SEASONAL VARIATION OF GOLD CONTENT OF STREAM SEDIMENTS, HARRIS CREEK, NEAR VERNON: A PROGRESS REPORT* (82L/02)

By W. K. Fletcher and S. J. Day
Department of Geological Sciences,
The University of British Columbia

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INTRODUCTION

Results of a preliminary study of seasonal variations of gold content in Harris Creek were given by Day and Fletcher (1987a). Subsequently, Day and Fletcher (1987b) presented a model for transport of gold in Harris Creek and suggested that heavy-mineral concentrates collected from bar-head gravels could provide a good exploration medium. To study seasonal variations at such sites, bar-head gravels at a single site have been sampled five times between July 1986 and July 1987. Results for these samples are presented and discussed in relation to the transport model developed by Day and Fletcher (1987b).

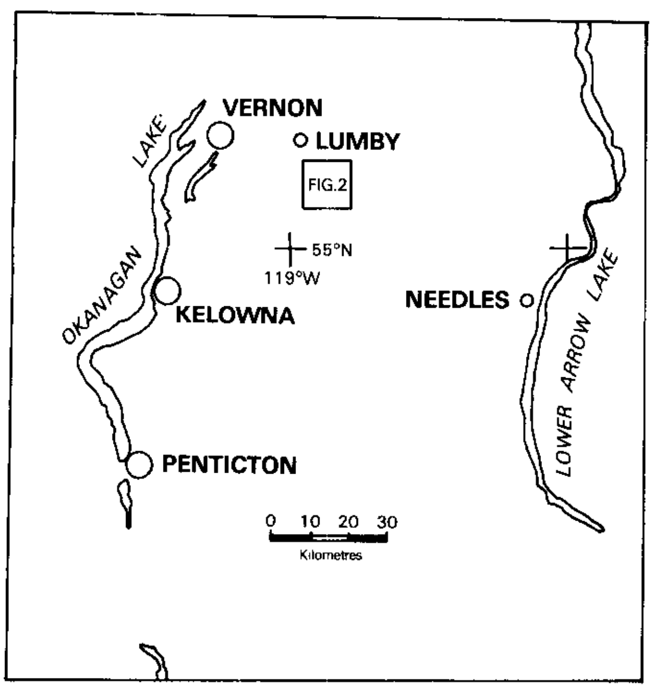

Figure 5-6-1. Location of Harris Creek.

LOCATION

Harris Creek rises in the Okanagan Highlands east of Vernon and flows north through Lumby (Figure 5-7-1). It was selected for study because it has exceptionally high gold concentrations and is easily accessible. The study reach, which has no major confluences, is approximately 2 kilometres long and 25 kilometres from the watershed (Figure 5-7-2). It has an energy slope of 0.03 and gravel point-bars are well developed in a typical sequence of alternating riffles and pools. Bulk sediment samples for this study were collected near the head of a gravel bar, site M1, at the downstream end of the reach.

SAMPLING METHODS

Previous studies of gold in Harris Creek (Day and Fletcher, 1986, 1987b) have shown that very large samples are nec-

