

# HEAVY METAL ANOMALIES IN STREAM SEDIMENTS

FIRST NAME \_\_\_\_\_ LAST NAME \_\_\_\_\_

## PART I - INTRODUCTION

This exercise is a follow-up to the lecture on mineral exploration. It provides you with a little first-hand experience on how the natural pollution associated with mineral deposits can be used to vector to their location during regional mineral exploration.

Sediment and water in streams provide information on the chemical composition of rocks in the drainage basin. Decomposition of rocks at the surface, releases clastic (rock and mineral fragments) and dissolved material that enters the stream. If an anomalous (unusual) concentration of elements is present in an area, it will be reflected in the stream water and sediment that drain the area. Thus, surveys that collect this material can be used to search for mineral deposits or anthropogenic pollution in a watershed. One type of anthropogenic pollution is waste rock that is left from mining and processing of mineral deposits. Although most modern operations do not release this material, waste released from mines that operated in the 1800's remains a problem in some areas.

The process by which rocks decompose at the surface is known as **weathering**. Weathering breaks rocks into clasts that range in size from boulders to ultra-small particles clay. Weathering also dissolves some minerals and disperses their constituent atoms in solution, first in pore waters in the soil and then in springs that feed water into streams and rivers. Most metals in ore deposits are in sulfide minerals, which usually dissolve during weathering. For example, the copper mineral chalcopyrite ( $\text{CuFeS}_2$ ) will dissolve to produce  $\text{Cu}^{2+}$  ions in aqueous solution (i.e., meteoric rain water that flows on the surface or through the subsurface). These dissolved ions often attach to the outer part of the clay-size particles by a process known as adsorption. Thus, by analyzing the amount of metal present in the fine-grained fraction of stream sediments, it is possible to detect upstream sources of the metals.

In general, metal concentrations in stream sediments are highest at the point in the river that is closest to the actual metal source, and decrease downstream until they reach the average or **background value** for that region. This decrease in metal content with distance from the source is caused largely by dilution with other sediment that contain lower concentrations of metal. As water flows down a stream, it erodes more and more sediment. So, any "anomalous", metal-rich sediment that entered the stream will be diluted gradually as the water flows downstream. More abrupt decreases take place at intersections between streams if a stream carrying sediment eroded from a mineral deposit merges with another stream that contains only sediment from rocks containing no mineral deposit. The amount of dilution depends on the relative volumes of sediment in the two streams.

If you were trying to locate an unknown source by following analyzed samples upstream and you came to the point where two rivers joined (let's say, the Arroyo Colorado and Arroyo Claro in the Dominican Republic), you probably would find that just above the junction one stream would have a low metal content. The other stream might have a higher metal content above the junction. If so, it would be identified as the stream that was draining the mineral deposit or polluted area.

## PART II - USE OF METAL CONCENTRATIONS TO SEARCH FOR NATURAL CONTAMINATION OF STREAM SYSTEMS

In order to recognize stream sediment samples that contain unusual or anomalous concentrations of metal, it is necessary to know the concentration of metal in samples that contain material from rocks that lack mineral deposits. This is the content of metal that would be there if the only source of metal for the stream were natural rocks of the region, with no mineral deposits or anthropogenic pollution. It is often referred to as the "background concentration" of the metal of interest. This value will vary depending on the type of rocks in the area and their chemical composition. After several streams in a region have been analyzed, it is possible to estimate a reasonable background value for the stream sediment samples in the area of interest. Knowledge of the background concentration is an important part of both exploration and environmental surveys. In both cases, it allows recognition of anomalous values. Without knowledge of the background, it is not possible to say that a value is anomalous....and therefore that it represents either natural or anthropogenic pollution.

If a surveyed region shows little or no variation in metal content across a wide area, then most values are at “background” and there is no near-surface metal source in the region --- either anthropogenic or natural ---- to create anomalous values. However, if some analyses have much higher metal contents than others, a metal source may be present. These high values are commonly known as anomalies because they are so different from the background values. The search for contaminant sources (whether natural or anthropogenic), then, is a search for anomalies.

