

# Investigation of wellbore skin: typology, composition and hydraulic properties



Georg Houben

Matthias Halisch, Stefan Kaufhold, Christoph Weidner,  
Jürgen Sander, Morris Reich



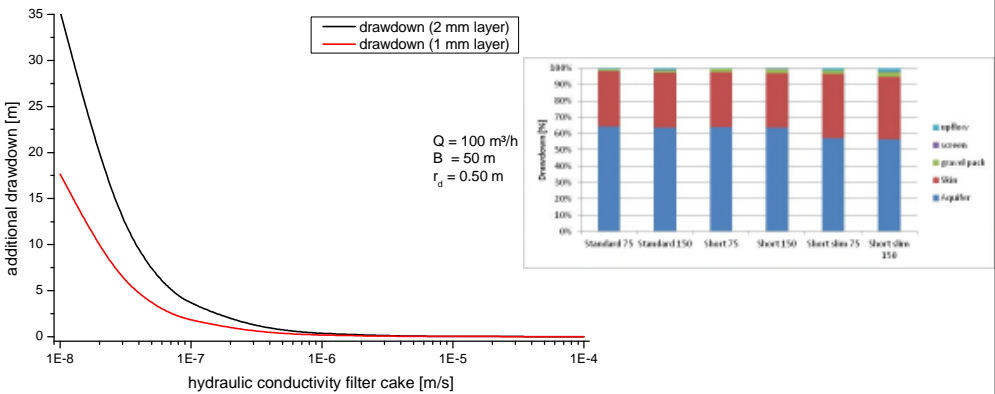
VORWEG GEHEN



## Hydraulic effects of wellbore skin: extra drawdown

Linear laminar drawdown calculated after THIEM (1870)

- function of hydraulic conductivity, layer thickness
- order of magnitude: meter to 10s of meters



## What do we now about wellbore skin?

Wellbore skin: deposition of fine particles at borehole wall, can impede gw flow, particle sources: aquitards, drilling additives

Scopus data base:

- 1,108 publications on “wellbore skin”,
- 3,625 publications on “formation damage”
- 38 publications on “wellbore skin” & “experiments”
- 3 publications on wellbore skin samples:
  - Howsam et al. 1989 (open borehole)
  - Timmer et al. 2003 (after removal of screen & gravel)
  - Etschel 2004 (only photos, pit mine Wackersdorf)

Yeh & Chen (2007) “[...], the skin thickness is actually **unknown** and **cannot be measured**. The identification of skin thickness as well as hydraulic parameters would be [...] useful”.

## Yes, we can! How to get samples



Houben et al. (2016)



gravel pack

skin

aquifer



Dewatering well open pit mine

Inclined core  
drilling (15°)  
into annulus of  
abandoned  
drinking water well

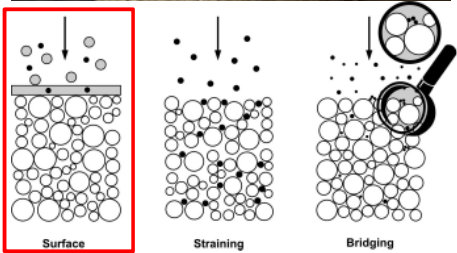


**DOWV** VORWEG GEHEN

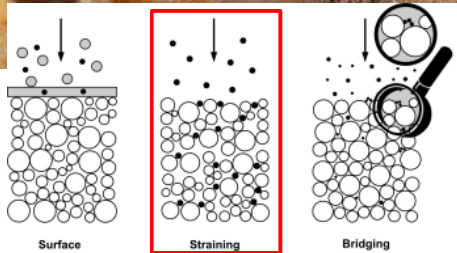
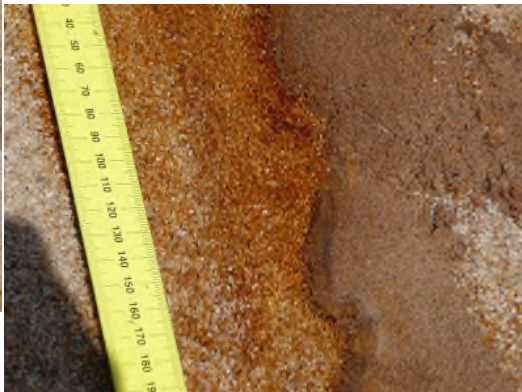
# Typology 1: surface cake