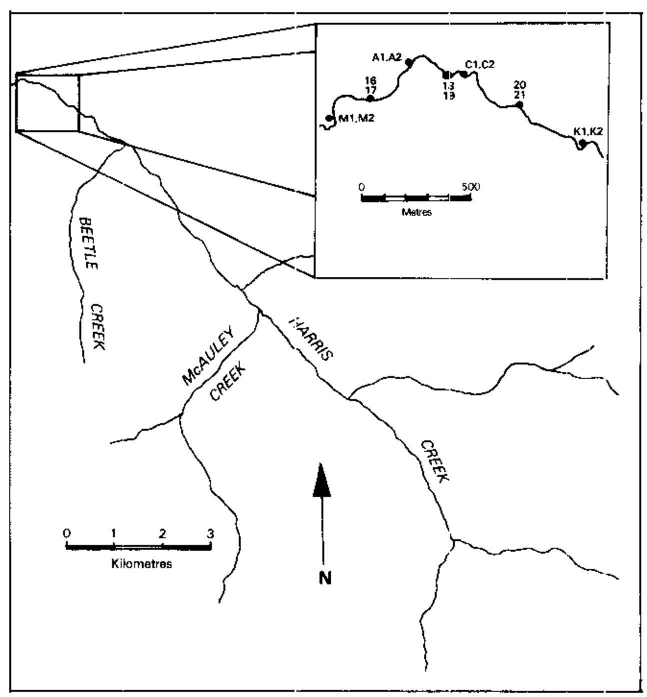

Figure 5-6-2. Catchment basin of Harris Creek, upstream from the study reach. Inset, sampling sites on the study reach — all samples used in this study were taken near the upstream head of the gravel bar at site M1.

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cessary to ensure sample representivity. Samples therefore consisted of approximately 50 kilograms of –10-mesh (2-millimetre) sediment obtained by field screening up to 300 kilograms of gravel dug from a square metre area of the active stream bed. Samples were obtained in this way from adjoining 1-square-metre areas of the bar on July 28 and October 1, 1986 and April 7, 1987. This resulted in three shallow pits that only disappeared after the stream bed had been reworked by high discharges associated with the 1987 freshet. Two additional samples were then collected from the restored bed of the stream, at the site of the original pits, on June 20 and July 11, 1987.

Samples were dry-sieved to eight fractions, using a Rotap, and then manually wet-sieved to clean up the finer fractions. Heavy-mineral concentrates were prepared for the −150+200 and −200+270-mesh (ASTM) fractions using methylene iodide (S.G. = 3.3) and analysed for gold by instrumental neutron activation.

RESULTS

Results are summarized in Table 5-6-1. Between July 1986 and April 1987 heavy mineral concentrations on the bar declined, with the greatest decrease (approximately 40 per cent) in the finer size fraction. Concentrations then showed an increase on June 20, shortly after the 1987 freshet, before declining to their final value.

Gold concentrations in the −200+270-mesh heavy-mineral fraction show similar but much stronger trends than the heavy-mineral fraction. Thus concentrations initially decrease from 3900 ppb in July 1986 to only 53 ppb in April 1987. A post-1987 freshet increase to 830 ppb in June then fell to 130 ppb over a three-week period. Gold concentrations in the −150+200-mesh fraction also decreased between July 1986 (1600 ppb) and April 1987 (260 ppb). However the decrease then continued with concentrations falling below the detection limit (5 ppb) in June and July following the 1987 freshet.

TABLE 5-6-1
SEASONAL VARIATIONS IN CONCENTRATIONS OF HEAVY MINERALS AND GOLD IN BAR-HEAD GRAVELS AT SITE M1, HARRIS CREEK

Date	Heavy Minerals (%)[1]		Gold (ppb)[2]	
	Size Fraction			
	−150+200	−200+270	−150+200	−200+270
1986				
July 28	9.83	8.40	1600 (1070-2275)	3900 (3390-4470)
October 1	7.56	5.78	140 (15-440)	1000 (690-1360)
1987				
April 7	7.49	4.97	260 (90-600)	53 (5-200)
June 20	8.19	6.77	<5 (0-260)	830 (520-1240)
July 11	7.09	6.30	<6 (0-260)	130 (35-350)

[1] Weight per cent heavy minerals S.G. >3.3.

[2] Concentration of gold in the heavy mineral fraction; 80% confidence limits shown in parentheses.