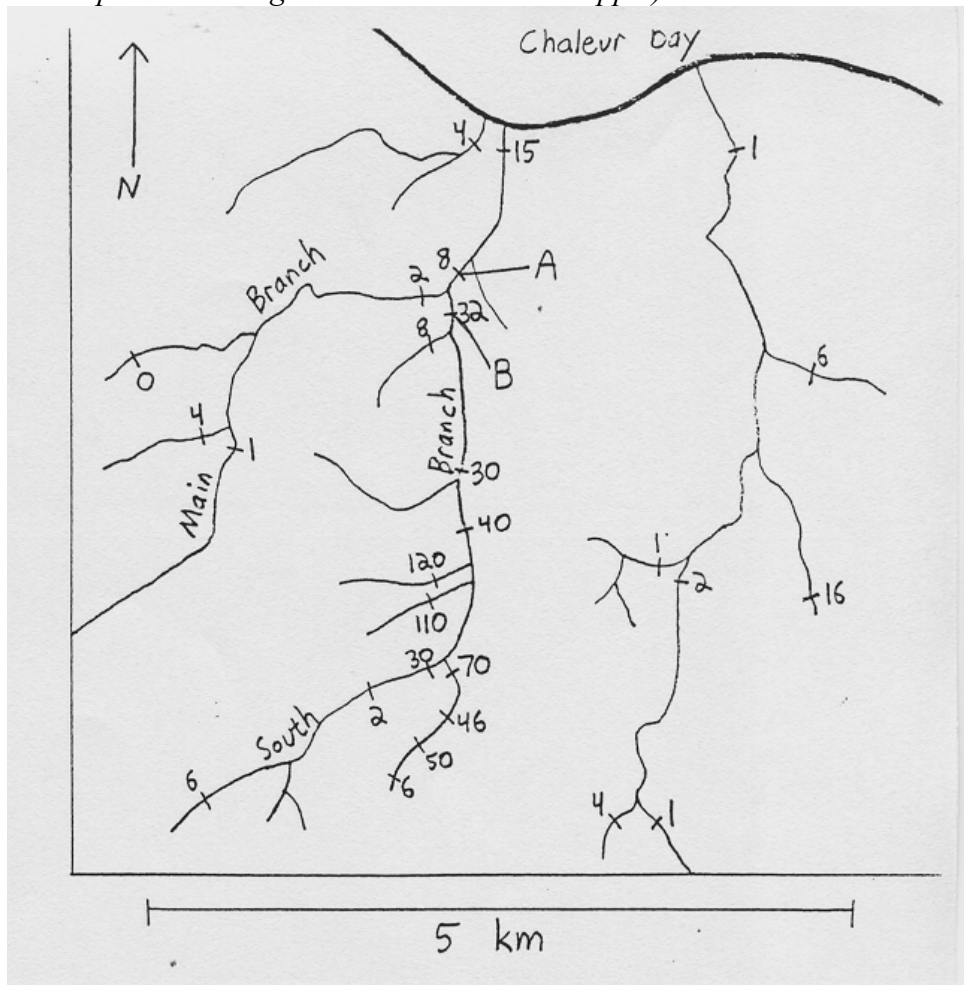
Natural Contamination of Stream Systems

Figures 1 through 3 show metal contents of stream sediments in three different parts of the world. All values are given in ppm (parts per million). The values are shown as cross marks across the stream at the point where the sediment was collected. Remember, water on Earth’s surface always flows down hill, and toward a larger body of water such as a bay or ocean. So you should be able to figure out the direction of water flow for each of the streams. If not, raise your hand and ask. Also, remember that streams flow in the lowest points in the valley (Areas between the streams are hills, and you can assume that the highest point on each hill is about midway between the two nearest streams. Please ask for clarification if this is confusing.

Using your knowledge of the general behavior of metals in sediments, answer the following questions about these three areas. The content of metal at the various sampled sites is shown as a number at each site (ppm metal).

**PART II- A**

Figure 1 – Lead content (in ppm) of sediment samples from the Nash Creek region, New Brunswick (numbers on sample locations give their lead content in ppm).



1) The values shown in Figure 1 (previous page) represent concentrations of lead in the stream sediment samples.

a) What is the highest lead concentration obtained in these sediment samples?

b) What is the lowest lead concentration?

c) What is the average (e.g. mean) of all lead concentrations?

2) Compare the average value (from #1 above) to the distribution of Pb concentrations for the entire area. Is the average value a good estimate of the background lead concentration in stream sediment samples in this area? Why or why not?

3) On Figure 1, circle the area(s) that is/are likely to contain a source of lead (e.g. a mineral deposit that is undergoing weathering). How did you determine where the mineral deposit is located? Can you tell how far from the river or creek the mineralized area might be (note that the map has a scale)? Explain.

## **PART II-B**

4) The survey shown in Figure 2 (next page) measured the copper content of stream sediments. Use the values of copper in these sediments to determine the likely location of the mineral deposit(s) that might have supplied anomalous amounts of copper to the streams. Circle the area of these deposits and explain how you determined the location(s).

