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TEMPORAL EVOLUTION OF EARTHQUAKE-INDUCED PRESSURE VARIATIONS IN A NEARBY GEOTHERMAL RESERVOIR: A CASE-STUDY FROM AFYON, TURKEY

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Within two hours a magnitude M_w=6.5 and a M_w=5.8 earthquake occurred in the Afyon province of southwestern Turkey on 3 February 2002. The first event occurred along the Sultandağı fault indicating normal faulting mechanism with nearly EW strike direction. The second event occurred about 30 km to the west inside the Afyon-Akşehir-Graben (AAG), again a normal faulting event, but with a strike of NNE-SSW. The latter event and its aftershocks occurred in a geothermal area called Heybeli also known as Kızıldağ. Aksari et al. (2010) calculated static Coulomb stress changes of +0.3 to +0.7 bar as well as much higher peak dynamic stress levels for the Heybeli area induced by the first event and thus proposed transient stress triggering, *"most likely involving elevated fluid pressures in the hydrothermal systems…"* might have played a major role in the occurrence of the M_w=5.8 event and its aftershocks. In the frame of a Task Force mission we studied the aftershock series in February and October 2002. Additionally, we investigated the fluid inventory of about 25 wells and springs within the AAG immediately after the events and in the following years. Here, we report on the long-term evolution of fluid pressure variations.

The geothermal field of Heybeli covers an area of a few square kilometers inside a roughly 10 km wide morphological and tectonic graben (AAG). In former times, several natural hot springs with discharge rates between 0.1 and 3.9 l/s and water temperatures between 30 and 50 °C could be found in this area. Exploitation of the geothermal water for spa purposes began in 1978, when a borehole named H-1 was drilled to a depth of 252 m into fractured marble covered by quartz-schist. Since then, more than 10 boreholes have been drilled, resulting in most of the natural springs now being dried out and the wells no longer being artesian.

The following changes in the fluid regime occurred after the 2002 events: (i) the "old spring" began to flow again after many years of dryness, (ii) well H-3 became a free-flowing artesian well (water level before the earthquake was about 10 m below surface), and (iii) about 50 m to the north of well H-1, thermal water with a temperature of 44 °C started to flow along two newly created fractures striking 34-40°NNE – coinciding with the strike of the M_w=5.8 event. By November 2003, the water level at H-3 dropped to 0.5 m below the surface. Because the fluid was still vigorously degassing, we closed the well-head and installed pressure sensors to record the gas pressure since then. Immediately after closing the well, a pressure of 1 bar was recorded. The pressure slowly decreased to 0.4 bar measured in December 2013. Water discharge from the new fractures and the old spring stopped again in 2005. Thus, the Heybeli reservoir seems to be capable to sustain pressure disturbances over relative long time periods.

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We will compare the temporal evolution of the fluid pressure with the temporal evolution of seismicity. Coulomb stress changes were recalculated for various published rupture models. Groundwater level data from two shallow wells were used to evaluate the quality of the models. A realistic model should predict – at least qualitatively – an observed co-seismic decrease of the water table at Bolvadin, as well as a rising water level for a well in Sultandağı. This leads us to a fine-tuned model of the ruptured fault geometry taking further into account geological (intersection of two graben structures) and geodetical (deformation deduced from InSAR) criteria as well as the observed aftershock patterns. Finally, we will compare the predicted pore-pressure changes at the reservoir site with the observed co-seismic pressure increase of about 2 bar.

REFERENCES

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