Real-time air mercury guide to discovery

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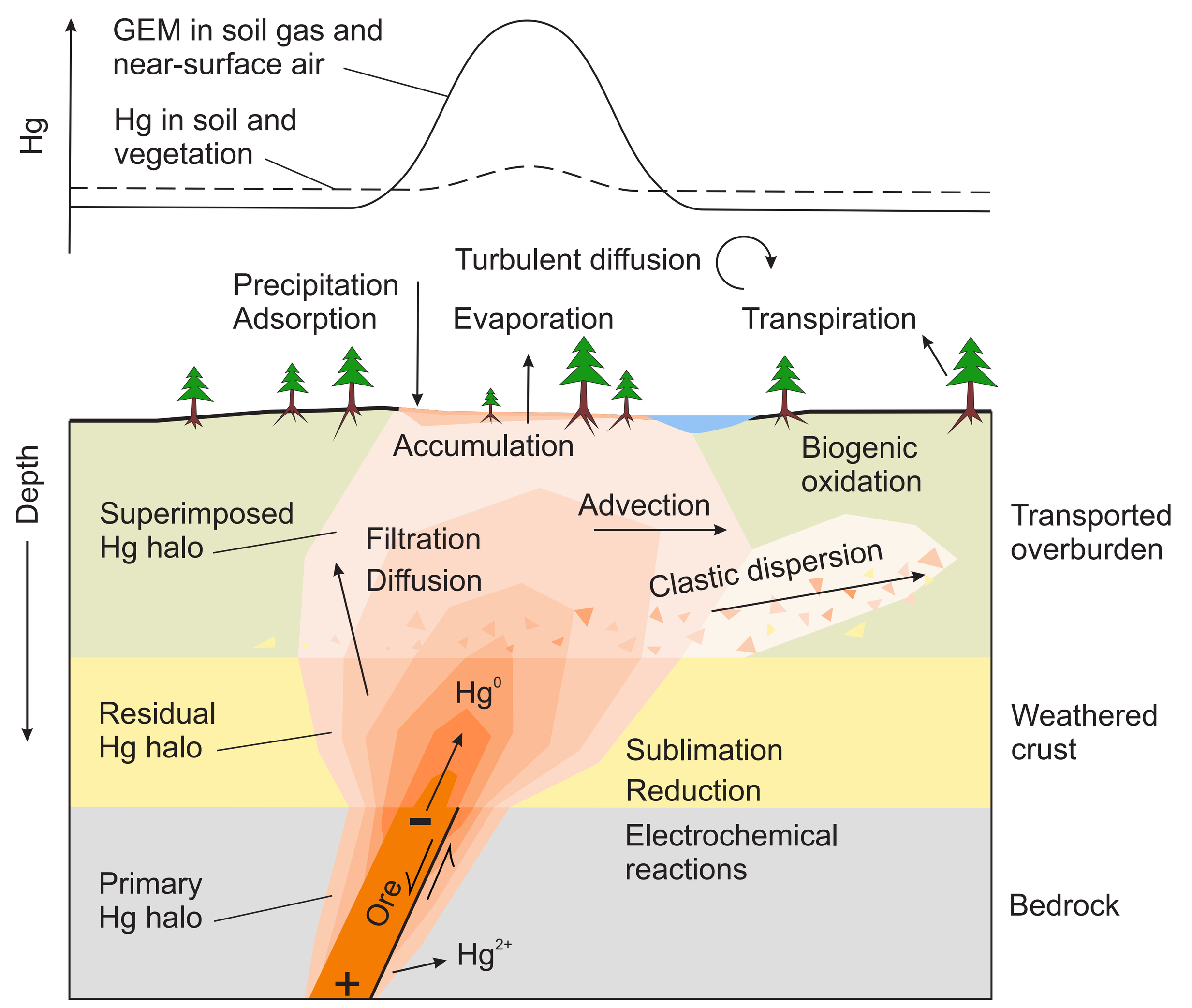
1. Key points

- Gaseous elemental mercury (GEM) in near-surface air is the most useful pathfinder for mineral exploration in overburden-covered areas.
- Direct and continuous analysis via a portable Lumex RA-915M mercury analyzer.
- Up to 206x background Hg response from a volcanogenic massive sulphide (VMS) Zn-Cu-Pb-Ag-Au occurrence.
- Real-time survey reveals a 224 by 30 m GEM halo in near-surface air above a polymetallic zone that is buried under overburden up to 22 m thick.

