COMUNICACIONES Nº 50 (1999): 87-90

BEHAVIOUR OF GOLD AND OTHER HEAVY MINERAL RELATED ELEMENTS IN STREAM SEDIMENTS: IMPLICATIONS FOR DESIGN AND INTERPRETATION OF EXPLORATION GEOCHEMICAL SURVEYS

W.K. FLETCHER

Earth & Ocean Sciences 6339 Stores Road University of British Columbia Vancouver, BC, Canada (fletcher@unixg.ubc.ca)

KEY WORDS: *Gold, heavy minerals, stream sediments*

INTRODUCTION

Stream sediment geochemistry, a widely used method of reconnaissance mineral exploration, is based on the premise that a sediment sample is representative of the products of weathering upstream of the sample site. It is also generally assumed that anomalous metal concentrations increase upstream towards the soil anomaly or bedrock source. However, for gold and other elements present in the stream as major constituents of heavy minerals, the relation between the anomaly source and the downstream geochemical anomaly is complicated by the fluvial processes that control transport of heavy minerals, and their deposition and accumulation on the stream bed. It will be shown that this has important consequences for the design and interpretation of stream sediment surveys with respect to where, when and what to sample.

To study the distribution of heavy mineral elements (HMEs) bulk sediment samples have been systematically collected from paired high and low-energy sites, at bar-heads and bar-tails respectively, downstream from mineralization. Element distribution has then been investigated for a range of size fractions and in relation to parameters such as stream width, depth and bed roughness. These studies have included gold in western Canada (Day and Fletcher, 1989, 1991; Hou and Fletcher, 1996) and Thailand (Paopongsawan and Fletcher,1993); scheelite in Yukon Territory, Canada (Saxby and Fletcher, 1986a); and cassiterite in Malaysia (Fletcher et al, 1987). In addition, pit traps have been used to obtain a more fundamental insight into effects of changing stream discharge on transport and deposition of heavy minerals (Fletcher and Wolcott, 1991; Fletcher and Loh, 1996a, 1996b, 1997).

Results of these studies show similar behaviour of HMEs in streams ranging from tropical rainforests to near-Arctic conditions. In particular, although concentrations of HMEs are generally greater in high energy environments, the difference in concentrations between high and low-energy environments decreases with decreasing grain size and becomes insignifcant as the sand-silt boundary at ~50 mm is approached (Table 1; Fig. 2). Results in Table 1 also show that, especially at low energy sites, concentrations of HMEs increase with decreasing grain size whereas there is considerably less variability related to grain size at high-energy sites.

Table 1: Comparison of concentrations of Sn in various size fraction of sediments from ten high and low energy environments in the S. Petal. All data in ppm. Data from Fletcher et al., (1987).

Size (mm)	Environment			
Element	High energy (n=10)	Low energy (n=10)	Ratio[1]	t[2]
<53	252 (24)[3]	260 (38)	1.03	-0.24
53-75	513 (38)	320 (54)	1.60	0.22
75-106	695 (63)	245 (41)	2.84	3.02
106-150	543 (60)	144 (35)	3.77	3.69
150-212	323 (95)	65 (55)	4.97	2.85
212-300	308 (78)	41 (55)	7.51	3.48
300-425	229 (169)	30 (27)	7.63	1.62
425-600	212 (171)	27 (32)	7.85	1.63

1: Ratio of concentration in high to low energy environment
2: t with 9 df $t_{.99} = 2.821$, $t_{.95} = 1.833$, $t_{.90} = 1.383$
3: Coefficient of variation (%)

Pit trap studies show that fine grained (<100 mm) light minerals are removed in suspension at the onset of bedload transport. This causes very fine-grained heavy minerals to be more or less uniformly concentrated on the stream bed (Table 1). Conversely, coarse grained heavy minerals are only concentrated in high energy environments which act as trap sites, particularly where there is also a decrease in stream gradient. This accumulation of coarse grained heavy mineral grains at trap sites can result in isolated anomalies that are displaced a considerable distance downstream from their source - the opposite of the usual dilution model of the relation between stream sediment geochemical anomalies and the location of their source (Fig. 2).

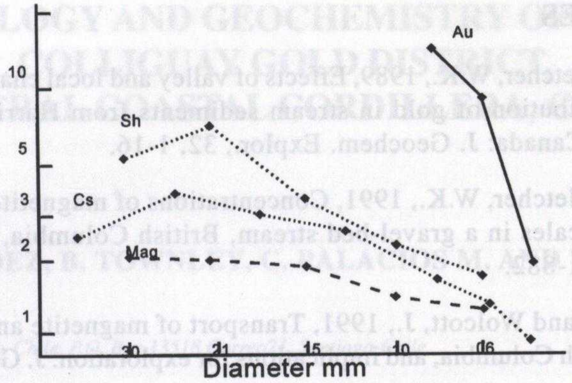

Fig. 1. The relation between grain size and the Geometric Mean Concentration Ratio (GMCR). The GMCR is the average ratio of the difference between HME concentrations in adjoining high and low energy environments. Au = gold; Sh = scheelite; Cs = cassiterite; and, Mag = magnetite. Based on Saxby and Fletcher (1986b).

