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Quantitative mineralogy of the Yukon River system: Changes with reach and season, and determining sediment provenance

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Abstract

The mineralogy of Yukon River basin sediment has been studied by quantitative X-ray diffraction. Bed, beach, bar, and suspended sediments were analyzed using the RockJock computer program. The bed sediments were collected from the main stem and from selected tributaries during a single trip down river, from Whitehorse to the Yukon River delta, during the summer of 2001. Beach and bar sediments were collected from the confluence region of the Tanana and Yukon Rivers during the summer of 2003. Suspended sediments were collected at three stations on the Yukon River and from a single station on the Tanana River at various times during the summers of 2001 through 2003, with the most complete set of samples collected during the summer of 2002.

Changes in mineralogy of Yukon River bed sediments are related to sediment dilution or concentration effects from tributary sediment and to chemical weathering during transport. Carbonate minerals compose about 2 wt% of the bed sediments near Whitehorse, but increase to 14 wt% with the entry of the White River tributary above Dawson. Thereafter, the proportion of carbonate minerals decreases downstream to values of about 1 to 7 wt% near the mouth of the Yukon River. Quartz and feldspar contents of bed sediments vary greatly with the introduction of Pelly River and White River sediments, but thereafter either increase irregularly (quartz from 20 to about 50 wt%) or remain relatively constant (feldspar at about 35 wt%) with distance downstream. Clay mineral content increases irregularly downstream from about 15 to about 30 wt%. The chief clay mineral is chlorite, followed by illite + smectite; there is little to no kaolinite. The total organic carbon content of the bed sediments remains relatively constant with distance for the main stem (generally 1 to 2 wt%, with one exception), but fluctuates for the tributaries (1 to 6 wt%).

The mineralogies of the suspended sediments and sediment flow data were used to calculate the amount of mineral dissolution during transport between Eagle and Pilot Station, a distance of over 2000 km. We estimate that approximately 3 wt% of the quartz, 15 wt% of the feldspar (1 wt% of the alkali and 25 wt% of the plagioclase), and 26 wt% of the carbonates (31 wt% of the calcite and 15 wt% of the dolomite) carried by the river dissolve in this reach.

The mineralogies of the suspended sediments change with the season. For example, during the summer of 2002 the quartz content varied by 20 wt%, with a minimum in mid-summer. The calcite content varied by a similar amount, and had a maximum corresponding to the quartz minimum. These modes are related to the relative amount of sediment flowing from the White River system, which is relatively poor in quartz, but rich in carbonate minerals. Suspended total clay minerals varied by as much as 25 wt%, with maxima in mid July, and suspended feldspar varied up to 10 wt%. Suspended sediment data from the summers of 2001 and 2003 support the 2002 trends.

A calculation technique was developed to determine the proportion of various sediment sources in a mixed sediment by unmixing its quantitative mineralogy. Results from this method indicate that at least three sediment sources can be identified quantitatively with good accuracy. With this technique, sediment mineralogies can be used to calculate the relative flux of sediment from different tributaries, thereby identifying sediment provenance.