Biogeochemistry of Arsenic in Eolian Sub-Arctic Soils, Yukon-Tanana Upland, Alaska

[1]L.P. Gough., [2]J.G. Crock, and [2]W.C. Day

[1]U.S. Geological Survey, 4200 University Dr., Anchorage, AK, 99508, USA;
[2]U.S. Geological Survey, Denver Federal Center, Denver, CO, 80225, USA;
e-mail: lgough@usgs.gov

Background--Biogeochemical investigations of As transport and uptake by vegetation are being conducted over a metamorphic and intrusive terrane of the Fortymile River watershed of eastern Alaska. The occurrence of As in eolian sub-arctic soils is examined, as well as its relative bioconcentration in willow and alder. This information is used by land managers to assess the importance of geogenic vs. anthropogenic metal sources of environmentally important trace elements in multi-use areas where mining, recreation, and ecosystem preservation are important land-use options (Wanty and others, 2000).

Study sites were located on Paleozoic (?) metamorphosed plutonic (supracrustal) metavolcanic and metasedimentary rocks (and associated marble units), and the younger (Jurassic) monzodioritic and tonalitic rocks (Day and others, 2000; Gamble and others, 2001). Samples of A, B, and C soil horizons (Cryaquepts/Cryochrepts), willow (*Salix glauca*) and alder (*Alnus crispa*) leaf and twig tissue, and feather moss *(Hylocomium splendens*) were collected at 36 sites within the lower part of the main-stem of the Fortymile River (~600 km^2 area; fig. 1). The relative contribution to this ecosystem of As from five major rock units was ascertained by the evaluation or rock and soil chemistry and by element uptake by plants.

Results--In general, the total concentration of As was surprisingly uniform in samples of the major bedrock units (i.e., mean around 1 ppm; fig. 2). An examination of soils, however, showed that As levels were highest in the C soil horizon, regardless of rock unit, and decreased in concentration with decreasing soil depth (fig. 2). Further, the plots of rare earth elements (REE, normalized to chondrite abundances) in soils were uniform and did not correspond to bedrock patterns. (The chondrite-normalized patterns, for our study area metasedimentary and metavolcanic rocks, correspond well to literature values for generalized upper crustal rock and mantle rock patterns, respectively.) The soils in our study area, therefore, closely reflect the influence of eolian input more so than the bedrock. REE patterns among the three soil horizons were similar differing only in magnitude due to the presence of organic matter.

The total concentration of As in plant tissue was not found to be strongly correlated with the As levels in rock units. Oxic, moderately acidic soils, such as those in our study area, favor arsenate formation which is both precipitated (by Fe and Al) and sorbed (onto Fe- and Mn-oxides). These factors would tend to immobilize As and would account for its lack of upward movement (plant uptake and deposition) in the soil column.

