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The behaviour of crustal fluids in the Bad Brambach mineral aquifer related to local swarm earthquakes

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Abstract

In the last 20 years, comprehensive new results about the interaction between geodynamic processes and fluid dynamics sustainably influenced the interpretation of seismological and seismo-hydrological investigations. After beginning with simple measurements of radioactivity in mineral waters, two main indicators for seismical-hydrological coherences had been identified over the years: the hydrostatic pressure (groundwater level) and the flow rate of the free gas escaping for springs and mofettes. The basic region for this research program was the Upper Vogtland (Saxony, Germany) and NW Bohemia (Cheb Basin, Czech Republic). Moreover, measuring devices of the research group have been applied successfully in areas of strong seismicity as in Italy, Israel and Taiwan. There, the results obtained in the Vogtland area could be verified.

Up to 1999, more than 20 radon anomalies had been recorded in the spring water of the 'Wettersquelle', Bad Brambach. Most of them were precursor effects which could be correlated with seismic events (swarm earthquakes) in the epicentre of Nový Kostel (CZ), about 10 km east of Bad Brambach. The anomalies indicate higher fluid pressures before the earthquakes resulting in a stronger gas emission from the narrow fissured aquifer system (slug flow process).

Particularly, the groundwater level anomalies before the autumn 2000 earthquake swarms, as well as before and during the 2008/09 local seismic period support the model conception about a pre- to co-seismic pressure perturbation within the pore/fissure space. Moreover, indications of fluid-induced earthquake triggering could be assumed in both seismic periods.

Long-term monitoring is scientifically very valuable as a basis for reliable and convincing trend analyses. Thus, the joint evaluation of GW level and seismic data over 27 years suggest that local earthquakes related to hydrological anomalies preferably occur during or after periods with low regional GW levels. Moreover, an uptrend of $^3\text{He}/^4\text{He}$ ratios between 1993 and 2005 at gas vents in the Vogtland and the Cheb Basin was proved by colleagues of UFZ Leipzig-Halle and GFZ Potsdam (Germany). This trend is overlapped by a significant increase of the gas flow rate between 1998 and 2009 at five springs and mofettes. Both phenomena indicate an increased activity of a magma chamber located below the Cheb Basin.