2. Problem

Mineral exploration in overburden-covered areas requires effective techniques such as atmochemical methods that sample highly mobile volatiles (e.g., Rn, He, and Hg), which form haloes in near-surface atmosphere directly above mineral deposits. Standard geochemical surveys that collect sediment, vegetation, and water are less effective, because their dispersion aureoles can be displaced or obscured by drift. In contrast, sampling GEM in near-surface air is particularly informative, because Hg is:

- highly mobile
- common in many ore deposits
- forms superimposed haloes directly above mineralization
- a trace metal, with the very low background abundance in the Earth's crust of 45 ppb and ultra-low background concentrations in the atmosphere (<1.5 ng·m^{-3}).



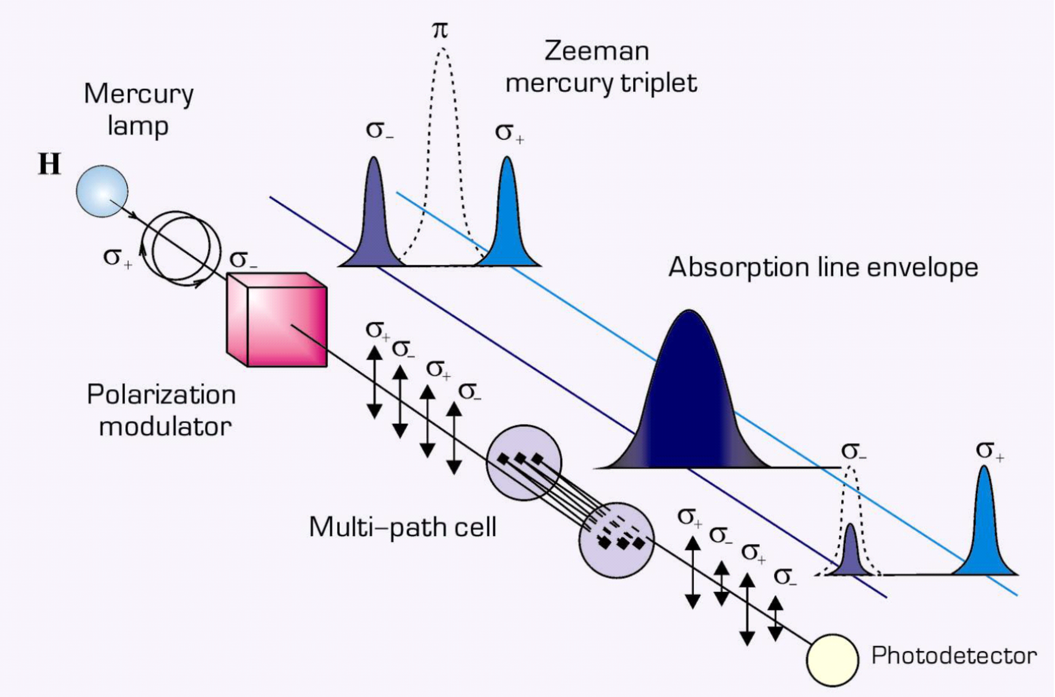
Model illustrating Hg dispersal from a drift-covered ore deposit and the processes forming Hg haloes in the surface environment. Schematic cross-section showing primary Hg halo of a partly eroded ore, residual Hg halo in weathered crust, and superimposed Hg halo in a transported overburden. The GEM halo in air is directly above the ore, because wind and turbulent air movement remove and dilute GEM.

3. Method

We use a Lumex RA-915M mercury analyzer:

- Portable (7 kg)
- Built-in battery for 12 hrs of operation
- Ultra-low detection limit of 0.5 ng·m^{-3} for background concentrations in air (1.2 to 1.5 ng·m^{-3})
- Several orders of magnitude concentration range (up to 20,000 ng·m^{-3})
- Response time of 1 s (continuous measurement)
- Automatic data processing and storage

Here is how RA-915M works:



- RA-915M is a Zeeman atomic absorption spectrometer (AAS).
- The 254 nm Hg resonance photon emitted by a lamp is split into three polarized Zeeman components in a permanent magnetic field.
- Only one of the two Zeeman components that reach the photodetector falls within a much wider absorption band.
- The difference in the intensity between the two Zeeman components is the measure of the amount of Hg in the analyzed air.
- The Zeeman correction for background absorption enables high selectivity of direct measurement.
- Multi-path analytical cell (about 10 m working length) provides high sensitivity required for measuring the ultra-low background concentrations in air

