UNIVERSITÄT DUISBURG ESSEN

Advective and diffuse degassing structures in a mofette field in the Wittlicher Senke (Southern Eifel, Germany)

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Introduction

The 65.000 m² sized investigation area is located near Heckenmünster, about 12 km southwest of Wittlich and is characterized by two main degassing sites located in dug wells, the Schwefelquelle and Victoriabrunnen, with amounts of about 350 $m^3\ d^{-1}$, respectively 18 $m^3\ d^{-1}$ gaseous emissions. A great number of smaller exhalations are postulated in the vicinity of the main degassing sites. A few of them can be identified after heavy rainfall. Chemical composition of the emitted gas is dominated by CO_2 (about 90 % Vol.) with significant amounts of trace gases like Helium (24.500ppb), H_2S (up to 20 ppm) and Radon (14.9 Bq l^{-1}). Isotopic analysis of Helium and Sulfur were made with R/Ra values of ~4 in case of Helium and δ34S values of 3.9 ‰. A first approach was made by sampling soil gas with a view to identify soil covered gas bearing structures. In a second step the amount of CO_2 emitted by exhalations or diffuse degassing was determined. First results show heterogeneous variation of both CO_2 concentrations in soil and gas fluxes. The amount of emitted CO_2 reached values of up to 2.000 $dm^3\ d^{-1}$ for a single measurement, respectively about 12.000 $dm^3\ d^{-1}$ for the tested area (~700 m²). Significant clustering of high CO_2 concentrations in soil proves localization of soil covered gas bearing structures.

Geological Setting

The "Wittlicher Senke" (c.f. Fig.1) is a postvariscan depression located in the southern Eifel, between the Eifel block in the north and the Hunsrück block in the south. The blocks of Eifel and Hunsrück are separated by the Boppard-Dausenau-Longuich fault which is supposed to be inactive at least since the beginning of the lowering of the "Wittlicher Senke". The depression has an extension of about 40 km from NE to SW and 2-7 km from NW to SE. The mean difference in altitude compared to the surrounding Eifel and Hunsrück is about 100 m. The maximal lowering is assumed to be about 700-900 m in the southwest of Wittlich. The Wittlicher Senke is interpreted today as a pull-part basin, proved by lateral displacements of alluvial fan deposits by up to 3 km between Eifel block and the depression itself (STETS, 1990). Both lowering and lateral displacement happened along two main fault structures, in the northwest the "Wittlicher Hauptverwerfung" and in the southeast the southern boundary fault (Südliche Randverwerfung, STETS, 2004, c.f. Fig. 1). Along the "Wittlicher Hauptverwerfung" a number of CO_2-dominated mineral wells and mofettes were found in the past. This is proof for the partial permeability of the fault for gases from the upper mantle. It can be assumed that the Eifel Plume (Ritter et al, 2001) whose southern boundary area extends beneath the southern Eifel is the source for those gases.

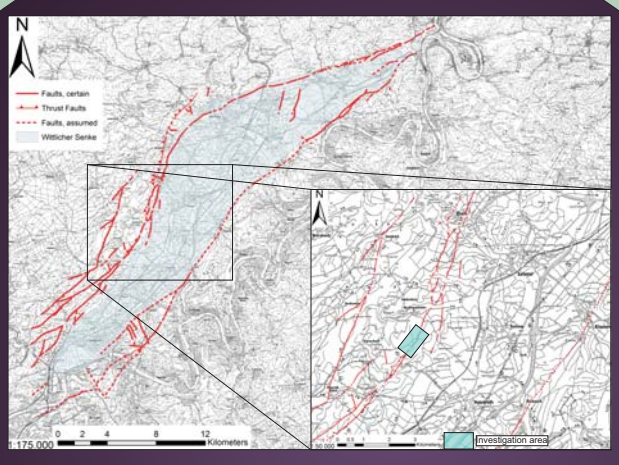


Fig.1: Overview of the Wittlicher Senke and the investigation area.

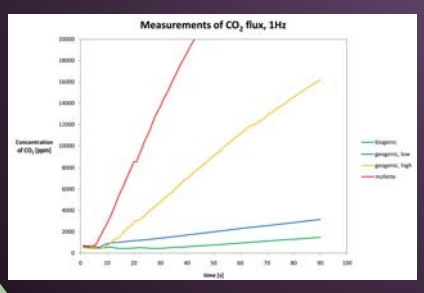


Fig.2: Selected measurements of CO_2 flux emitted by different sources.

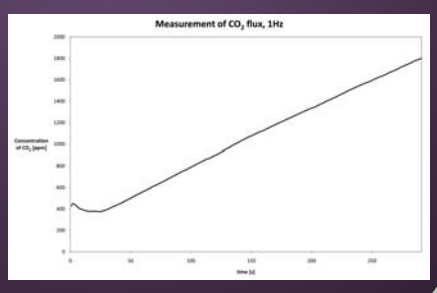


Fig.2.1: Selected measurement of CO_2 flux with steady rise of concentration of Co2 in CDC during longer sampling time.

