New Findings on Gas Migration and Active Tectonics in the East Eifel Volcanic Field

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In the Eifel volcanic field gas analyses (carbon dioxide, helium, radon, hydrogen sulphide and methane) of mofettes and mineral springs were performed in several campaigns during the period 2008 to 2012. Additionally soil gas samples were collected by pounding a stainless steel probe (with a sacrificial tip) to the desired depth of 1.0 m into the unsaturated zone of selected locations. Based on the analyses results specific distribution patterns can be identified, which allow conclusions to be drawn to tectonic and magmatic activities.

In the East Eifel volcanic field, the recent gas anomalies are connected to tectonic faults which are part of the postvariscan shear system and to normal faults which are formed in the direction of the main stress direction. The most clear appearence are 105° trending strike-slip faults, which are staggered in equidistant intervals of several kilometers. This system continues to the North into the Ruhr Carboniferous, where it has been recognized due to the extensive underground coal mining first (Loos et al. 1999). Our recent research on analyses of tectonics in quarries, quartz/ore-dykes, mapping of minerals springs and gas analyses, has revealed a 105° trending strike-slip fault („Laacher See Strike-slip Fault“) cutting the South of Laacher See. At present, the „Laacher See Strike-slip Fault“ can be tracked from Holzmühlheim in the West, Spessart, Wehrer Kessel, Laacher See, Plaidt to Bad Ems in the South-East. In the tectonic depression of Neuwied Basin, near Plaidt, the „Laacher See Strike-slip Fault“ is intersected by the NW-SE-trending Ochtendung Fault. Along this fault system, an area of intensive micro-seismicity and a new seimically active zone with local magnitudes up to 4 has developed over the last 40 years (Hinzen 2003). In the last decade, a second new seismically active zone developed in the Bad Ems region with local magnitudes up to 4.4 (BNS 2012).

Our results of gas analyses show a split of the East Eifel volcanic field into two parts. Helium (He) anomalies with concentrations exceeding up to seven-fold the atmospheric standard of 5.220 ppb (Holland & Emmerson 1987) are evident in the northern and in the northwestern part of Laacher See, whereas Helium anomalies with concentrations up to 70-fold of the atmospheric standard are evident southeast of Laacher See, indicating a large-scale anisotropy in the tectonic depression of Neuwied Basin. East of Laacher See, Radon anomalies up to 130 Bq/l are found. H_2S anomalies are evident northeast of Laacher See. The highest gas anomalies are evident in the mofette field (500 m length) in the river Lahn in Bad Ems: Helium anaomalies with concentrations exceeding up to 150-fold the atmospheric standard, Radon anomalies up to 500 Bq/l and H_2S anomalies up to 18 ppm were found.

The mofette field in the river Lahn is prolonging the Laacher See Fault. The position of this mofette field seems to be far away from the East Eifel volcanic field with a distance of appox. 30 km to an assumed center in the East Eifel volcanic field South-East of Laacher See. But the Quaternary volcano Rodderberg near Bonn and the youngest Eifel volcano, the Ulmener Maar (it is not clearified yet whether this Maar is part of the West Eifel or East Eifel volcanic field) show the same distance to the assumed center. It is also striking to see, that all three loactions lie on a circle with equal distance to each other. Together with the assumed center they form sectors with an angle of 120 degrees.

Strikingly high He values within the new seismically active zone near Plaidt can be associated with tectonic movements along the „Laacher See Strike-slip Fault“ which lead to the formation of secondary faults. But tectonics as the only cause for the high He values is called into question. In the East Eifel, movement rates of active tectonic faults are approx. 1 mm/year. Block rotation in combination with uplift could have provided the voids for the magma chambers of the Wehrer Kessel and the Laacher See Caldera. Our research findings suggest that due to the slow movement rates of active tectonic faults, an estimated 18 km^3 magma chamber within the brittle fracture section of the earth's crust beneath the Laacher See (Bogaard & Schmincke 1984) cannot be confirmed yet. The Laacher See caldera has a volume of 0.5 km^3 with regard to the pre-eruptive surface (Viereck & v.d. Bogaard 1986). A volume compensation of an ascending magma of approx. 6 km^3 which could have prevented a further subsidence of the magma chamber seems to be an unrealistic assumption. An order of magnitude smaller magma chamber of 1 km^3 stretched over a longer vertical crustal section could help to better match the given tectonic movement rates.

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