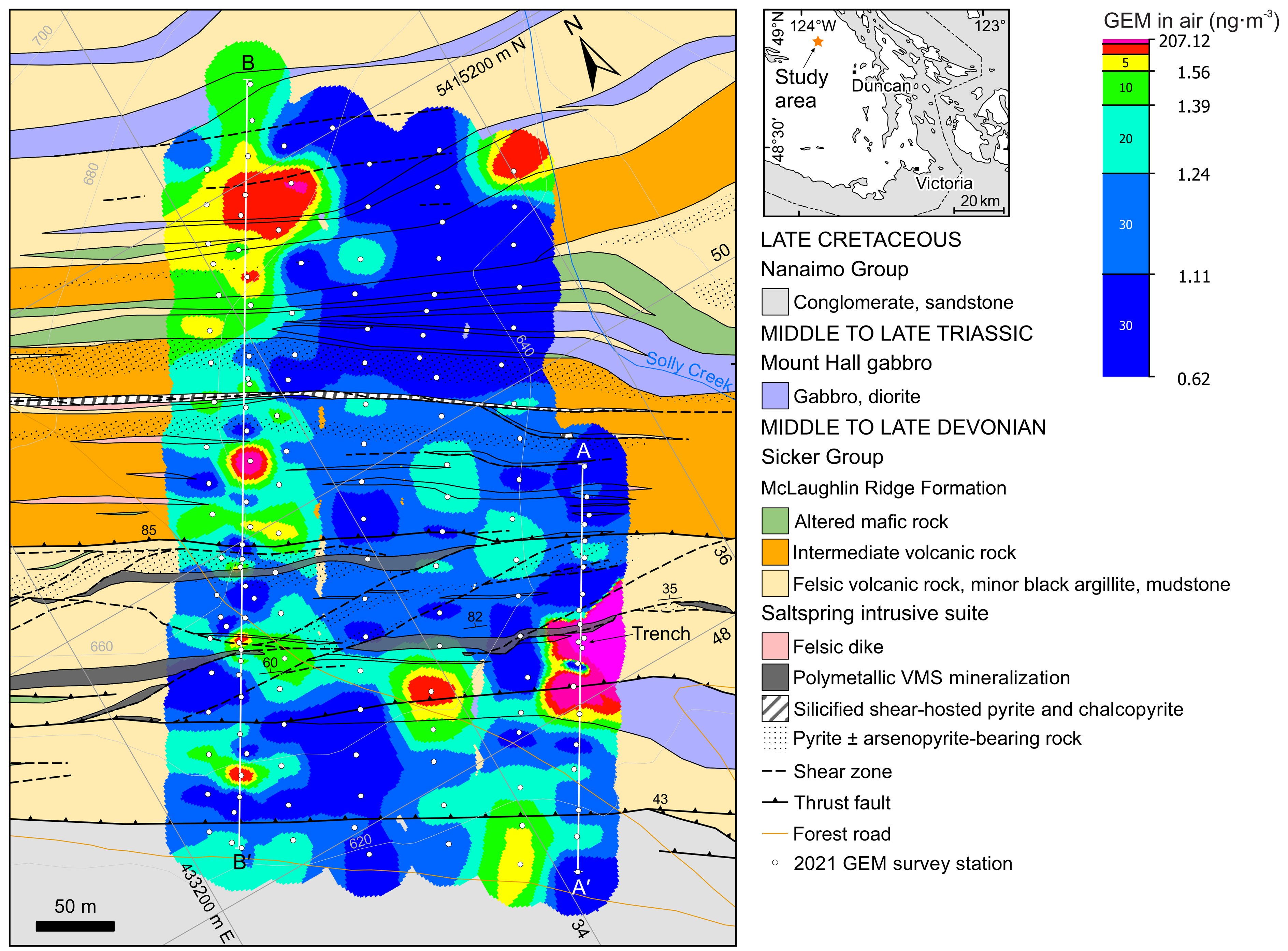
4. Real-time sampling of near-surface air

We sampled air 1 cm above ground under a bucket to minimize wind influence on GEM concentration. We used the average of 60 or 120 readings (1 second each) per station every 5 to 25 m along foot traverses.

Before sampling GEM above overburden, we disturbed surface sediment mechanically with a hoe pick to release Hg^0 adsorbed in soils and vegetation.

