The implications of a new paradigm for granite generation and ore

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Ideas about granite genration considerably evolved during the last decades. Fluid assisted melting produced granitic melt by water seepage into meta-sedimentary rocks and CO_2 released by the mantle transformed rocks into granulites, as documented by fluid inclusions. Dehydration melting of hydrous minerals is now considered as being at the origin of most granitic melts. Involved minerals are first muscovite, then biotite at higher temperature. In deeper conditions, hornblende dehydration melting leads to calcalkaline magmas.

Melt segregation has been first attributed to compaction and gravity forces. It revealed non adapted to magma segregation in the continental crust. First, those models used erroneous values of viscosity contrast. Second, they revealed inadequate, since they ported studies in the mantle conditions (decompression melting) to crustal conditions (dehydration melting). Rheology of two-phase materials documents that melt segregation is irregular in time with successive bursts. Analogue and Lagrangian models confirm irregular melt segregation. Compaction and shear localisation non-linearly interact, so that melt segregates into tiny conduits. Melt segregation occurs whatever the degree of melting.

Global diapiric ascent and fractional crystallisation in large convective batholiths also revealed inadequate. Diapiric ascent cannot overcome the crustal brittle-ductile transition. Fracture-induced ascent faces a neutral buoyancy level at which depth the ascent stops, but it doesn't. Non-random orientation of magma feeders in the ambient stress pattern indicates that deformation controls magma ascent.

Detailed gravity and structural analysis indicated that granites are built from several episodes of magma, each of small size and with evolving chemical composition. Mapping contacts between successive magma batches documents either continuous feeding, leading to normal petrographic zoning, or by periods separated in time, leading to inverse zoning. Magma emplacement is controlled by the local deformation field, imposing the shape of plutons.

A typical source for granite magmas involves three components from the mantle, lower and intermediate crust. Mantle drives and controls essential crustal processes. It appears necessary, providing stress and heat. The successive phases constitute a new paradigm for granite generation.

Implications for ore genesis mostly relate to succesive magma inputs, that induce strong variations in the diffusion properties of minerals. Magma replenishment during a long-lived magma chamber may induce large scale ore deposits.

Tracing geochemical processes and pollution in groundwater

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The dynamic behavior of groundwater, and the many processes that affect trace element concentrations, as well as analytical uncertainties, hamper the proper interpretation of trace element concentrations in groundwater. Especially the distinction between contamination and naturally elevated concentrations is important but difficult. In this perspective, we will show repeated sampling of multilevel wells can be very useful for the understanding of trace element behavior compared to single level wells or monitoring networks.

The dynamics of trace elements in groundwater over a period of fourteen years is studied in a 10 km x 50 m cross-section of 10 multilevel wells in an unconsolidated aquifer in the eastern part of the Netherlands. The area was cultivated in the last century. The 250 miniscreens were sampled in 1989, 1996 and in 2002; trace elements were analysed in the last two measuring rounds.

First, analytical noise can be distinguished from true hydrochemical signal for trace elements by comparing measuring rounds and by inspecting consistency within the depth profiles.

From hydrological modeling and macro elemental chemistry - depth profiles information concerning hydrological system boundaries, the location and dynamics of reaction boundaries in the sediment, age of the water, and local flow direction (seepage or infiltration) can be deduced. This enables the identification of the these natural processes that control trace element concentrations.

More importantly, within the multilevel wells water volumes that originate from geochemically homogeneous areas (i.e. areas with the same input) can be discerned, providing the possibility to distinguish between sediment-water and input controlled trace element concentrations. Speciation calculations are used to compare solubility differences within and between the different water types as this may also be a cause for differences between water types. Trace element concentration differences within water types form the final step in determining how concentrations are set. By comparing measuring rounds, temporal changes in depth of a concentration gradient point to input related concentrations.

By following this approach on the more than sixty water type boundaries, eleven Fe/NO_3 redox boundaries, five sulphate reduction boundaries, the various buffering stages, and the major changes in macrochemistry, the behavior of trace elements can be better understood.