Available online at www.sciencedirect.com
ScienceDirect
ELSEVIER
Physics and Chemistry of the Earth 32 (2007) 629–638
PHYSICS and CHEMISTRY of the EARTH
www.elsevier.com/locate/pce

Modelling of an in situ ventilation experiment in the Opalinus Clay

Gerhard Mayer, Georg Klubertanz [1], Jean Croisé *

Colenco Power Engineering AG, Department of Groundwater Protection and Waste Disposal, Täfernstr. 26, CH-5404 Baden, Switzerland

Received 15 April 2005; received in revised form 10 February 2006; accepted 8 March 2006
Available online 7 November 2006

Abstract

The so-called Ventilation Experiment (VE), located in the Opalinus Clay formation of the Mont Terri underground rock laboratory in Switzerland (www.mont-terri.ch), is aimed at investigating in situ the effect of tunnel ventilation on the hydro-mechanical conditions in the rock around the excavations. For this purpose, a hermetically separated tunnel section is ventilated under well-controlled conditions. Humidity, temperature and volumetric airflow are measured in the tunnel, porewater pressure, water content and deformation are monitored in the surrounding rock. Three major experimental phases have been accomplished till end 2004: a saturation phase between July 2002 and April 2003, a desaturation phase between July 2003 and February 2004 and a subsequent resaturation phase.

The two-phase flow code TOUGH2 has been used to model the VE and to derive the hydraulic properties of the Opalinus Clay and the excavation damage zone (EDZ). The investigation is based on a radial symmetric model configuration with a horizontal axis located at the axis of the ventilation tunnel (1.3 m diameter and 10 m length) and an external boundary in a radial distance of 8 m.

The focus of this paper is on the interpretation of the desaturation phase comprising three periods of varying humidity and flow-rates of the air entering the tunnel. The permeability of the undisturbed Opalinus Clay and of the excavation damage zone (EDZ) of Opalinus Clay are derived by means of numerical modelling based on the measurements in the rock and the ventilated tunnel.

The simulated desaturation depth inside the rock corresponding to the 95% water saturation level is 0.35 m from the tunnel wall and well in accordance with the experimental data. The permeability level of the undisturbed rock has been estimated to be about 3×10^{-20} m^2, a value which is very consistent with measurements in boreholes at the Mont Terri underground laboratory.

Keywords: Opalinus Clay; Mont Terri; Hydraulic parameters; Ventilation experiment; Desaturation

1. Introduction and experimental setup

The aim of the Ventilation Experiment (VE) conducted at the Mont Terri underground rock laboratory (Switzerland) is to investigate the potential impact of the ventilation imposed during the construction and operational phases of a deep repository for radioactive waste, on the argillaceous host rock located around the underground drifts (for more details see e.g. Mayor et al., 2005). A similar experiment has been conducted in the underground rock laboratory of Mol in the soft Boom Clay (Palut et al., 1998).

The VE is carried out in a non-lined microtunnel, 1.3 m in diameter, excavated using the raise-boring technique in the Opalinus Clay formation at the Mont Terri underground laboratory. A 10 m long section of the tunnel has been sealed off by means of two doors and is subjected to de- and resaturation by prolonged ventilation periods. The evolution of a number of parameters is monitored at different locations in the rock-mass and in the microtunnel: point measurements of the saturation, pore pressure, capillary pressure, displacements (within the rock-mass) and relative humidity (within the tunnel) are available. The ventilated tunnel and its surrounding rock-mass are heavily

* Corresponding author.
E-mail address: jean.croise@colenco.ch (J. Croisé).
[1] Present address: Now at Emch and Berger Gartenstrasse 1, Postfach 6025, CH-3001, Bern.

1474-7065/$ - see front matter
doi:10.1016/j.pce.2006.03.016

instrumented. The instruments are placed in various cross sections, grouped by type of instruments. Fig. 1 presents a schematic of the instrumentation of the VE.

More details on the experimental set-up are provided in Mayor et al. (2005).

The ventilation rate and the humidity of the inflow-air were varied during the three successive desaturation phases as presented in Table 1.

1.1. Experimental data

A wealth of experimental data is available on the experiment and has been reported in Mayor et al. (2005). For the purpose of the present paper, the humidity data in the tunnel, as well as water flow rates from the rock are used as they have been considered as most reliable.

1.1.1. Humidity data in the tunnel

The humidity of the air in the tunnel was recorded by a total of 8 hygrometers. Two Sensors are located at the upstream side of the system, two downstream. Further two sensors are placed at the wall surface close to the sections SB1 and SB2 and the last two are located in the middle of the tunnel, at opposite sides of the walls.