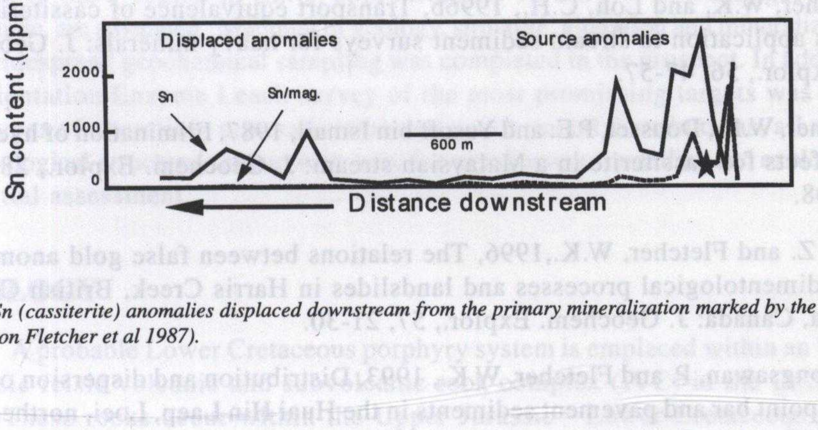

Fig. 2 Sn (cassiterite) anomalies displaced downstream from the primary mineralization marked by the asterisk (Based on Fletcher et al 1987).

CONCLUSIONS

These findings have important practical implications for the design and interpretation of stream sediment surveys for HMEs. In particular, the most consistent and longest anomalous HME dispersion trains are likely to be obtained by use of size fractions much finer (at least <100 mm and preferably <75 mm) than the traditionally used -80# (<180 mm) fraction. Because use of the fine sediment fractions minimizes variation in concentrations between adjoining locations on the stream bed, such samples can be collected from a variety of sites. However, it is easiest and fastest to collect suitable material at relatively low energy sandy sites. If coarser size fractions are analyzed larger samples are needed to ensure sample representativity and there is a greater chance of anomalies being displaced a significant distance downstream from their source.

REFERENCES

Day, S.J. and Fletcher, W.K., 1989, Effects of valley and local channel morphology on the distribution of gold in stream sediments from Harris Creek, British Columbia, Canada: J. Geochem. Explor., 32, 1-16.

Day, S.J. and Fletcher, W.K., 1991, Concentrations of magnetite and gold at bar and reach scales in a gravel-bed stream, British Columbia, Canada: J. Sed. Pet., 61, 871-882.

Fletcher, W.K. and Wolcott, J., 1991, Transport of magnetite and gold in Harris Creek, British Columbia, and implications for exploration: J. Geochem. Explor., 41, 253-274.

Fletcher W.K. and Loh, C.H. 1997, Transport and deposition of cassiterite by a Malaysian stream. J. Sed. Research, 67: 763-775.

Fletcher, W.K. and Loh, C.H. 1996a. Transport of cassiterite in a Malaysian stream: implications for geochemical exploration: J. Geochem. Explor., 57, 9-20.

Fletcher, W.K. and Loh, C.H., 1996b, Transport equivalence of cassiterite and its application to stream sediment surveys for heavy minerals: J. Geochem. Explor., 56, 47-57.

Fletcher, W.K., Dousset, P.E. and Yusoff bin Ismail, 1987, Elimination of hydraulic effects for cassiterite in a Malaysian stream: J. Geochem. Explor., 28, 385-408.

Hou, Z. and Fletcher, W.K.,1996, The relations between false gold anomalies, sedimentological processes and landslides in Harris Creek, British Columbia, Canada: J. Geochem. Explor., 57, 21-30.

Paopongsawan, P. and Fletcher, W.K., 1993, Distribution and dispersion of gold in point bar and pavement sediments in the Huai Hin Laep, Loei, northeastern Thailand: J. Geochem. Explor., 47, 251-268.

Saxby, D. and Fletcher, W.K. 1986a. Behaviour of scheelite in a Cordilleran stream. In: GEOEXPO/86 Symposium Volume, Association of Exploration Geochemists, Vancouver, 177-183.

Saxby, D. and Fletcher, W.K., 1986b, The geometric mean concentration ratio (GMCR) as an estimator of hydraulic effects in geochemical data for elements dispersed as heavy minerals. J. Geochem. Explor., 26, 223-230.