Lignite open pit mine Garzweiler  
Photos: Weidner, Houben



# Typology 2a: straining (bed filtration)



Hambach  
Photo: Houben

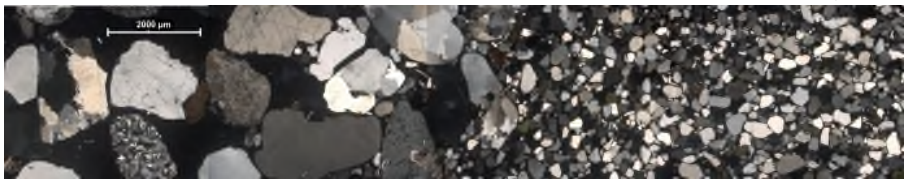
# Typology 2b: straining (but not at borehole wall)



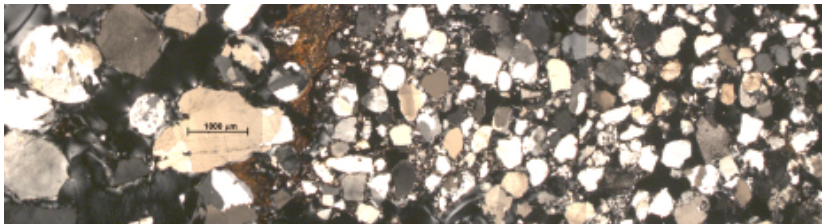
Hambach  
Photo: Weidner

## Wellbore skin under the microscope: thin sections

Polarized light



Grossenkneten 31: no wellbore skin (well-developed drinking water well)

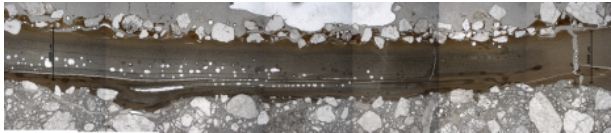


Hambach HS41: bed filtration, plus secondary particle accumulation

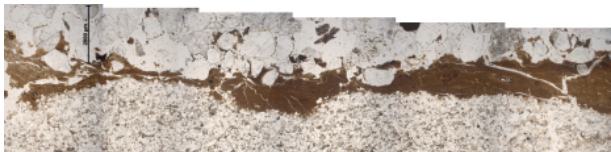
Houben et al. (2016)



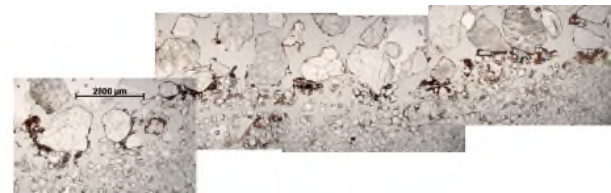
Wellbore skin under the microscope: thin sections



Hambach HS1133



Garzweiler WS5015



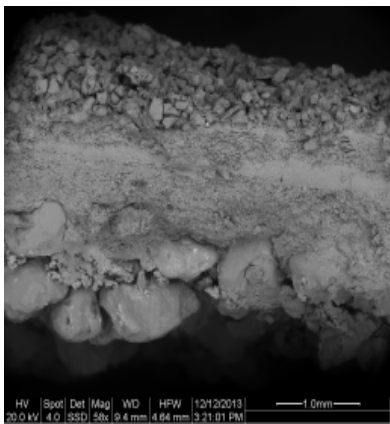
Garzweiler WS3120

Houben et al. (2016.)

