Fluid and gas migration in the southwestern part of the Lower Saxony Basin (Germany)

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The Lower Saxony Basin (LSB) in NW Germany forms part of the Southern Permian Basin gas province in Central Europe. Commonly, methane-rich gas generated from Upper Carboniferous coal-bearing strata and accumulated in Permian sandstones and carbonates. In contrast, in the southwestern part of the LSB the gas composition in reservoirs can be very variable with respect to CO_2 content which varies between 0 and up to 90% [1]. Locally, organic matter in Upper Jurassic and Lower Cretaceous rocks locally shows matury as high as 4.5% VRr. The area is characterized by a magnetic and a positive gravity anomaly which has been related to the Early Cretaceous igneous intrusion of the so-called Bramsche Massif. Therefore, a thermal influence of magmatic intrusion(s) in the southwestern part of the LSB has been favored. However, more recent studies focusing on numeric modeling suggest a model that includes deep burial during Early Cretaceous times followed by Late Cretaceous/Tertiary uplift and subsequent erosion of several thousands of meters of sedimentary rocks [2].

Fluid inclusions studies in hydrothermal minerals from wells and outcrops in the study area yield migration of differently composed fluids and gases during stages of burial and uplift. Migration of CH_4-CO_2 gas mixtures along fissures and veins occurred in the presence of saline brines at elevated pressure conditions during the Mesozoic. Similar saline brines were typically also traced in other parts of the Central European Basin [3]. Locally, the formation of Pb-Zn-(Ba-F) mineralization is related to the migration of these brines. In contrast, in the vicinity of supposed intrusion the migration of hot fluids (>200°C) is recorded in quartz mineralization that is hosted by Upper Carboniferous to Cretaceous sediments. The salinity of fluid inclusions is highly variable suggesting that different fluid reservoirs were drained. However, fluid entrapment often occurred along with the entrapment of gas mixtures with variable contents of CH_4, CO_2, and locally N_2. These gas inclusions formed at pressure conditions close to hydrostatic most probably during basin inversion.

[1] Lokhorst (ed.) (1998) *NW European Gas Atlas*. [2] Petmecky *et al.* (1999) *Tectonophys* **304**, 317-344. [3] Lüders *et al.* (2005) *Int J Earth Sci* **94**, 990-1009.

Magmatic metasomatism, HSE and ^{187}Os-^{186}Os isotope signatures of the oceanic mantle

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Highly Siderophile Elements (HSE: Os, Ir, Ru, Pt, Pd, Re) are concentrated in base-metal sulfides (BMS). During partial melting of the mantle, BMS melt incongruently, producing a Cu–Ni-rich sulfide melt that concentrates Pt and Pd in the basaltic melt; and a refractory monosulfide solid solution (Mss) ± discrete Os-Ir-Ru-rich phases (e.g. alloys) that sequester Os, Ir and Ru in the residue. Cu-Fe-Ni sulfide melts have a high wetting capacity, and thus are highly reactive and highly mobile phases which are potentially important metasomatic agents of the mantle.

Abyssal peridotites, which provide direct sampling of the oceanic upper mantle, display evidence of magmatic overprinting. Depending on P-T-FeO-fS_2-fO_2 parameters, magmas en-route to the surface precipitate Cu-Ni-Pd-rich metasomatic BMS within the mantle column. This magmatic metasomatism process produces, at the whole-rock scale, significant S and Pd enrichments [1]. Such metasomatic BMS have high Re/Os and radiogenic ^{187}Os/^{188}Os ratios while the residual Mss develop unradiogenic ^{187}Os/^{188}Os [2]. Addition of metasomatic BMS to a mantle residue shifts the whole-rock Os isotope composition to higher values that provide only minimum age constraints.

Metasomatic sulfides may also have suprachondritic Pt/Os ratios, especially when related to pyroxenite and eclogite-derived melts. Over the few Gy that crust recycling has operated, the high Pt/Os ratio of these BMS will evolve toward radiogenic ^{186}Os/^{188}Os ratios, well in excess of any plume-related lavas or modelled outer core compositions. Upon melting, a peridotite enriched by such metasomatic BMS will transfer the radiogenic ^{186}Os/^{188}Os signatures to the basaltic melts. The entire spectrum of ^{187}Os-^{186}Os variation in plume-related lavas can be explained in this way without requiring any core-mantle exchange [3].

[1] Luguet *et al.* (2003) GCA **67**, 1553-1570. [2] Alard *et al.* (2005) Nature **436**, 1005-1008. [3] Luguet *et al.* (2008) Science **319**, 453-456.