GSC Scientific Presentation 75 – Presenter's notes

Slide 3

As part of the GSC Metals In The Environment (MITE) initiative, we have examined the distribution of smelter dust in humus. In this powerpoint presentation, morphotypes, textures, element associations, and particle size and distribution of smelter dust will be examined in humus around the Horne smelter at Rouyn-Noranda, to provide a basis for explaining the geochemical anomaly in humus and interpreting of the emission record.

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Smelter emissions in the form of aerosols fall on the trees, plants, and ground around the smelter. Metal enrichment within these compartments is greatest within kilometres of the source and decreases with distance until background concentrations were reached, usually within tens of kilometres for most elements. Through settling and/or biochemical recycling, some dust is retained in soil and/or humus where it is subject to weathering and soil-forming processes.

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Humus was collected near Rouyn-Noranda, Quebec, as part of a multidisciplinary program designed to examine the distribution and concentration of smelter dust in various sample media, including soils. In humus, the presence of smelter dust is indicated by elevated elemental abundances of Cu, Pb, Zn, As, and Cd, among other elements, at distances ranging from tens of kilometres to over 100 km from the smelter, depending on the prevailing wind direction and particular element

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Humus was collected at 106 sites within a 100 km radius of the Horne smelter in Rouyn-Noranda, Quebec. On the left is an interpolated map of the distribution of Cu in humus. The same map is displayed on the right as a variable dot sized map. The dominant wind directions are displayed in the green box on the left of the slide. Note how the wind directions are reflected in the distribution of Cu.

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Results indicate that metals associated with smelter emissions are enriched in humus in the vicinity of the smelter and decrease in concentration with distance. The relative extent of metal enrichment associated with the smelter is higher for Cu than Pb, which suggests that a higher percentage of Cu is retained in humus than Pb. The results of sequential analyses of humus indicate that the chemical phases of Cu and Pb vary depending on the element and distance from the smelter. Within 10 km of the smelter, both Cu and Pb are primarily retained in the labile phase associated with soluble organic material and the relative proportion in this phase decreases with the decrease in metal loading associated with the smelter.

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The geographic distribution of dust correlates with the geographic distribution of the geochemical signature of anthropogenic input to humus. Close to the Horne smelter, the mean particle size and abundance increase with distance to about 17 km from the smelter. At 35 km and beyond, the number of dust particles/mount decreases although the mean size does not change. The range in dust size at sites nearing 100 km from the smelter is much smaller (10 - 11 µm) than at other sites, whereas the mean size of 3 µm is similar to that at 35 km from the source.

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Microbeam analyses can be used to determine the morphology, texture, size and abundance of smelter dust trapped in humus. The two typical morphologies of smelter derived dust observed in humus. Many angular dust particles are unreacted flux or concentrate minerals. The spherical dust can be subdivided into 5 distinct classes.

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The surface of the class 1 sphere is covered in raised platelets that are commonly three or four sided. Internally, the sphere is composed of agglomerates of angular to rounded particles consisting of Fe or Fe+Si, Al, Cu set in a Si+Al, Mg+Fe matrix (darker coloured material). Voids are common. Surface-element associations are Fe, Fe+Si and Fe+Si+Cu+K, Mg, Al.

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The class 2 sphere surface is covered with short, elongated, worm-like features. Internally, original grain boundaries are indistinct. Matrix is more abundant than in class 1 particles with agglomerated particle centres containing small zones of matrix. Element associations for the grains are Fe and Fe+Si+Al. The matrix consists of Si+Al+Fe.

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Three-sided to irregular cavities ((?) moulds) of varied depth cover the surface of class 3 particles. Sectioned spheres display an irregular outer edge and a massive internal structure that commonly contains holes and fractures. No distinct internal textures were observed and relict dust edges were not visible. Surfaces are composed of Fe and Fe+Si+Al with minor Cu whereas interiors consist of agglomerated particles comprising S+Cu+Fe that may represent unreacted chalcopyrite in a matrix of Si+Al+Fe. It should be noted that S and Pb were not differentiated by X-ray detection.

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Class 4 sphere surfaces range from rough to smooth and commonly show fine geometric shapes on the exterior. Gas escape craters are rare, although CuS inclusions are common. Elements detected on the external surface of the sphere are Fe, Fe+Si+Al, Mg, Cu, Ca and Fe+Cu+Si. Sphere interiors commonly contain two phases of Fe occurring as angular grains or dendritic to trellis textures in a glass matrix. Partial dissolution textures such as ferning and particle embayments are common. Elements detected in the dendritic to trellis textures consist of Fe, Fe+ Si+Al, Ca, whereas the glass matrix consists of Si+Al+Mg, K, Fe, Cu. The outer 0.5 µm to 1.5 µm rims of several grains contain copper.

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Class 5 spheres are commonly smooth and/or covered with gas-bubble craters. Internally the sphere edges are highly corroded and the centres commonly contain numerous holes. The spheres range from having zones that contain Fe-enriched small angular grains, to worm-like, Fe radial features concentrated toward the grain edges, or homogeneous Si spheres. External surface-element associations are Al+Si+Fe with minor amounts of K+Cu+Zn+Pb. Internal element associations are slightly different and consist of Si+Al+Na with minor Ca, Mg, K, Ti. Note edge corrosion with hot gas

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The image on the right displays Cu as bright white zones and spheres. Note the small coating of Cu around the outer edge of the sphere.

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Numerical analyses of the EDS image produces a value of 6% Cu by area for the dust particle.

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Numerical analyses of the EDS image produces a value of 17% Cu by area for the dust particle.

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Numerical analyses of the EDS image produces a value of 19% Cu by area for the dust particle.

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A point count analyses of the number of particles in a sample of dust and the amount of Cu those particles contain results in the amount of 1 ppm of Cu in a sample which is far less than the amount of Cu that results from geochemical analyses. Although emission of smelter-derived dust is likely the primary mechanism for delivery of metal to humus, the preserved particles are not the current primary residence site of metal in the humus. This suggests that, soon after deposition, weathering processes have released metals and other elements from the dust to the humus.

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Besides examining the amount of Cu in humus particles we also looked at the chemistry of particles in peat.

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Besides examining the amount of Cu in humus particles we also looked at the chemistry of particles in snow. Note that even after melting the snow to obtain the residual particle a crystal of S was observed as displayed in the lower right photo. The dust in humus is less diverse in composition and texture than dust in snow which suggests, at least in part, that dust in humus represents a non labile phase.

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Cu 85 % extraction from 6hr contact with pure H2O and 5 % from lake water. Preserved dust in humus is commonly larger in diameter than particles observed in snow or aerosols, which suggests that some dust in humus was released into the environment before the installation of electrostatic precipitators and therefore represents only part of the historical record of smelter emissions. Further physical and chemical breakdown of dust in humus through weathering and soil-forming processes will probably not contribute any significant incremental amounts of metal to the geochemical signature of the humus. Although emission of smelter-derived dust is likely the primary mechanism for delivery of metal to humus, the preserved slag-phase particles are not the current primary residence site of metal in the humus. This suggests that, soon after deposition, weathering processes released metals and other elements from the dust to the humus.