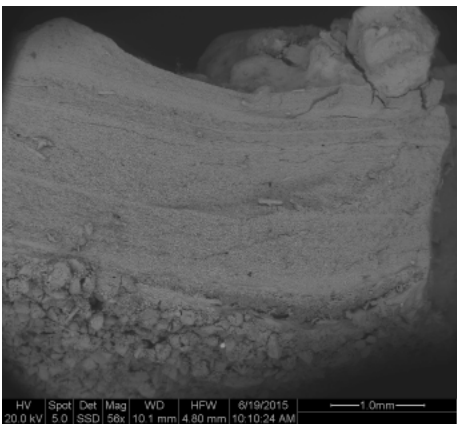
Non-polarized light



Wellbore skin under the electron microscope



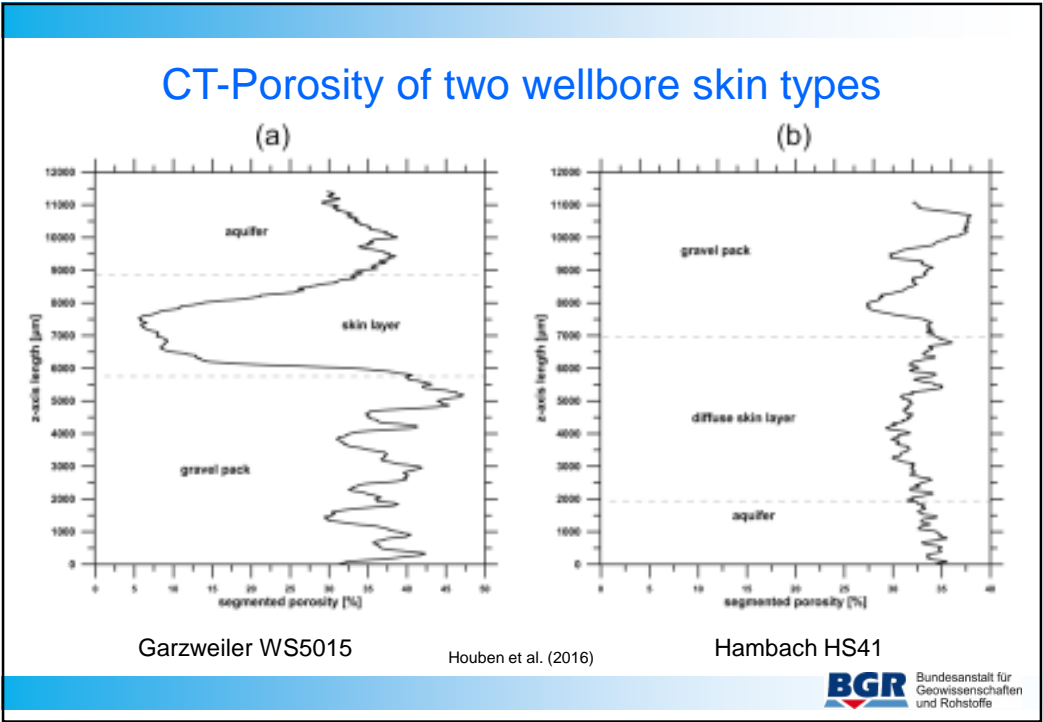
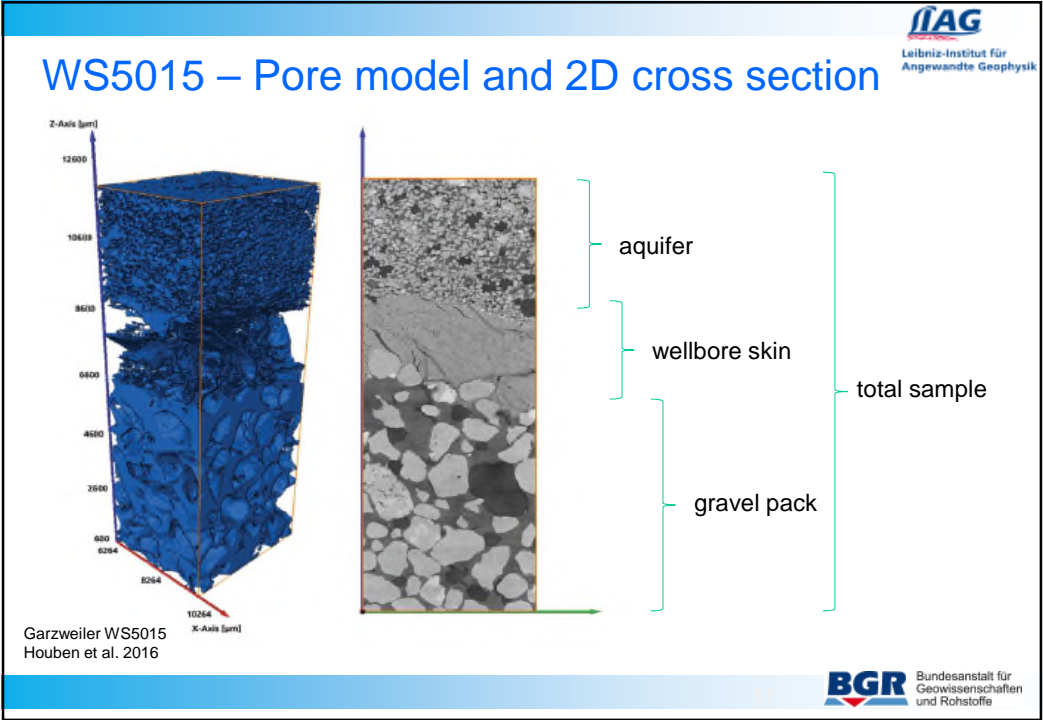
Garzweiler WS 5015

