Using CO_2 flux to constraint a 3D physical model of the Campi Flegrei caldera geothermal system

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Fluids release at depth has a primary role in generating volcanic unrest periods at Campi Flegrei (CF). According to [1] 5000 ton/day of a CO_2 - H_2O gas mixture is released in the Solfatara area (~1.4 km^2). Heat flux associated to this degassing process was estimated to be ~100MW, representing the most important term in the energetic balance of the whole caldera. We have developed a 3D physical model of the CF geothermal system which accounts for the caldera rocks physical properties, bathymetry and water table topography. The new model, developed by using the TOUGH2 code simulator, was constrained by density values obtained by tomographic inversion of gravity data collected both onshore and offshore the caldera. Empirical relations between density and porosity and between porosity and permeability, derived by published data on samples cored in deep wells or collected in outcrops, allowed us to characterize the main rocks physical parameters controlling the dynamic of the CF geothermal system. We have investigated the effects of the injection at depth, in axis with Solfatara crater, of a hot gaseous mixture rich in CO_2 (5800 ton/day), according with the estimated mass flux released in the area through diffuse degassing. We show that the effects of the water table topography together with the bathymetry and the heterogeneous distribution of the rocks physical properties, lead to important differences in the hydrothermal circulation of fluids at CF. These constraints allow the activation of convective cells with different behaviour, which produce variable pattern of temperature inside the hydrothermal system. As a consequence, the predominant effect is again represented by a central plume below the Solfatara crater, but with a non-axisymmetric structure and a wider extension. Additionally, high temperature zones are present near the coastline and the in the middle part of the submerged area of the caldera with a SE-NW alignment.

[1] Chiodini *et al* (2001) *JGR* **106**, 16216-16221

Composition-dependent anisotropic interdiffusion tensor obtained from cation exchange between alkali feldspar and NaCl-KCl salt melt

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While homogeneous diffusion is fully described by a scalar diffusivity, diffusion in anisotropic crystals requires a tensor describing transport in each direction and correlations between different directions. Reconstruction of the scalar diffusion coefficient is an important inverse problem, which is addressed using backward integration of the concentration profile from a known solution of the diffusion equation. Moreover, by adjusting an experimental setup, even a composition-dependent diffusion coefficient can be reconstructed from the self-similar solution of the nonlinear diffusion equation.

We demonstrate that this method can be naturally generalized for an anisotropic system. The generalization is then applied to quantify the full composition-dependent anisotropic diffusion tensor for Na-K interdiffusion in alkali feldspar. Composition profiles obtained from cation exchange at 850°C and 1 bar between oriented cylinders and plates of sanidine with $X_{Or} = 0.84$ and a KCl salt melt show a plateau of compositions in equilibrium with the salt melt at the crystal surfaces separated from the unaffected interior regions of the crystals by a transition zone that is sharp in the *b*-direction and comparatively shallow in all directions lying in the *a*-*c* plane. Given that a 40 fold molar excess of alkali cations in the salt mixture relative to the feldspar was applied, the composition of the salt remained essentially constant during cation exchange. The presence of an inflection point in the composition profiles can thus only be explained by a composition dependent Na-K interdiffusion coefficient.

For 850°C we show that the Na-K interdiffusion coefficient is by a factor of about 10 larger in the *a*-*c* plane than in *b*-direction. There is only a weak composition dependence in the range $0.86 < X_{Or} < 0.95$. Only at $X_{Or} > 0.95$ the interdiffusion coefficient increases by about a factor of 10. These results were thoroughly tested by obtaining numerical solutions of the nonlinear diffusion equation with the reconstructed diffusion tensor and the initial conditions describing the experimental setup. Thereafter the numerical results were compared with the actually observed concentration profiles. Good agreement was found.

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