CONTROL ID: 1462972

TITLE: Geodetic measurements and numerical models of deformation at the Svartsengi Geothermal Field, Iceland, 1992 - 2010

AUTHORS (FIRST NAME, LAST NAME): Kurt Feigl[1], Tabrez Ali[1], Herbert F Wang[1], Gudmundur O Fridleifsson[2], Omar Sigurdsson[2], Freysteinn Sigmundsson[3]

INSTITUTIONS (ALL): 1. Department of Geoscience, University of Wisconsin, Madison, WI, United States.
2. HS Orka hf, Reykjanes, Iceland.
3. Nordic Volcanological Center, Institute of Earth Sciences, , University of Iceland, Reykjavik, Iceland.

ABSTRACT BODY: To study rheology — the constitutive relations between stress and strain— we apply a known impulse to a mechanical system and then measure the subsequent response. For example, by ringing a bell and listening to the resulting sound, we can infer that the material in the bell behaves as an elastic solid with little attenuation. By modeling the impulse (stress) and measuring the response (strain), and defining the constitutive relations between the two, we can make inferences about the underlying physical processes. In the case of the earth, the response is crustal deformation that can be measured using interferometric synthetic aperture radar (InSAR). Such experiments are feasible where industrial extraction of oil, gas, water, or heat causes subsidence, provided that data are available to describe both the impulse and the response.

The Svartsengi geothermal field meets the requirements for a rheological experiment. Located on the Reykjanes Peninsula in Iceland, it is associated with a segment of mid-ocean ridge of the same name. The operators of the Svartsengi field have monitored the water level, borehole pressure and surface deformation since beginning production in 1976.

In this study, we analyze radar images acquired on 78 distinct dates between 1992 and 2010 by six satellite missions: ERS-1, ERS-2, Envisat, ALOS, TerraSAR-X, and TanDEM-X. As in previous studies (Vadon and Sigmundsson, 1997, Keiding et al., 2010), the InSAR results indicate subsidence at the order of several centimeters per year over an area roughly five kilometers in radius. To describe this deformation, one can consider a simple model that assumes a half space with uniform elastic properties. For a reservoir shaped like a prolate spheroid, the model parameters include depth, length of the semi-major axis, width of the semi-minor axis, strike of the spheroid axis, plunge of the spheroid axis, and a pressure change (Yang et al., 1988). This model has been applied to the Coso geothermal field in California (Fialko and Simons, 2000). To estimate the parameters in this model, we apply the General Inversion for Phase Technique (GIPhT), as developed by Feigl and Thurber (2009) and extended by Ali and Feigl (2012).

The rate of change of the excess pressure estimated from the InSAR data, however, is more than an order of magnitude faster than that measured in the reservoir, assuming reasonable values of the elastic coefficients. From this result, we infer that an elastic rheology is not an appropriate description of a medium that includes fluids, fractures, and other geological heterogeneities. To account for such features, we apply poro-elastic rheology, using the Biot theory of poroelasticity (e.g., Wang, 2000).

KEYWORDS: [1855] HYDROLOGY / Remote sensing, [8485] VOLCANOLOGY / Remote sensing of volcanoes, [1822] HYDROLOGY / Geomechanics, [3260] MATHEMATICAL GEOPHYSICS / Inverse theory.

(No Image Selected)

(No Table Selected)

Additional Details

Previously Presented Material: We have not presented these results before. Nor have we submitted them for publication.

Contact Details

CONTACT (NAME ONLY): Kurt Feigl

CONTACT (E-MAIL ONLY): feigl@wisc.edu

TITLE OF TEAM: