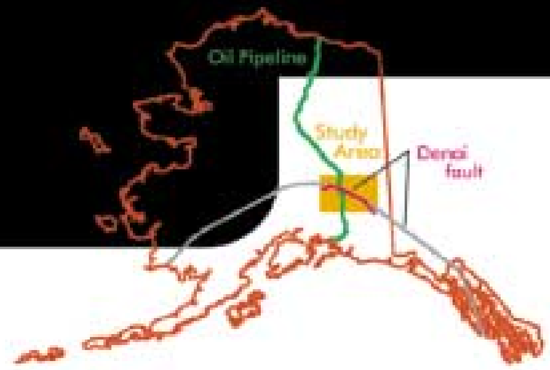
Alaska



Geologic Map Aids Mitigation of **Earthquake Damage**

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Defining the Problem

The 800-mile long **Trans-Alaska Pipeline** can carry 2 million barrels of oil per day — equal to 17% of the nation's daily consumption. A major earthquake along the Denali Fault where the pipeline crosses the Delta River in the rugged Alaska Range, could cause a potentially **catastrophic** oil spill.

The Geologic Map

Geologic mapping of bedrock and unconsolidated deposits along the 1,000 mi. extent of the **Denali Fault** revealed a long and complex history that involved large-scale dominantly horizontal right-lateral slip, as well as local vertical separations (Fig. 1). The geologic map (Fig. 2) shows the distribution of several regional terranes, as well as many local details, along the active fault.

Applying the Geologic Map

By matching geologic units of known age on opposite sides of the fault, geologists determined that horizontal offset totals about 280 mi. since Early Tertiary time (55-65 million years ago): about 22 mi. since early Oligocene time (38 million years ago); and 98-164 yds. since the late Pleistocene glacial maximum (8,000-12,000 years ago). On the basis of the relative freshness of **fault** features, it was determined that the eastern 220 mi. of the Denali and Totschunda fault system — including the pipeline **crossing** — was the most likely segment to have movement which could generate an 8+ magnitude earthquake.

Conclusion

On November 3, **2002**, the magnitude 7.9 **earthquake** generated by movement along the Denali fault and the Totschunda fault was the largest ever recorded in North America from a dominantly strike-slip event. Horizontal and vertical surface fault offsets were as much as 30 and 3.3 ft. respectively, and violent and prolonged shaking triggered thousands of landslides and avalanches. The **pipeline** remained intact despite ground offset beneath the pipeline of 18 ft. horizontally and 3.3 ft. vertically within a zone about 230 ft. wide, and violent shaking. Survival of the pipeline was a **triumph** of innovative engineering design that met stringent earthquake design specifications (Fig. 3). The pipeline was able to withstand the largest recorded earthquake for the Denali fault without spilling a drop of oil and with only 3 days shutdown time for inspections. The survival of the pipeline demonstrates the value of combining careful **geologic studies** of earthquake hazards and creative engineering design.

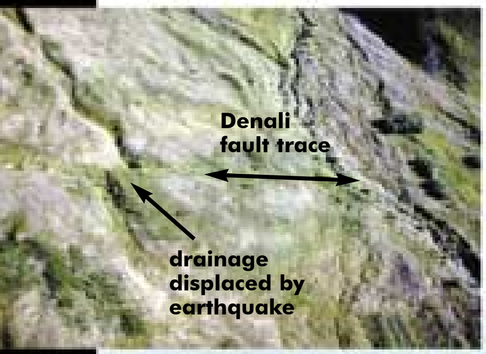
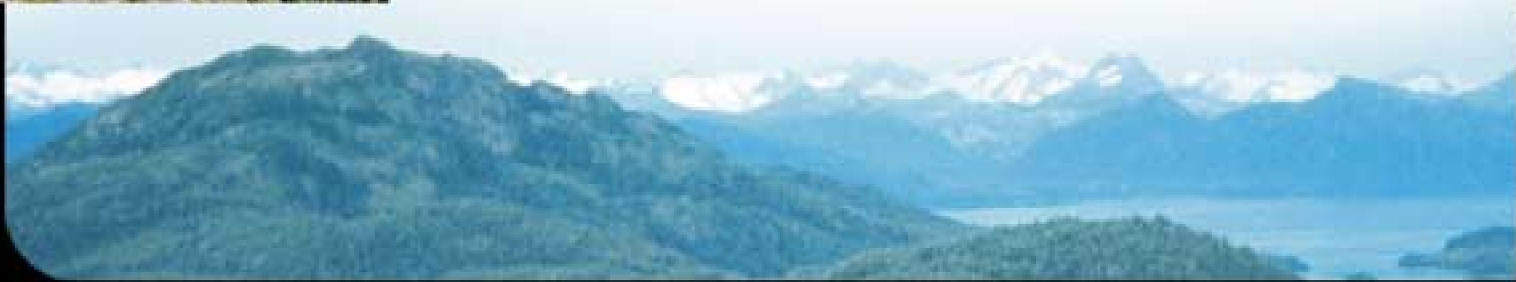


