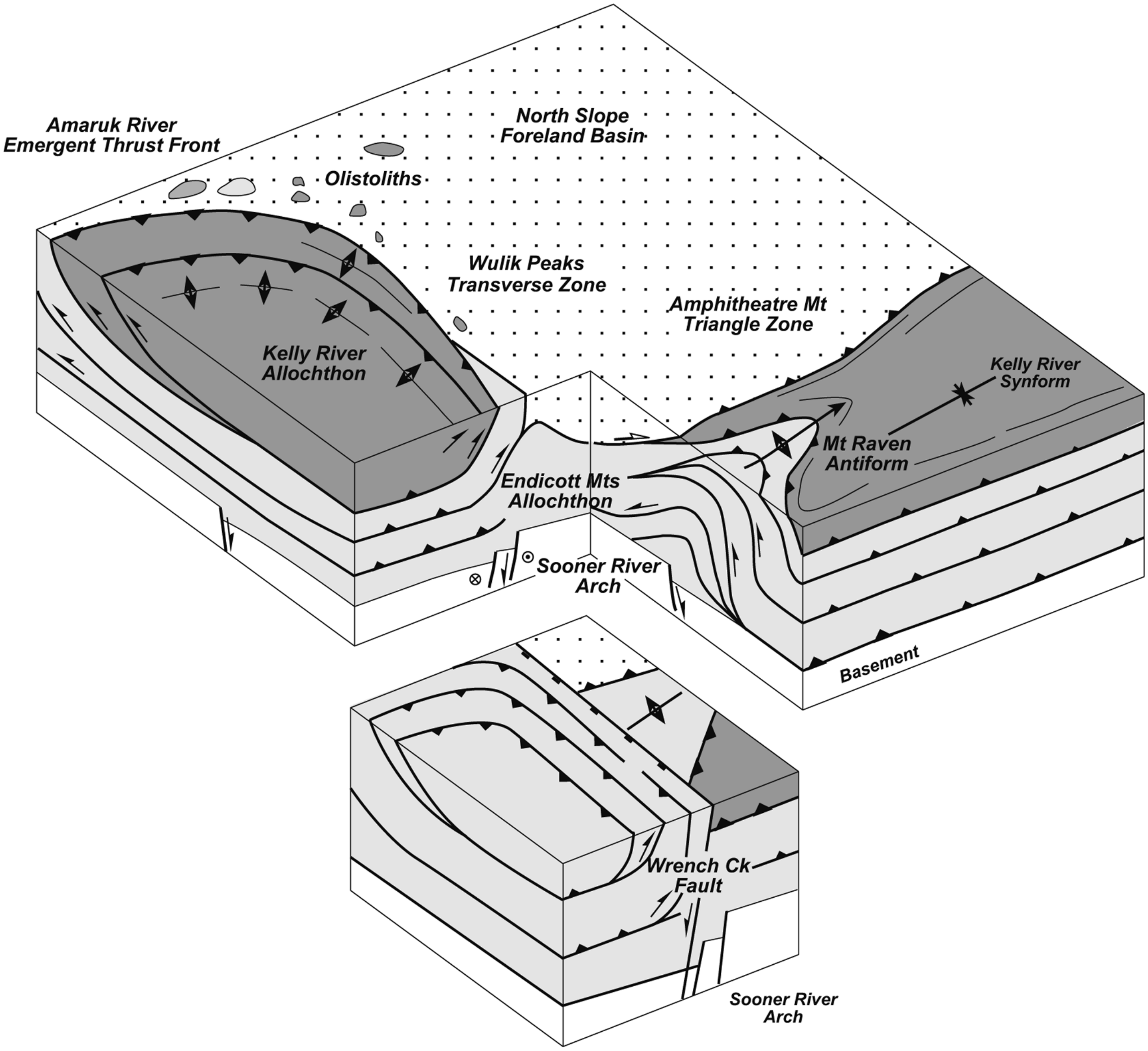

Figure 5. 3D synoptic diagram illustrating the control of pre-existing extensional faults on the structure of the thrust front of the western Brooks Range.

References

BIRD, K. J. and HOUSEKNECHT, D. W. (2002): *Petroleum resource assessment of the National Petroleum Reserve Alaska (NPRA): Play maps and technically recoverable resource estimates.* U.S. Geol. Surv. Open-file Report 02-027, 18 pp.

MOORE, T. E., WALLACE, W. K., BIRD, K. J., KARL, S. M., MULL, C. G. and DILLON, J. T. (1994): Geology of northern Alaska. In: G. PLAFKER and H. C. BERG (eds): *The Geology of Alaska. Geol. Soc. Am., Boulder, Colorado*, G-1: 49-140.

MULL, C. G. (1982): Tectonic evolution and structural style of the Brooks Range, Alaska: an illustrated summary. In: R. B. POWERS (ed): *Geological studies of the cordilleran thrust belt. Volume 1*, Rocky Mountains Association of Geologists: 1-45.

PLAFKER, G. and BERG, H. C. (1994): An overview of the geology and tectonic evolution of Alaska. In: G. PLAFKER and H. C. BERG (eds): *The Geology of Alaska. Geol. Soc. Am., Boulder, Colorado,* G-1: 989-1021.

YOUNG, L. E. (2004): A geologic framework for mineralization in the western Brooks Range. In: K. D. KELLEY and S. JENNINGS (eds): *A special issue devoted to barite and zinc-lead-silver deposits in the Red Dog district, western Brooks Range, northern Alaska. Econ. Geol.*, 99: 1281-1306.