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Multi-Scale Environmental Geochemical Mapping and Modelling in Hungary. Results, On-Going Efforts, and Prospects for Trans-Boundary Collaboration

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Geochemical Mapping in Hungary has been carried out by the Geological Institute of Hungary (MAFI) for over 20 years. One of the major results is the National Geochemical Atlas (Figure 1). The Atlas followed a catchment-based sampling strategy, the sample media was stream sediment for a multi-element survey covering the whole country, compled between 1986 and 1989.
The Groundwater Geochemical Atlas of Hungary at scale 1:500,000 based on producing groundwater wells shows multi-element distributions for the whole country. Mapping was completed in 1999-2003.
As a follow-up of the National Geochemical Atlas, a nation-wide survey produced the 1:100,000 scale National Geochemical Maps of Source Areas. These map are based on stream sediment samples and cover headwater areas in hilly regions. Mapping was completed in 1995-1998 (Figure 3).
Geochemical interpretation of maps enabled the identification of geochmical provinces (Figure 4), regional geochemical background values, and locations of anthropogenic contamination, including trans-boundary effects. An important aspect of our research is geochemical mapping and modelling across various spatial scales from local to regional scales (Figure 4).
Current activities focus on the interpretation of existing maps, follow-up geochemical mapping in Hungary and contribution to international projects. For example, identification of Geochemical Landscape Regions in Hungary studies the carbonate region in the middle of the country by means of detailed site investigations and analysis of soil. Involvement of the Geological Institute of Hungary in international project such as the Geochemical Mapping of Agricultural and Grazing Lands in Europe (GEMAS) and the Geochemical Mapping of Groundwater Quality in Europe. In general, contribution to geochemical mapping projects in the EU, in the Danube Basin and collaboration with neighbouring countries are high priorities of our geochemical research programme.
Another direction of geochemical research is geochemical modelling with emphasis on contamination (acid mine drainage, heavy metals) modelling in mining areas. This activity includes thermodynamic reaction and transport modelling of liquid (AMD) and solid (soil and sediment particles) phases at sources of mine waste rock and tailings dumps, and mine workings; natural contamination at mineralised areas; modelling along transport pathways, to the final receptors (receiving water bodies , floodplain sediments). Modelling activity also includes the development and

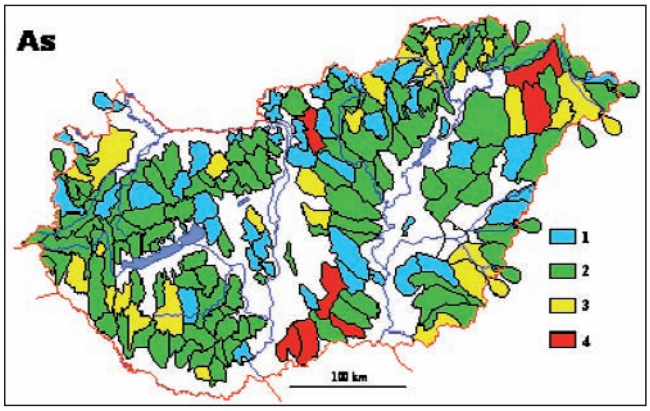

Figure 1.
Geochemical Atlas of Hungary. Example: as in stream sediments.

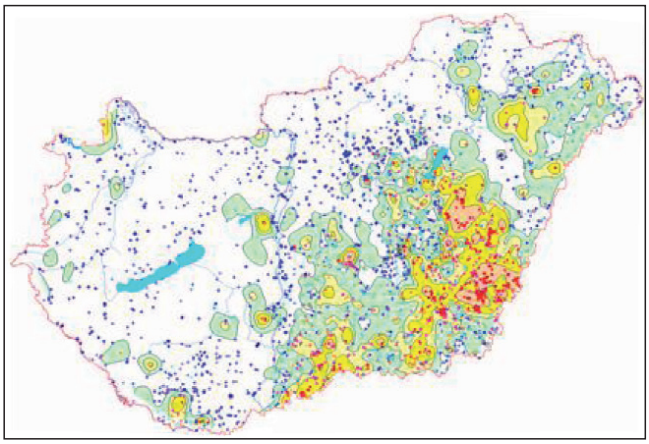

Figure 2.
Groundwater Geochemical Atlas of Hungary. As in groundwater. Dots: sampled water wells; red dots: As above drinking water standards; blue dots: As below drinking water standards. Colour shading: green-yellow-orange shows increasing concentrations. Compare to Figure 1.

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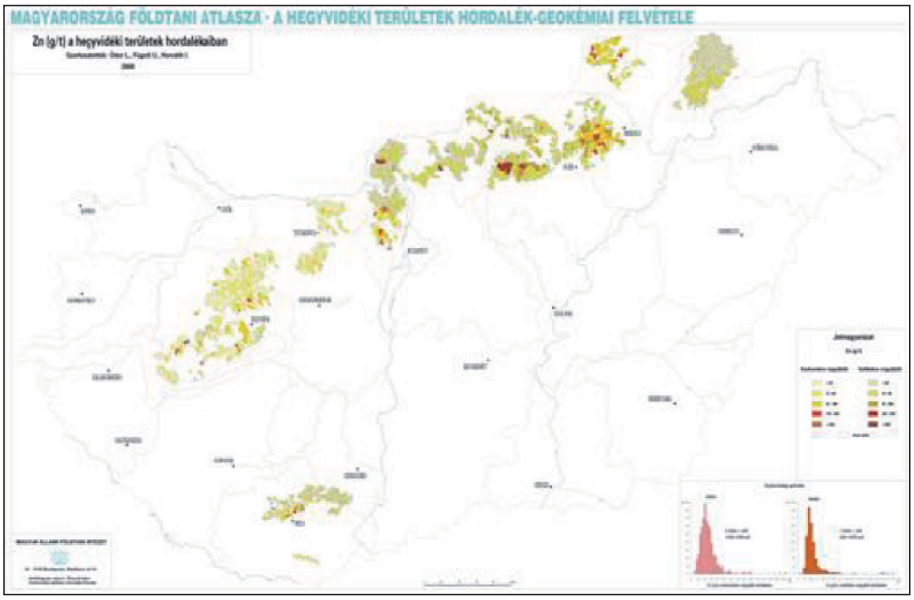