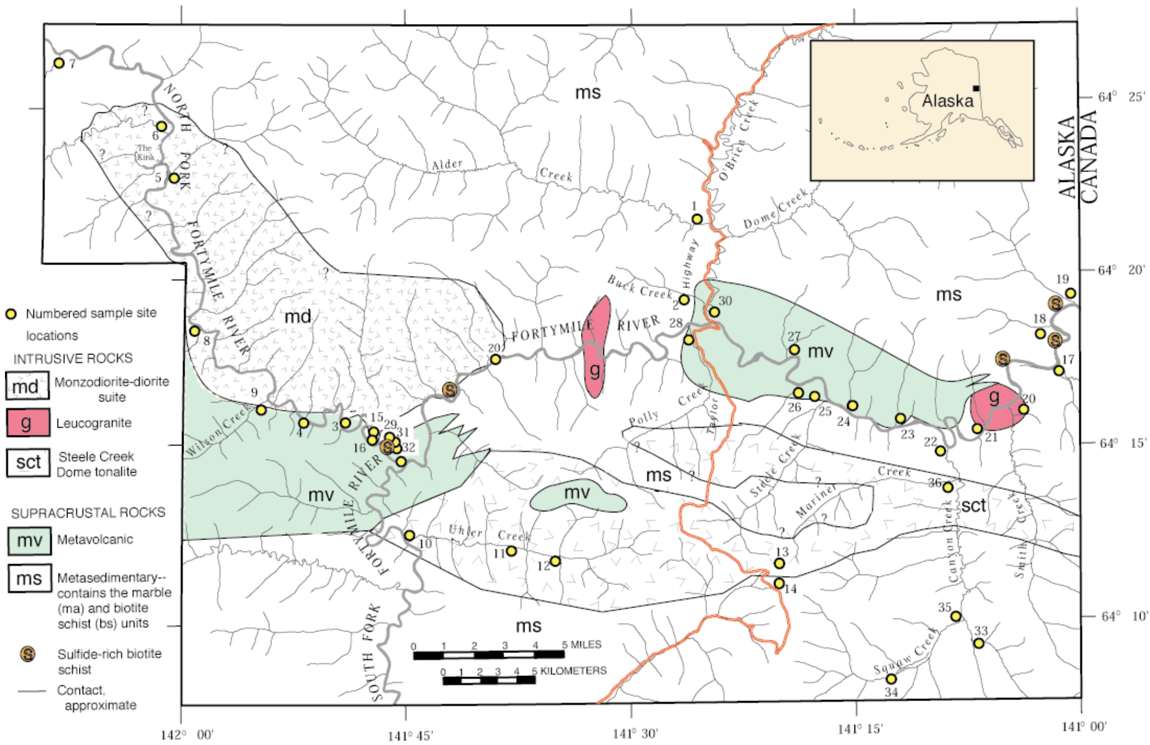

Figure 1. Generalized geology and study site locations within the Fortymile River watershed, east-central Alaska.

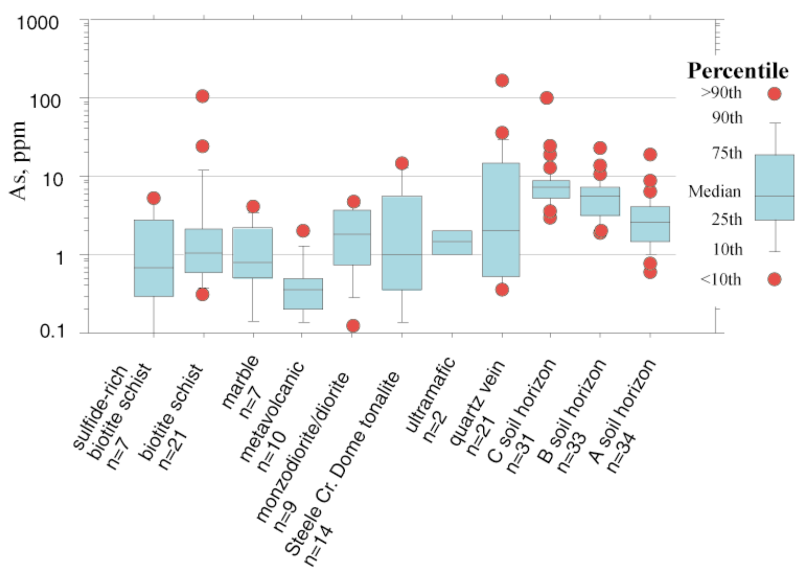

Figure 2. Percentile box plots of As concentrations in rock units and soil horizons, Fortymile River watershed study area. Selected rock units keyed to figure 1 include supracrustal rocks (biotite schist, ms; marble, ma; basaltic metavolcanic, mv) as well as intrusive rocks (monzodiorite and diorite, md; Steele Creek Dome tonalite, sct.).

Enrichment factors (EF), a measure of the relative uptake by a plant of an element from its substrate--a sort of "bioavailability" assessment, are presented for willow leaf material in figure 3. This procedure normalizes the data, with respect to a geochemical reference element (in this case Ce), for each of the soil horizons developed over five major rock units. For example, As concentrations in willow leaf material are enriched relative to soils developed over the metavolcanic rock unit.

Regional biogeochemical baseline values for As in plants and soils are presented and represent a "snapshot" for the material sampled during the study (table 1). In general, the baselines for As (defined as the 95 percent expected range of the data) for plants and soils fall within the range observed for similar material collected throughout the state of Alaska (Gough and others, 2001).

