Geophysical Research Abstracts
Vol. 13, EGU2011-3063, 2011
EGU General Assembly 2011

Integrative characterization of faults' hydraulic role in low-permeability environments

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Structural elements generally represent key geological factors in fluid migration and retention. Fractures and faults can be conduits for migration of water, hydrothermal fluids, contaminants, and hydrocarbons as well. Furthermore, hydraulic role of faults particularly in low-permeability environments is of interest in radioactive waste disposal, contaminant hydrogeology, and hydrocarbon exploration to name but a few.
Low-permeability formations, thought to be regionally extensive and effective aquitards, can be heterogeneous and more permeable indeed as a consequence of crosscutting faults and/or intercalated high-permeability lenses ("sedimentary windows"). Misleading interpretations are usually due to the data scarcity in these zones, as well as the constant "scale problem" of the domains of interest and interpretation, which is more pronounced and complex in low-permeability formations. Additionally, such environments still have a lot of theoretical and practical questions and unsolved problems, such as the query of Darcy's law's validity and reliable hydraulic testing.
However, a hydrogeological approach proved to be suited for characterizing the hydraulic behaviour of a regionally extensive aquitard unit (Algyő Aquitard) in the Pannonian Basin, Hungary. During the integrative study, seismic, lithostratigraphic, well-log, as well as hydraulic, hydrochemical, and temperature data were interpreted simultaneously in order to characterize the tectonics, fluidstratigraphy, and fluid flow systems of the research area. Among the hydrogeological research methods, hydraulics was found to be the most effective, while though geothermics and hydrochemistry supported the hydraulic results, these were not appropriate for interpretation in themselves. As a conclusion, upward dissipation of overpressure from the Pre-Neogene basement was identified across the Neogene basin fill with differing rates pending on the heterogeneity (e.g., fault density) of the Algyő Aquitard. As the manifestation of pressure dissipation in a heterogeneous flow field, diagnostic anomalies can be observed in the fluid-potential field, as well as in the geothermal and hydrochemical patterns. These anomalies usually coincide with fault zones and hydrocarbon accumulations as well. On the margin, a simple method was developed for identify fluid-potential (i.e. hydraulic head) anomalies caused by pressure data, which were measured in gas pools. Moreover, direction dependent hydraulic behaviour of high-permeability faults, as well as their role in the development of thermal water reservoirs and hydrocarbon entrapment was also demonstrated. These faults as transversal flow barriers are bounding gas pools in sandy layers of the Algyő Aquitard, while as vertical flow conduits their junction in the south of the gas field causes a more intensive (thermal) water upwelling, i.e. a fluid-potential anomaly. In addition, their flow barrier function transversally is simply due to the configuration of the fluid-potential field, and not to their permeability.