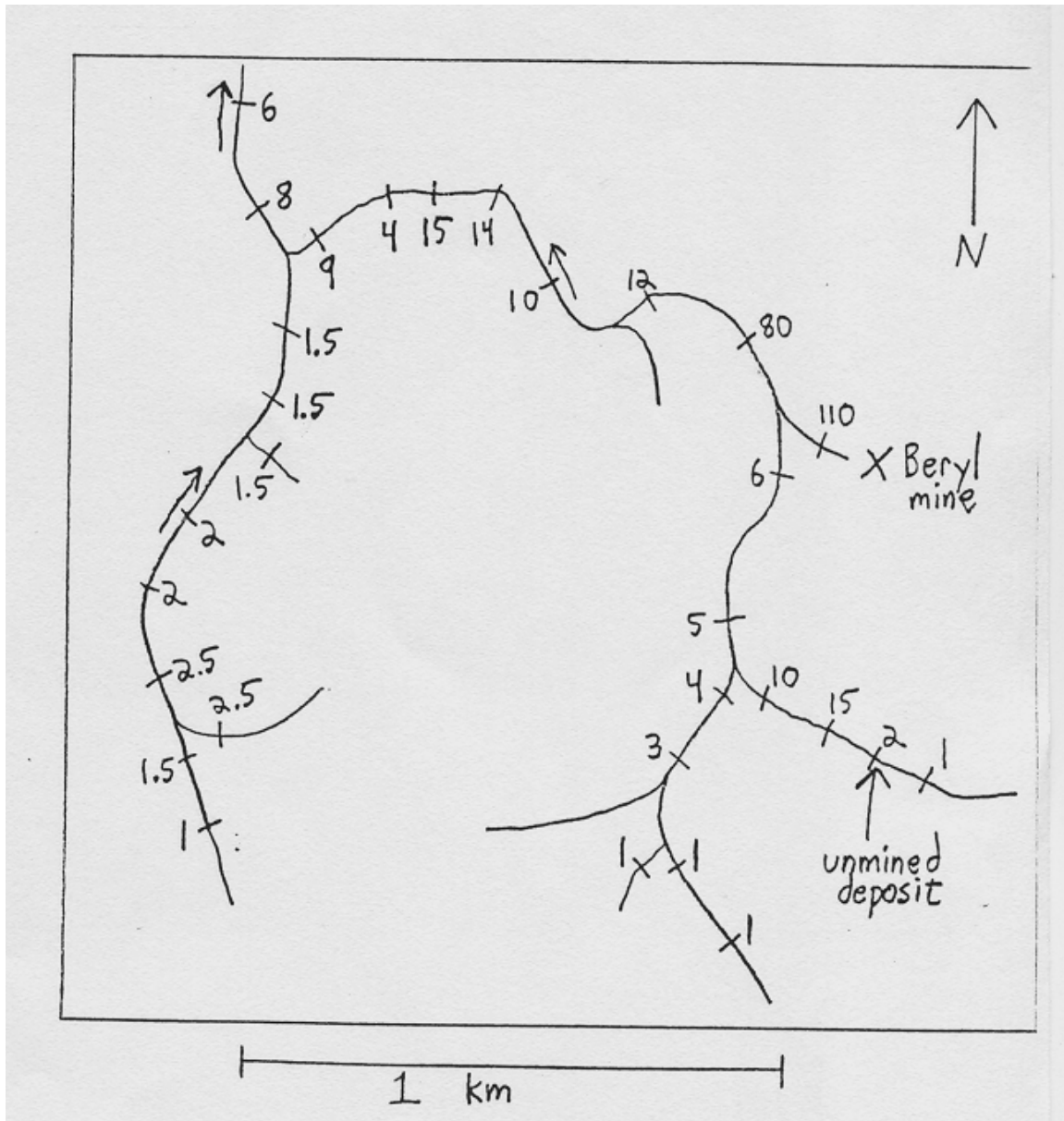
5) Based on the data shown here, what is the regional background value for copper in these stream sediments? How did you determine this value?



this mineral is green and forms good, clear crystals, it is the gem stone emerald. Note that there are two beryllium deposits in the area, one that has been mined and another that has not been mined. What is the regional background content of beryllium in the stream sediments? How did you arrive at your estimate and why?

8) Assume, for the moment, that the amount of rock and beryllium are the same at both the Beryl mine and the unmined site. Why, then, is the beryllium sediment anomaly so much higher at the mined site compared to the unmined site?

Figure 3 – Beryllium content of stream sediments in the Ishasha area of SW Uganda (values shown are Be content in ppm).



9) Explain how geologists use geochemistry to explore for mineral deposits.