DISCUSSION

The limited size of the bar and large sample size prevents use of replicate sampling to establish confidence limits to the gold content of the gravels at any one time. However, the sampling variability of discrete grains of a very rare mineral can be approximated by the Poisson distribution (for example, Fletcher, 1981; Ingamels, 1974; Phillips, 1971). Confidence limits have therefore been calculated using the Poisson distribution[1] and an estimate of the number of particles of free gold in each sample. This was obtained by assuming that the minimum mass of gold (that is, gold concentration times weight of heavy-mineral fraction) in a series of samples of the same size fraction corresponds to the mass of a single particle of free gold in that fraction. Calculated (80 per cent) confidence limits (Table 5-6-1 and Figure 5-6-3) only overlap with those of samples collected on adjoining dates for the low gold contents found in the −150+200-mesh fraction from October 1986 on. It is therefore believed that the major trends in gold concentration versus time are probably real, rather than random variations in gold content of the gravels.

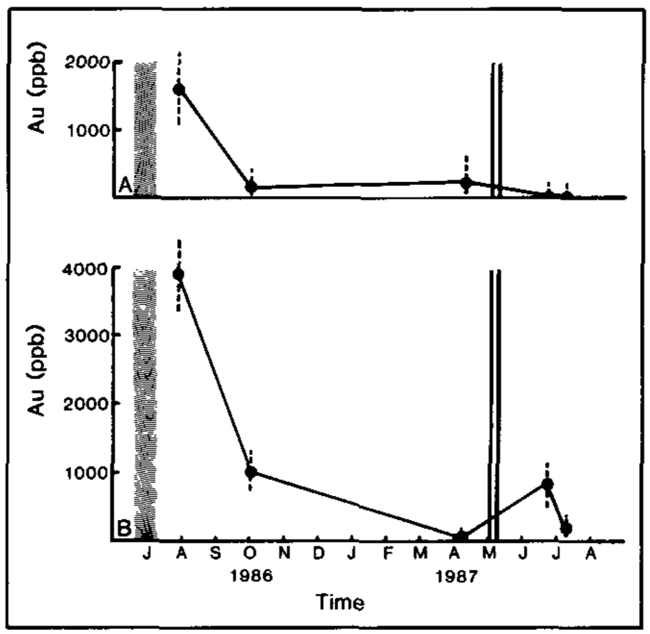

Figure 5-6-3. Gold concentrations in heavy mineral fraction (S.G. = 3.3) versus time at site M1, A: −150+200 mesh; B: −200+270 mesh. Vertical dashed lines indicate the 80 per cent confidence limits on the gold concentrations. Shaded areas indicate the periods (June 19-July 11, 1986, and April 30-May 2 and May 7-May 10 1987) when stream discharges at Environment Canada Station 08LC042, near Lumby, exceeded 10 cubic metres per second (unpublished data, Environment Canada). Note: This station is downstream from the now inoperative Station 08LC005 and discharges at this site are typically twice as large as those shown in Figure 5-6-4.

[1] A table of the confidence limits of expectation of a Poisson variable is given by Pearson and Hartley (1966) or can be calculated from the χ^2 distribution (Zar, 1984).

Heavy-mineral concentrations can develop on a stream bed in response to either their selective deposition as sediment is transported over the bed or winnowing of lighter minerals from the bed. For Harris Creek, Day and Fletcher (1987b) have suggested that the accumulation of gold in bar-head gravels results from its preferential deposition and entrapment at these sites as stream discharge falls after the freshet. In contrast, lighter minerals and very fine heavies are more likely to be swept over bars and collect in back-bar eddy pools. In this model, concentrations of gold in the bar-head gravels would be expected to decline with time as stream discharge continues to fall after the freshet and less dense minerals are progressively deposited in the voids of the gravel pavement to dilute the gold. [Infilling of voids in gravels by finer sediment has been described by Einstein (1968), Beschta and Jackson (1979) and Frostick *et al.* (1984).]