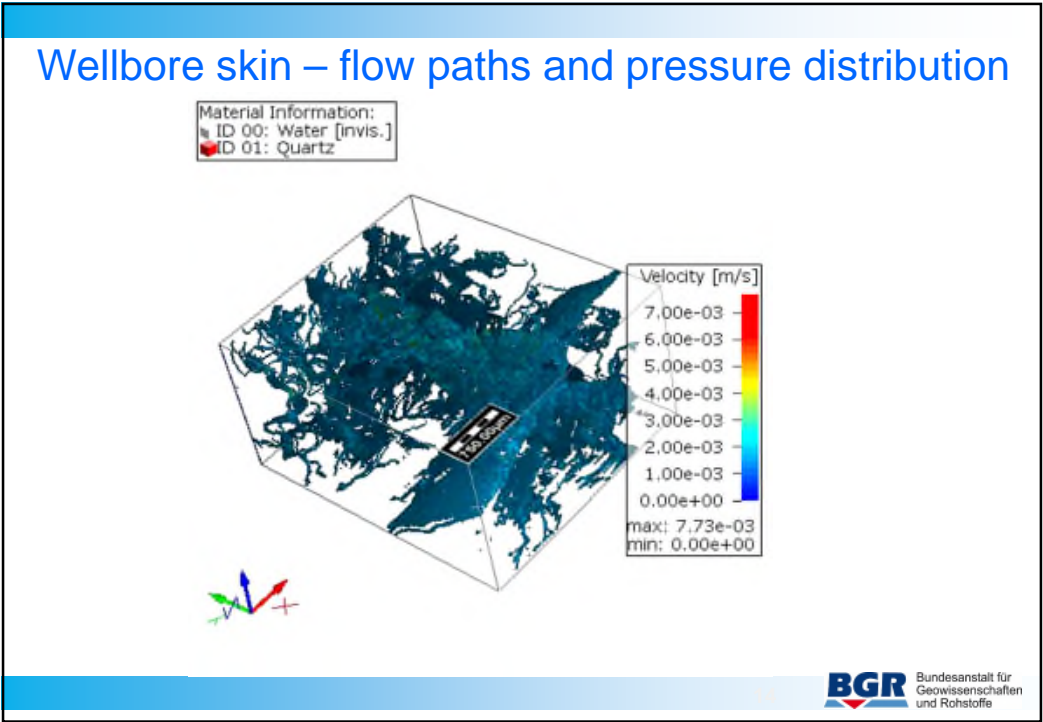


WS5315

Houben et al. (2016.)







## Conclusions & outlook



- wellbore skin causes high entrance losses, distorts pump tests, maybe aggravate well ageing (particle accumulation)
- different types: complex interplay of aquifer permeability, pressure difference between borehole and aquifer, suspension load as function of the type of drilling fluid, traversed clay layers etc.
- layering indicates multi-stage formation
- thickness: 0 to 3 mm (so far!)
- micro-cracks may dominate resulting permeability

## Want to know more?

### Groundwater

#### Analysis of Wellbore Skin Samples—Typology, Composition, and Hydraulic Properties

by Georg J. Houben<sup>1</sup>, Matthias Halisch<sup>2</sup>, Stephan Kaufhold<sup>3</sup>, Christoph Weidner<sup>3</sup>, Jürgen Sander<sup>4</sup>, and Morris Reich<sup>5</sup>

##### Abstract

The presence of a wellbore skin layer, formed during the drilling process, is a major impediment for the energy-efficient use of water wells. Many models exist that predict its potential impacts on well hydraulics, but so far its relevant hydraulic parameters were only estimates or, at best, model results. Here, we present data on the typology, thickness, composition, and hydraulic properties obtained from the sampling of excavated dewatering wells in lignite surface mines and from inclined core drilling into the annulus of an abandoned water well. Despite the limited number of samples, several types of skin were identified. Both surface cake filtration and particle straining in the aquifer occur. The presence of microcracks may be a determining feature for the hydraulic conductivity of skin layers. In the case of the well-developed water supply well, no skin layer was detected. The observed types and properties of wellbore skin samples can be used to test the many mathematical skin models.