Figure 3.
Geochemical Maps of Source Areas in Hungary. Zn in sediments of headwater areas.
Colour shading: green-yellow-red shows increasing concentration.

application of landscape geochemical methods, time series analysis of water quality monitoring data by signal processing methods and geochemical studies in small catchments.

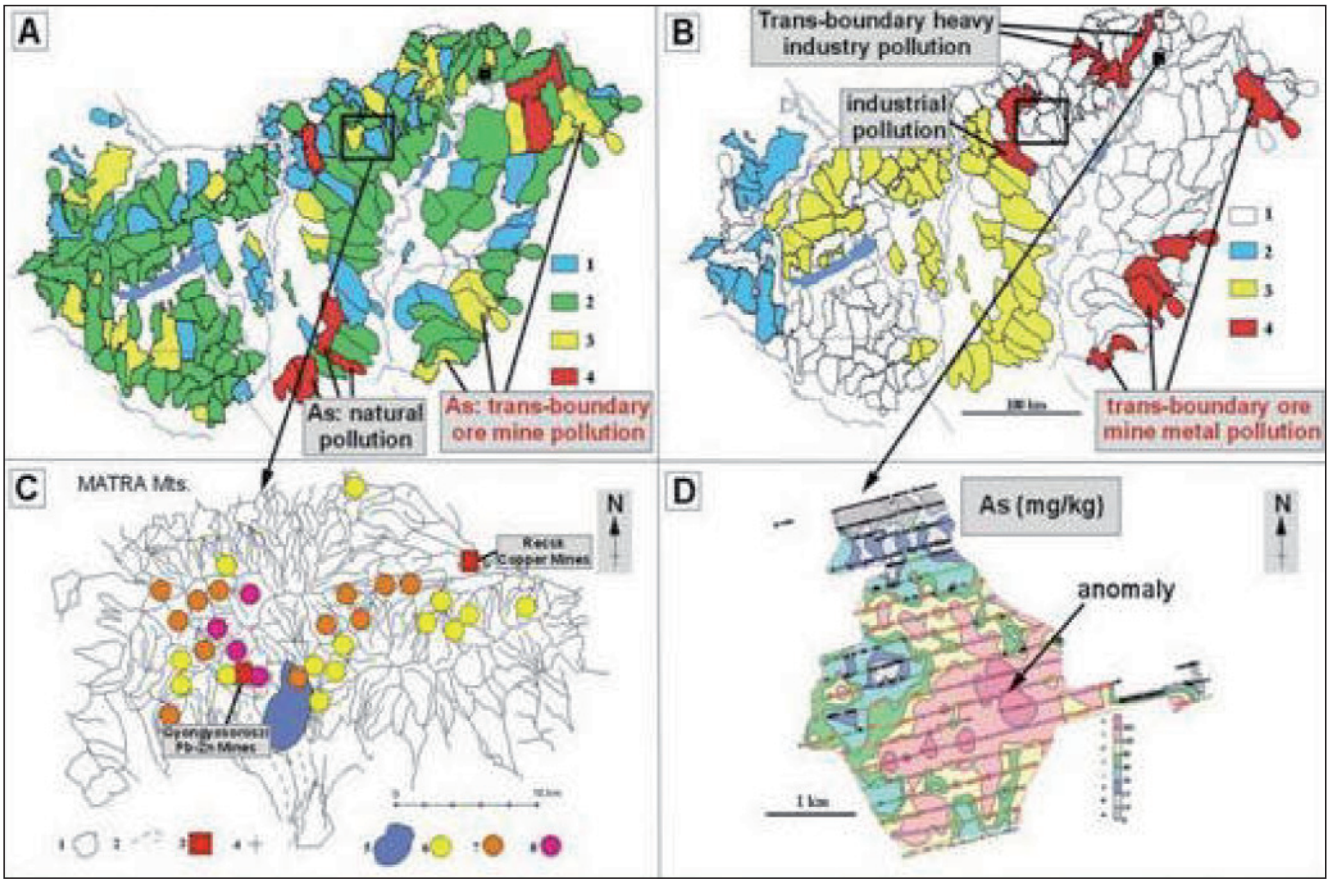

Figure 4.
Multi-scale environmental geochemical survey, an example in Hungary.
A) Regional survey: geochemical atlas of Hungary, As content in stream sediment.
B) Geochemical Atlas of Hungary, regional element associations in stream sediment based on Principal Components Analysis.
1: no association; 2: Co, Cr, Ni; 3: Ca, Mg, Sr, (and SO4); 4: Ag, As, Au, Cu, Pb and Zn.
C) Combined anomaly map of the stream sediment survey based on Pb, Zn, As, Cu and Cd at mineralisations in the Matra Mts., Hungary..
: drainage basins; 2: location of the detailed investigations; 3: abandoned ore mines; 4: Asztagko Hill; 5: low-temperature hydrothermal mineralization zone; 6: poorly prospective; 7: prospective; 8: with proven ore mineralization or strongly prospective.
D) High-resolution geochemical survey at mineralizations. Natural As anomaly at the Korom Hill, Hungary.
Sample locations along transects are shown.