Fig. 1. An earthquake offset the drainage shown in this 1976 aerial view of the Denali Fault by 26 ft. horizontally and 5 ft. vertically. Sites such as this one provided the data for designing the pipeline fault crossing.



geologic map

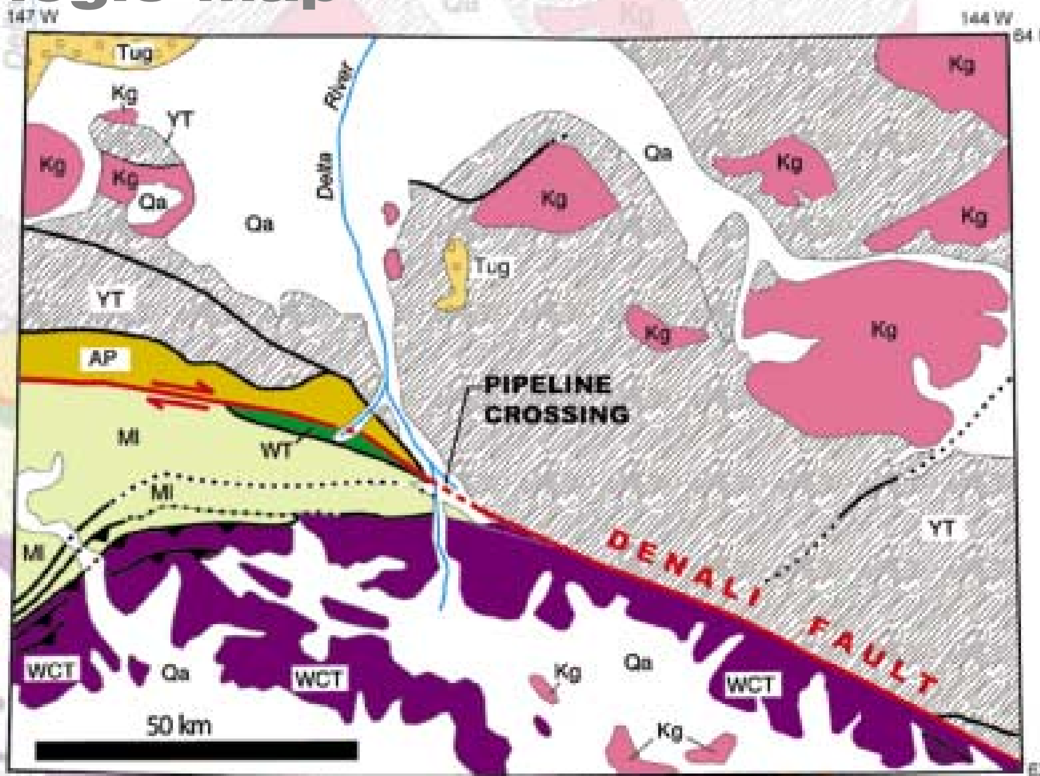


Fig. 2. Geologic map of part of the 2002 Denali Fault rupture near the Trans-Alaska Pipeline crossing in the Alaska Range. Note the striking contrast in rock type and age of units on opposite sides of the fault.

Fig. 3. View of part of the Trans-Alaska Pipeline at the Denali Fault showing major design features. Fault movement and intense ground shaking were accommodated by zigzagging the pipeline and leaving it free to slide by supporting it on Teflon shoes mounted on long horizontal steel slider beams that parallel the fault trend. This slider design was used in a corridor 1900 ft. wide to accommodate uncertainties in the exact position of the fault trace at the pipeline crossing.