##### Introduction

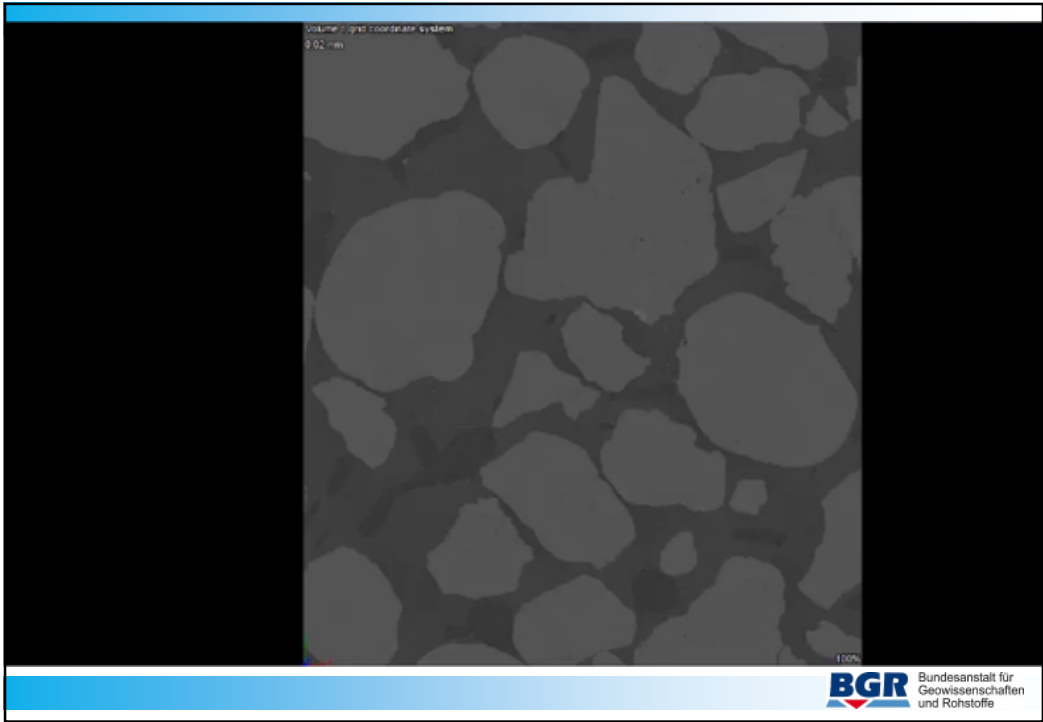
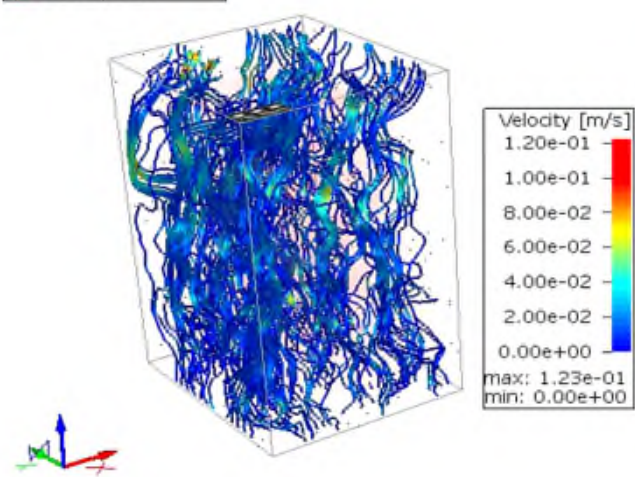
A wellbore skin is a thin layer of mostly fine-grained material of low hydraulic conductivity, deposited close to the borehole wall, which usually forms during

formations and deposit them at the wellbore. During the well's operation, additional fines from the aquifer can accumulate upstream of the skin layer (van Beek et al. 2009; Oliveira et al. 2014; Wilson et al. 2014).



Gravel pack – flow paths and pressure distribution

Material Information:  
ID 00: Water [Invis.]  
ID 01: Quartz



## Features in the gravel pack



Garzweiler  
(1) Incrustations at screen  
(2) Aquifer sand pockets in gravel pack  
(3) Uneven incrustation distribution in gravel pack  
Photo: Houben

## Eccentric wells



Garzweiler  
Photo: Weidner

## How to remove/prevent skin layers?

- Mechanical abrasive removal via drilling fluid circulation  
→ erosive material (e.g. pumice, concrete fragments etc.)
- Mechanical removal  
→ *Backreamer*
- Drilling fluid exchange  
→ after traversing clay layers  
→ prior to completion
- Chemical methods  
→ polyphosphates (destroy  
house-of-cards structure of clay particles)
- Replace drilling fluid additive bentonite by organic additives, e.g. CMC  
→ biological degradation (?)

