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Why does the Size of the Laacher See Magma Chamber and its Caldera Size not go together? – New Findings with regard to Active Tectonics in the East Eifel Volcanic Field

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The East Eifel's early Cenozoic tectonic development is characterized by a main stress field trending in NW-SE direction, causing a re-organisation of postvariscan dextral strike-slip faults in approximately 105° direction, the formation of the tectonic depression of the Neuwieder Basin and small-scale transtension zones. The 105° trending strike-slip faults are staggered in equidistant intervals of several kilometers. This system continues from the Eifel 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 prominent 105° trending strike-slip fault cutting the South of Laacher See („Laacher See Strike-slip Fault"). Within the Laacher See caldera, the "Laacher See Strike-slip Fault" can be tracked by a wide mofette zone that was mapped with a self-propelled submarine. 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 and furthermore to the South-East. Along this direction five intersections points of the „Laacher See Strike-slip Fault" with the Lahn River are documented, creating small-scale mofette fields in the Lahn River. In the Neuwied Basin, near Plaidt, the „Laacher See Strike-slip Fault" is intersected by the NW-SE-trending Ochtendung Fault. Regional strike-slip faults in combination with block rotation and uplift could have provided the voids for the magma chambers of the Wehrer Kessel and the Laacher See Caldera. Holohan et al. (2005) showed in analogue models that regional strike-slip regimes (including Riedel shears, chamber-localised graben fault, and a partial Y-shear) play a decisive role for caldera formation. In the East Eifel tectonic movement rates of active faults are approx. 1 mm/year (Meyer & Stets 2002, Cambell et al. 2002). 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 (v. d. Bogaard & Schmincke 1984) cannot be confirmed yet. Another discrepancy is given by a comparison of modeling of caldera evolution (Acocella 2007) with the Laacher See Caldera formation. The Laacher See caldera has a volume of 0.5 km^3 with regard to the pre-eruptive surface (Viereck & v.d. Bogaard 1986). According to v. d. Bogaard & Schmincke (1984) a volume of 6.3 km^3 dry rock equivalent of lava and basic rock was erupted. This magnitude is contradictory to the calculated 0.5 km^3 volume of the Laacher See caldera. A volume compensation of approx. 6 km^3 which could have prevented a further subsidence of the magma chamber cannot be a scientific possible explanation. This hypothesis is strengthened by performed sonar recordings of the post-eruptive Laacher See sediment layers which do not show any displacements that might indicate a doming caused by magma. Estimations of the erupted tephra volume provided the basis for the calculation of the size of the Laacher See magma chamber (v.d. Bogaard 1983), but there is no statistical significant data set with regard to spatial distribution of the erupted tephra amount. Our findings show an overestimation of the tephra thickness in published isopach maps of the Westerwald. Therefore, an order of magnitude smaller magma chamber stretched over a longer vertical crustal section can help to better match the given tectonic movement rates and the size of the caldera. To estimate the future development of the East Eifel volcanic field, a good knowledge of the active tectonics is an absolute prerequisite. Along the "Laacher See Strike-slip Fault", an area of intensive micro-seismicity and a new seismically 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/Nassau region with local magnitudes up to 4.4 (BNS 2012). Our data generated from a combination of mapped active strike-slip faults and gas analyses along these gaspermeable faults provide, besides a seismic monitoring, integrated knowledge on the future evolution of the East Eifel volcanic field. The 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 in the East Eifel volcanic field (Berberich 2010, Schreiber & Berberich 2012). Based on the results specific distribution patterns can be identified, which allow conclusions to be drawn to tectonic and magmatic activities. Our results 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. H2S anomalies are evident northeast of Laacher See. The highest gas anomalies are evident in the mofette field (500 m length) in the Lahn River in Bad Ems: Helium anomalies with concentrations exceeding up to 150-fold the atmospheric standard, Radon anomalies up to 500 Bq/l and H2S anomalies up to 18 ppm were found.

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