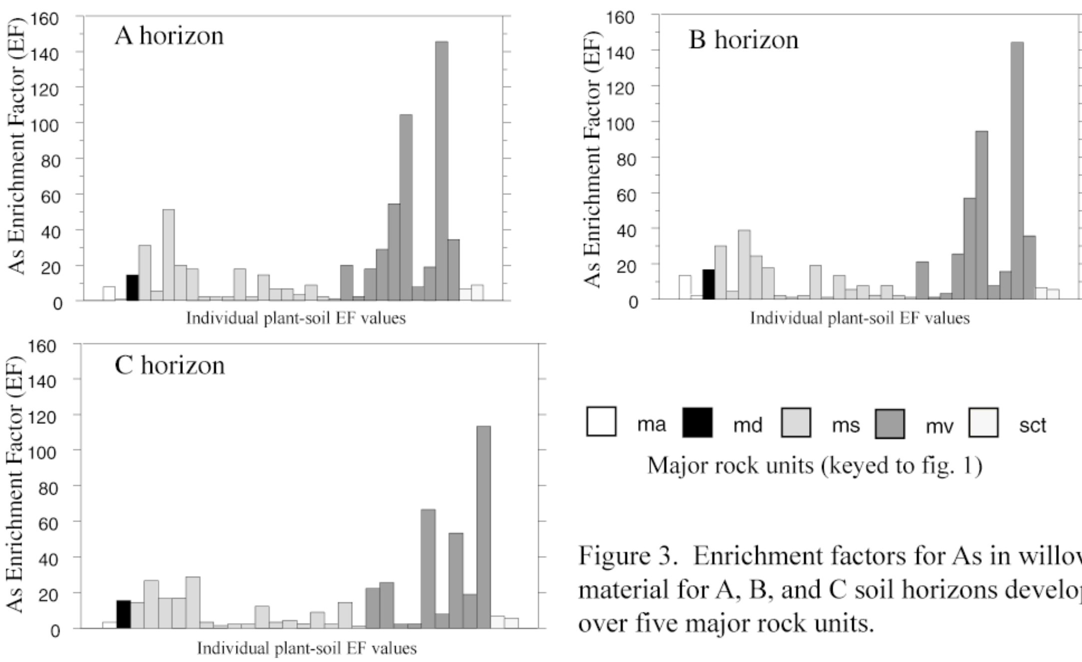

Figure 3. Enrichment factors for As in willow leaf material for A, B, and C soil horizons developed over five major rock units.

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Table 1. Summary statistics for the concentration of As in plants and soils, Fortymile River watershed study area (dry weight basis).

[six replicated samples (Crock and others, 1999) used for QA/QC estimations were averaged prior to calculation of the summary statistics; except for the GD, values reported to two significant figures]

			Summary statistics			
Material, Element	Lower limit of analytical determination, LLD (ppm)[1]	Analytical detection ratio[2]	Geometric mean (GM), ppm	Geometric deviation (GD)	Observed range, ppm	Expected 95% range (baseline), ppm[3]
Alder twig	0.02	23:31	--[4]	--	<0.02 - 0.46	--
Alder leaf	0.03	21:31	--	--	<0.03 - 0.44	--
Willow twig	0.02	24:32	--	--	<0.02 - 0.76	--
Willow leaf	0.03	19:32	--	--	<0.03 - 1.0	--
Moss	0.02	36:36	0.22	1.71	0.099 - 1.2	0.076 - 0.64
A-horizon soil	0.02	34:34	2.2	2.23	0.53 - 19	0.44 - 11
B-horizon soil	0.02	33:33	4.6	1.75	1.9 - 23	1.5 - 14
C-horizon soil	0.02	31:31	7.1	1.81	2.8 - 101	2.2 - 23

1 LLD can vary between groups of samples because of among-sample ash-yield percentage variability.
2 Number of uncensored analytical values (reported above the LLD) / total number of analyses.
3 GM/GD^2 to $GM \times GD^2$ (baseline as proposed by Tidball and Ebens, 1976).
4 --, not calculated because of presence of censored (below the LLD) values.