APPLICATION OF CATCHMENT ANALYSIS TO REGIONAL STREAM SEDIMENT DATA SETS

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OUTLINE

- Statement of problem
- Background to catchment analysis
- Examples of interpretive approaches
- Using catchment analysis to plan surveys
- Conclusions
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STATEMENT OF PROBLEM

- How do we correct stream sediment data for the effects of variable geochemical background due to different lithological units?
- How do we take into account surficial processes such as scavenging of metals onto secondary Fe and Mn oxides, clay minerals or organics?
- How do we correct for the differential effects of dilution in catchment basins of differing area?
- What is the optimal catchment area for sampling and has the region been effectively sampled? (i.e. are there opportunities for further exploration? Are we over- or under-sampling).
THEMATIC MAP VS TARGETING PRODUCTS

How do we get from this .... To this?

(From Arne et al., 2018)
GRIDDED PERCENTILE IMAGE OVERLAIN WITH STRUCTURAL TRENDS

(From Arne & Blumel, 2011)

Or this?
CATCHMENT ANALYSIS METHODOLOGY

- Collate sample information and analytical data
  - Verify location datums and analytical units
- Geochemical data conditioning
  - Determine optimal analytical data set and data quality
  - Treat values below lower limits of detection
- Obtain DEM at suitable resolution
  - Pit-fill to remove topographical sinks
  - Derive or import hydrology layer
- Validate sample locations against hydrology
  - Locations may need adjustment
- Generate individual catchments for each sample
  - Each sample to be attributed with entire catchment
- Attribute samples/catchments with lithological information
  - Geological legends must be simplified for statistical analysis
Derived from digital elevation model (DEM).

Suitable data sources include Shuttle Radar Topography Mission (SRTM – 30m resolution at equator) or Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER – 15 to 90m resolution), plus other commercial satellite, government and geophysical survey elevation data.

Note minor locational issues with some of these data sets.

Project area is the White Gold District, Yukon Territory, Canada.
Regional Geochemistry Survey samples from British Columbia, Canada were mainly collected prior to the widespread use of GPS.

- i.e. physical transcription of data from paper maps and manual entry into GSC database (plenty of scope for error!)

- Original topographical maps used to locate samples may have been inaccurate compared to present day terrain data.

- Sample locations were adjusted to lie on correct drainage, based on original topographic maps.

(From Arne & Brown, 2015)
DERIVATION OF CATCHMENTS - 3

- Previously done by tracing out the heights of land surrounding the catchment basin by hand.
- Now automated using a number of software packages – note that not all allow determination of a catchment from an arbitrarily located sample point rather than a stream outlet.
- Generally iterative as location problems are recognised by nonsensical catchments.
- Sample points are from the Yukon regional geochemical survey (RGS) program.

Sample locations in green with derived catchment basins in orange outlines.
A low -80# Au from the Yukon open file data in the stream leading from Golden Saddle led to the assumption that stream sediment data didn’t work in this area.

While subtle anomalies are present at Golden Saddle and the Coffee deposits using raw element data, an index using As and Sb levelled for dominant catchment lithology provides an enhanced response.

Note that the raw Au is only weakly anomalous at Golden Saddle if an average of the primary and field duplicate sample are plotted.

(From Arne & MacFarlane, 2014)
DATA ANALYSIS APPROACHES

- Raw data
- Residuals following regression against regolith control elements
- Data levelled by dominant catchment lithology
- Data levelled by presence/absence of a particular unit
- Data levelled by catchment weighted background value
- Multiple regression analysis using catchment geology
- Productivity analysis
- Weighted sums model
- Weighted sums model adjusted for catchment area size
- Residuals following regression against principal components
- Machine learning algorithms
• Data compiled for 1835 samples in total
• Catchment basins delineated for 1725 samples

(From Arne & Brown, 2015)
IMPORTANCE OF LITHOLOGY

- Geology is interpreted in terms of lithology, rather than map units.
- The distribution of Cu is clearly influenced by the Karmutsen basalt; difficult to distinguish Cu anomalies associated with porphyry Cu deposits in those areas.

(From Arne & Brown, 2015)
LEVELLING Cu DATA FOR LITHOLOGY

- Levelling by dominant lithology or presence/absence of basalt both reduce lithological effects.

(From Arne & Brown, 2015)
Average background values have been estimated for most lithologies.

These have been used to calculate weighted average background values, which were then used to calculate robust Z-scores ((observed – median)/interquartile range).
ASSUMPTIONS USING CLASSICAL APPROACHES

- Methods based on levelling against known geology depend on the following assumptions:
  - That the samples are located correctly
  - That the geology of the area is accurately known
  - That the lithological character of mapped units is known and consistent
  - That there are no minor but geochemically distinct lithological units in the area that have not been mapped (i.e. black shales)
  - That erosion from all lithological units is similar so that the contribution from each unit is consistent and represented by its areal extent within the catchment

- Methods that make use of principal component analysis depend on the following assumptions:
  - That the principal components represent recognisable geochemical processes (lithology, scavenging, mineralisation)
The most important principal components from regional stream sediment geochemical data usually reflect bedrock lithology.

PC1 from northern Vancouver Island separates felsic and mafic lithologies.
PC1 provides a better discriminator for the Karmutsen basalt than raw Cu, which is influenced by the Mt. Hall Gabbro.
REGRESSION AGAINST PC1

- Cu can be regressed against PC1 (lithological control).
- High positive residuals represent Cu above predicted background.

(From Arne & Brown, 2015)
Data processing methods were validated against known occurrences.

Known occurrences in the upper 90th percentile plotted relative to the proportion captured by raw Cu data.
• Geochemistry in catchment areas >10 km² mainly reflects regional background
• Catchments > 10 km² have not been effectively sampled

(From Arne & Brown, 2015)
CONCLUSIONS

- The effects of elevated background metal contents are easily filtered using a variety of methods of varying sophistication.
- Processing methods using several commodity and pathfinder elements weighted for the effects of dilution work best.
- Existing mineral occurrences & deposits are more readily apparent and new targets evident in processed data.
- An empirical assessment of sampling effectiveness indicates whether there are still exploration opportunities in under-sampled areas and defines the optimal density of follow-up sampling.
REFERENCES


