

Toward calibrating the paleosol carbonate CO₂ barometer for paleoVertisols

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The concentration of CO₂ ([CO₂]) in soils during soil calcite formation must be known in order to accurately calculate ancient atmospheric [CO₂] using the paleosol carbonate CO₂ barometer [1]. The average $S(z)$ value ($S(z) = [CO_2]_{soil} - [CO_2]_{atmosphere}$) appropriate in the barometer has recently been estimated at 0.25% [2]. In the present study, we measured soil [CO₂] in modern Vertisols (high shrink/swell clay content soils) in order to test the value of 0.25% and help calibrate the barometer for paleoVertisols which are commonly used to reconstruct ancient atmospheric [CO₂].

We installed 7 soil gas wells in the Bkss horizon of modern Vertisols in a C₄ grassland at the USDA Riesel Watershed in Riesel, TX, USA. Soil [CO₂] was measured in soil gas samples withdrawn from the wells on a monthly basis. The resulting time series currently extends from January 2010 through March 2011. Soil [CO₂] varied seasonally and interannually during the period of study, reaching a maximum of 9.3% in June 2010 and a minimum of 0.13% in February 2011. Soil [CO₂] was above 1% at every site during the winter of 2009/2010 when the soil was water-saturated and was below 1% at every site during the winter of 2010/2011 when the soil was dry and cracked. Soil [CO₂] decreased rapidly from maximum values (~3-9%) in June 2010 to values as low as 0.2% in August 2010 as the soil warmed, dried and cracked. Without independent evidence for the timing of calcite formation, we cannot yet confidently quantify $S(z)$ values appropriate for the barometer. However, the decrease of $S(z)$ values below 0.25% during the summer when soil calcite is thought to form is consistent with the conclusions drawn by [2]. Our data suggest that soil [CO₂] is strongly decoupled from temperature in Vertisols and is controlled by soil moisture and the opening and closing of soil cracks which act as gas transport conduits. Preservation of foraminifera skeletons from parent material in this soil suggest that calcite dissolution/reprecipitation is limited, even under seasonal changes in soil pCO₂ that span orders of magnitude.

[1] Cerling (1991), *American Journal of Science* **291**, 377-400. [2] Breecker, Sharp & McFadden (2010) *PNAS* **107**, 576-580.

Hydraulic-hydrochemical modelling of a geothermal reservoir in Indonesia

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The purpose of this study is to explain the hydraulic and hydrochemical connection between different surface and subsurface reservoirs at a geothermal site in Indonesia. By using an integrated model to determine hydraulic pathways through porous media as well as fault structures and connecting it to a chemical transport model, the effect of geology on the hydrochemical characteristics should be explained. The numerical simulator OpenGeoSys is used for modelling the thermo-hydraulic situation. Results will eventually be combined with hydrochemical PHREEQC calculations.

In November 2010 a geothermal plant has been visited and available hydraulic, geological, and hydrochemical properties were reviewed. Additionally, water samples from production wells, hot springs, and a lake have been taken and analysed. Physicochemical parameters were measured *in situ*.

At the investigated site three different fluid containing reservoirs have been identified at various depths with temperatures between 250 and 350 °C, which show each different hydrochemical characteristics: The deepest reservoir (2300 m) with a moderate pH of 5 is marked by silicium (Si) concentrations up to 350 mg/L and high chloride (Cl) concentrations of 430 mg/L. The fluid in the most shallow (1000 m) reservoir above is highly acidic (pH 1). Still higher Cl (1550 mg/L), Si (1600 mg/L), and sulphate concentrations (460 mg/L) appear in this reservoir. Acid water (pH 2.6) was also observed in a nearby lake indicating a hydraulic connection to that reservoir. PHREEQC-calculations show an oversaturation of several minerals such as alunite, silicates e.g. kaolinite, Ca-montmorillonite, and quartz at temperatures between 25 and 45 °C. Therefore silicate mineral precipitation upon fluid cooling can be expected to occur in the wells, pipes or the reservoir, which would harm the plant components or even damage the reservoir in the long term.

Apparently three aspects are challenging for the model build-up: (I) a three level-reservoir with the connected acidic lake; (II) the oversaturation of silicates upon cooling; (III) the change in composition over time.