A typical hydrograph for Harris Creek (Station 08LC005, Environment Canada, 1984) shows a short period in May (or June) when discharge increases by about an order of magnitude due to the snowmelt freshet (Figure 5-7-4). Discharge then falls rather smoothly and asymptotically over a two-month period to reach baseline discharges of less than 1 cubic metre per second by early August. Unfortunately monitoring at station 08LC005 was discontinued in 1984. Gold and heavy mineral abundances in this study cannot, therefore, be directly related to stream discharge for 1986-87. Nevertheless, the association of high concentrations of gold with periods of high discharge is consistent with the model of Day and Fletcher (1987b) for its early preferential entrapment in the gravels as the freshet subsides. In this respect, it is interesting that the heavy mineral and gold concentrations found during and shortly after the strong freshet of 1986 were appreciably higher than those found after the very weak freshet of May 1987.

Despite the dramatic fall in gold concentrations with time, absolute abundance of heavy minerals in the samples remains relatively constant (10-20 grams and approximately 5 grams in the −150+200 and −200+270-mesh fractions, respectively) in all the samples. Simple dilution, as voids in the gravels are filled with less dense minerals, is therefore not responsible for the decreases observed in relative concentrations of gold. Alternative possibilities are that free gold gradually works its way down through the voids until it is below the sampled depth or as voids in the gravels are filled with fine sediment, a smaller volume of the stream bed (and thus a shallower depth) is sampled to obtain the requ red amount of −10-mesh sediment.

With respect to exploration geochemistry, the large variability in gold concentrations with values ranging from strongly anomalous to less than the detection limit within a 3-square-metre area of the stream bed, is extremely disturbing, whatever its cause. However, assuming that the seasonal trends are real, there is a considerable dilemma in recommending an optimum time for sampling. Enhanced concentrations of gold (and presumably anomaly contrast) are associated with periods of high discharge. Sampling at such times should therefore improve the chances of identifying catchments containing gold mineralization. However, high discharge events are typically of short duration (hours to days) and unpredictable. They are therefore likely to become a source of unwanted noise in geochemical or heavy mineral surveys that must often be undertaken over much longer periods of time. Conversely, samples collected when stream discharge is lower and more stable may give less variable gold values, but fail to detect the presence of anomalous concentrations in the catchment.

Clearly more studies are needed to establish the cause of the seasonal variations in gold concentrations and to avoid this as a problem in the design and interpretation of geochemical and heavy mineral surveys. Nevertheless, it is already apparent that, insofar as gold concentrations appear to be at least partly related to the seasonal cycles of stream erosion and deposition, the stream hydrographs published by the Water Resources Branch of Environment Canada (and similar agencies in other countries) could be useful in planning such surveys.

The size of the bar at site M1, and the need to take very large samples to ensure representivity, make adequate experimental replication difficult. The authors intend to continue the study through at least one more freshet in order to confirm the present observations and resolve their interpretation.

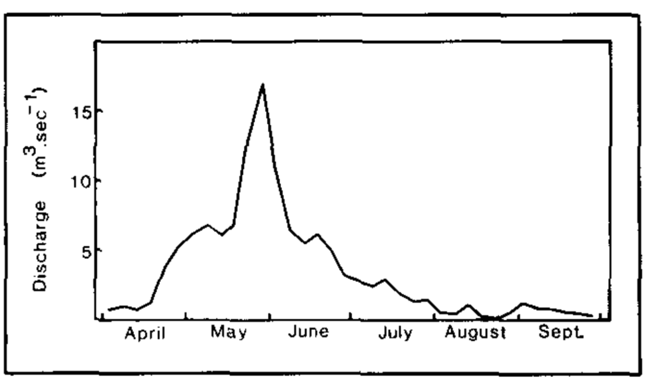

Figure 5-6-4. A typical hydrograph for Harris Creek; 5-day average discharges based on data for 1983 at Station 08LC005 (Environment Canada, 1984).

CONCLUSIONS

Gold content of stream sediments collected from gravel head-bars can show considerable seasonable variability. In Harris Creek maximum gold concentrations were found at or shortly after the periods of maximum discharge.

ACKNOWLEDGMENTS

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