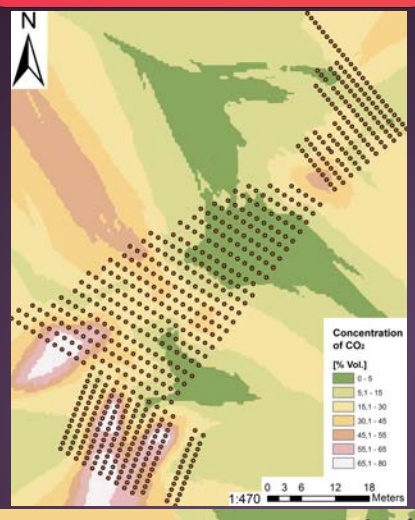
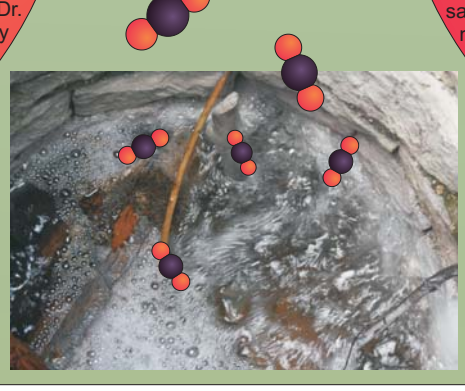


Fig. 3: Position of sampling points and interpolation of concentrations of Co_2.

Fig.4: Position of flux measurements and interpolation of CO_2 flux.

Methods

Flux measurements of CO_2 were carried out with an accumulation chamber (AC) of the type of a closed dynamic chamber (CDC). For investigations in volcanic areas the use of CDCs has been developed to a common method in the last ten years. Multiple field researches have been carried out, e.g. at Stromboli/Italy (Carapezza et al. 2009), Mt. Etna/Italy (GIAMMANCO et al. 2007), Popocatépetl/Mexico (VARLEY et al. 2001), Iwojima volcano/Japan (NOTSU et al. 2005) and the Horseshoe Lake tree kill, Mammoth Mountain, California/USA (GERLACH et al. 2001). The principal of a CDC is the determination of the increase of the CO_2-concentration over time in a cylindrical chamber which is placed on top of the soil. For homogenization of the air/gas-mixture a slow moving fan is installed inside the chamber. The CO_2-concentration of the air/gas mixture is determined by a fast responding NDIR gas analyzer (Licor Li-820). A maximum threshold value for CO_2-fluxes of biogenic origin was defined at $9*10^{-3}$ $dm^3\ m^{-2}\ min^{-1}$, based on biological studies in different areas during summer (KORDOWSKI 2009, LIANG et al. 2010). Sampling of soil gas was made by inserting a steel tube into the soil to a depth of 80-100cm. By use of a Draeger X-am 7000 multigas monitor concentrations of CO_2, H_2S and CH_4 were determined on site. Additionally soil gas samples were stored in sample containers for later determination of Helium concentration in a mass spectrometer (SIMON, 2007). Radon concentration was determined by use of a Lucas Detector (scintillation counter). Helium isotopic analysis was accomplished by Prof. Dr. Aeschbach-Hertig, University of Heidelberg and sulfur isotopic analysis by Prof. Dr. Strauß, University of Münster.



First Results

Until now, about 370 measurements of CO_2 flux have been carried out in grids of 0.5x0.5 m, respectively 2x1.5 m with a view to identify small and hidden exhalations and to quantify the amount of CO_2 released. The results are shown in figure 4. A background value for the central area was defined at 0.02 $dm^3\ m^{-2}\ min^{-1}$. Fluxes below the biological threshold value are shown in green color. Based on the measurements, the area can be characterized as a mofette field with an average background flux and high fluxes in local degassing sites. A linear degassing structure which could be interpreted as the "Wittlicher Hauptverwerfung" is not yet provable.

Interpolated overall emission of CO_2 is approximately 200 $m^3\ d^{-1}$ in an area of about 700 m² whereof nearly 9 $m^3\ d^{-1}$ are assumed to be of biological origin.

In addition to flux measurements a number of 600 soil gas samples were taken in the investigation area in grids of 1x1.5 m respectively 2x1.5m. Distribution of sample locations and interpolation (Gaussian kriging) of the results are shown in the map (fig.3). High concentrations correlate in most cases with high gas flux. The results prove that CO_2 degassing is not limited to the known wells and mofettes. It can be shown that a wider area is affected by diffuse and advective CO_2-degassing and it is assumed, that other areas along the "Wittlicher Hauptverwerfung" can also be characterized as gas bearing structures. Future work is to carry out sampling between the worked sampling sites to prove a possible trend of the fault. Parallel gas flux measurements will be made to determine the overall gas flux in the investigation area.