Table 1
Characteristics of the three successive desaturation phases of the VE

Period (d)	Ventilation-rate (m^3/h)	Relative humidity (%)	Temperature (°C)	Air-inflow (kg/h)	Vapor-inflow (kg/h)
0–28	20	80	15	26	0.205
28–91	30	30	15	39	0.231
91–237	30	0	15	39	0

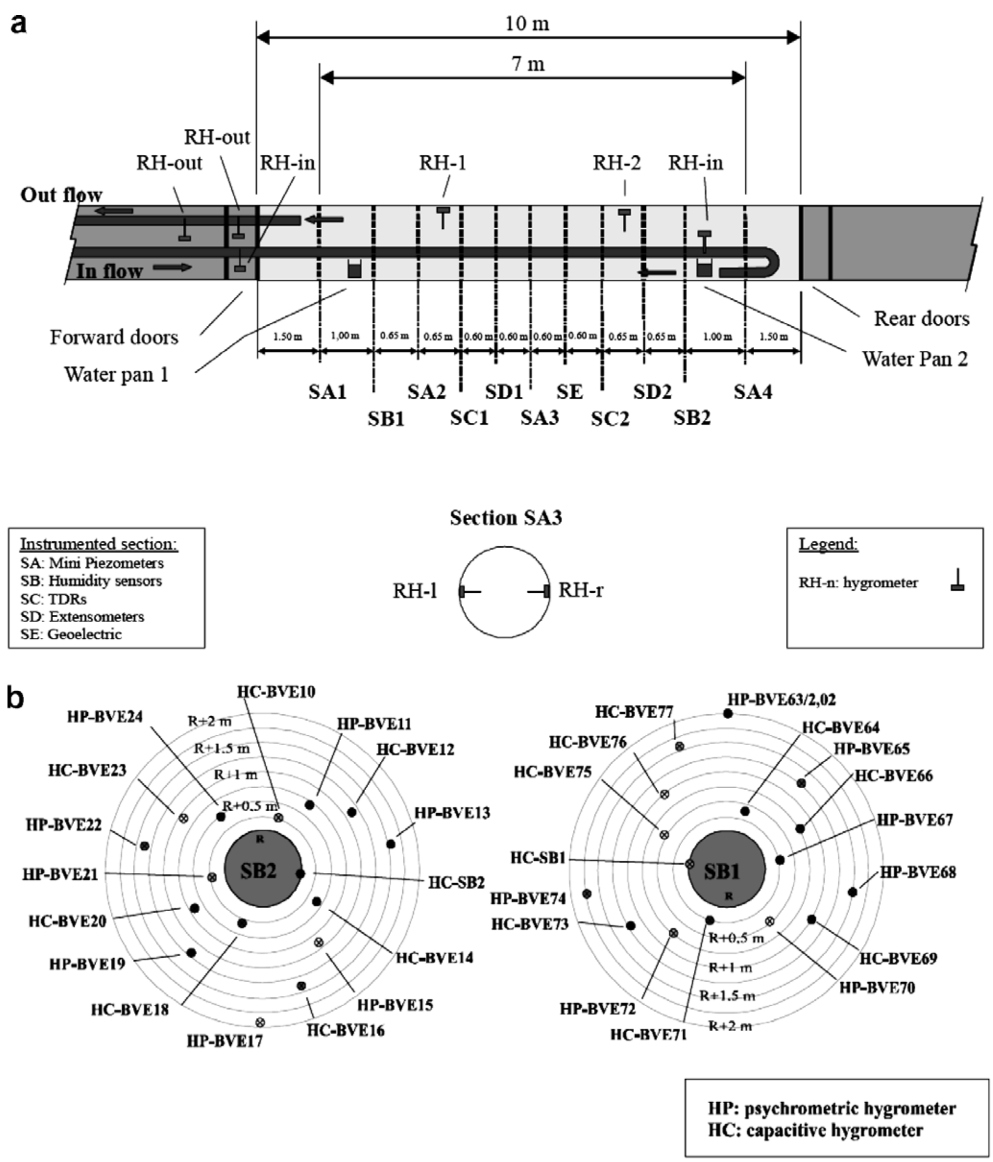

Fig. 1. Instrumentation of the VE: (a) longitudinal section of the VE-tunnel and (b) cross-sections SB1 and SB2 (from Mayor et al. (2005)).