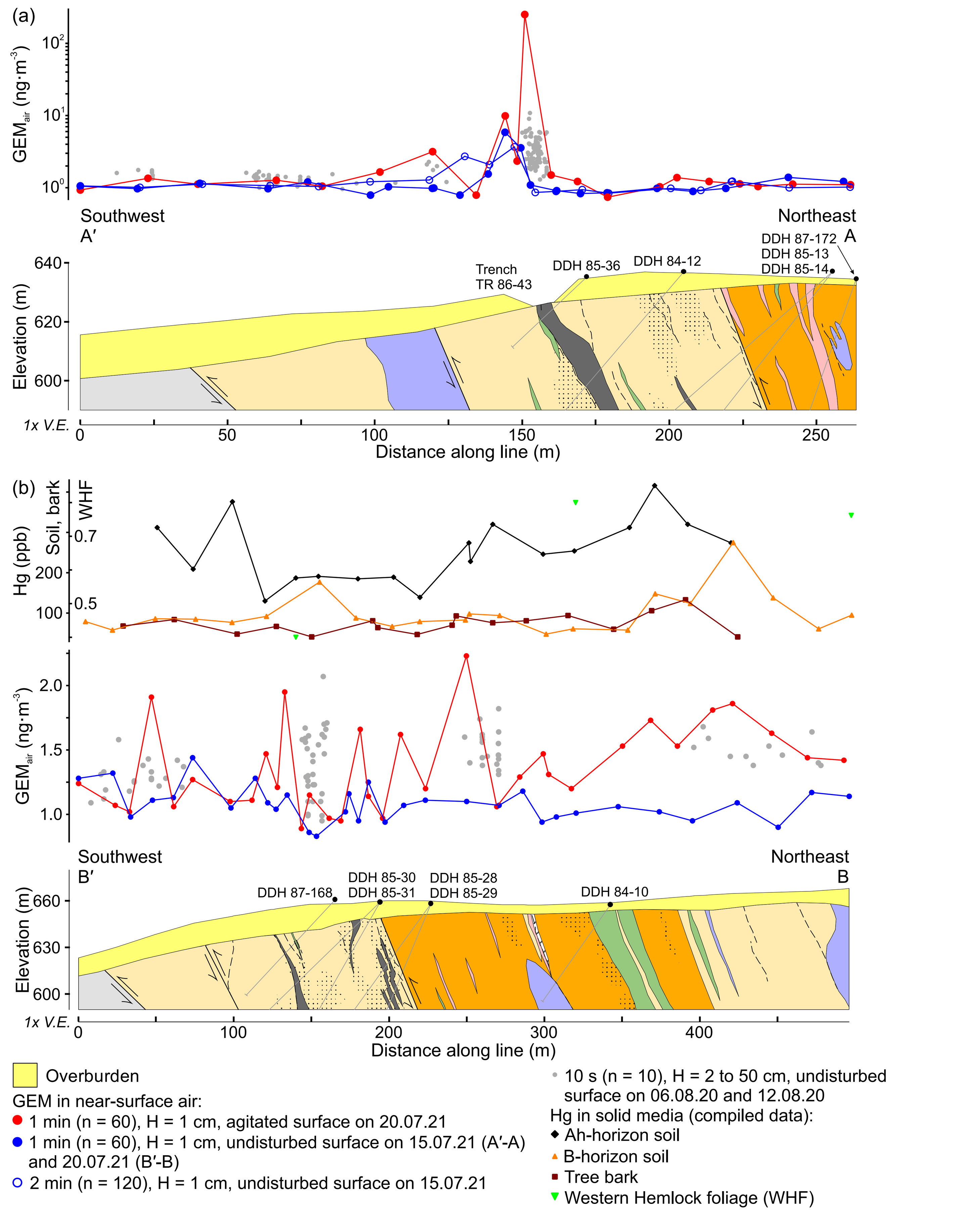
5. Percentile-gridded Hg concentrations in near-surface air

Real-time survey of near-surface air reveals a 220 by 30 m Hg halo above a VMS zone buried under 22 m of overburden; the Lara occurrence, southern Vancouver Island.



6. Orientation across known mineralization

Detailed, real-time sampling of GEM in air 1 cm above ground in this study confirmed GEM haloes in near-surface atmosphere above sediment-covered, polymetallic mineralization at the Lara occurrence (Rukhlov et al., 2021). Mechanically induced release of Hg^0 adsorbed in overburden results in two orders of magnitude stronger anomalies. Historical soil and vegetation samples (Bodnar, 2017; Heberlein et al., 2017) have elevated background Hg concentrations, reflecting a superimposed Hg aureole above the VMS zones.



7. Conclusion

This study confirms that the real-time GEM sampling of near-surface air can instantly delineate mineralized zones that are buried beneath overburden 10s of m thick. Real-time GEM sampling is a simple and effective technique for mineral exploration in overburden-covered areas. See Rukhlov et al. (2022) in Geological Fieldwork 2021, British Columbia Geological Survey Paper 2022-01 for details.