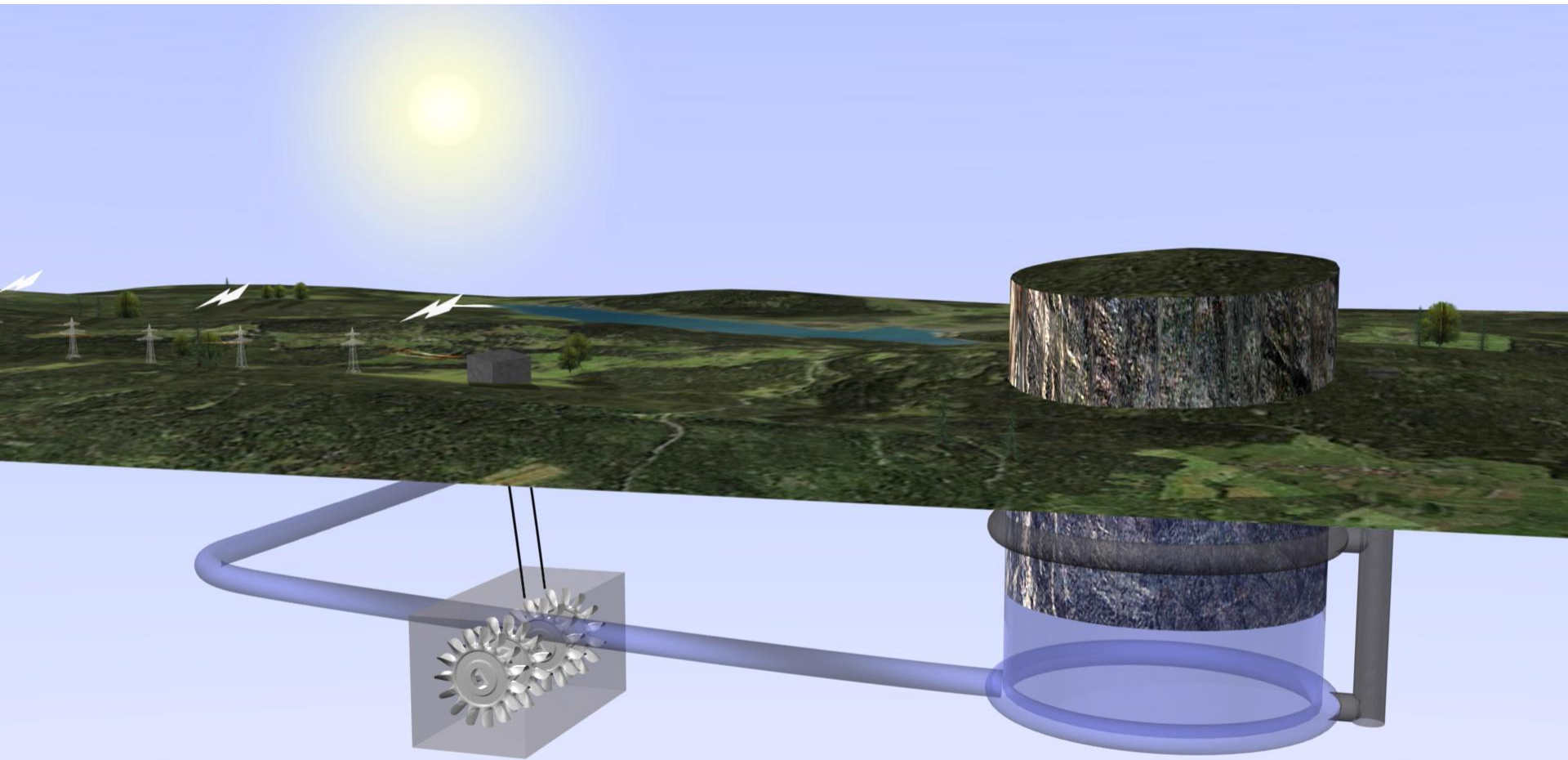


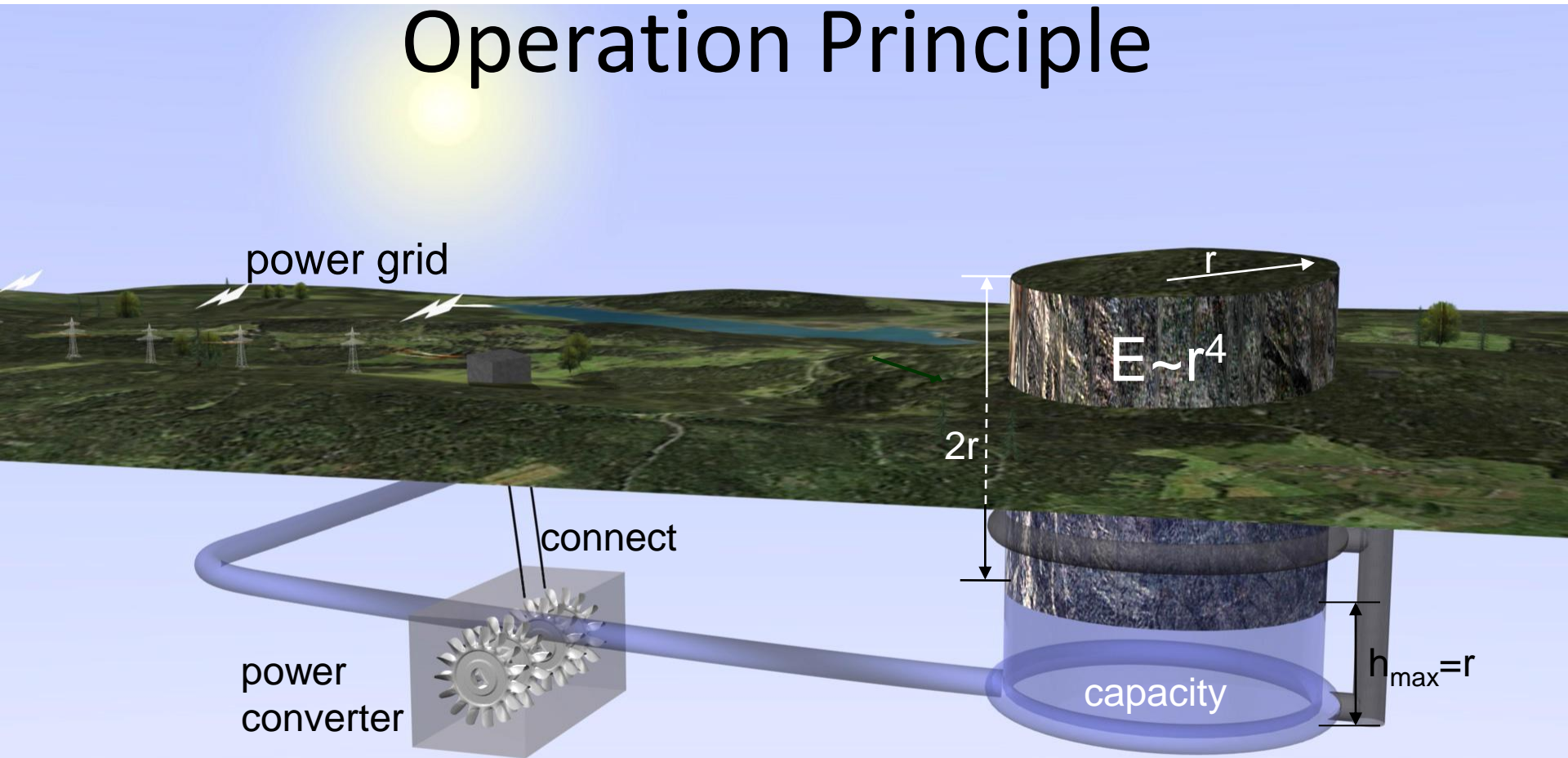
Hydraulic Hydro Storage System



Prof. Dr. rer. nat. **Eduard Heindl** Furtwangen University

Hydraulic Hydro Storage System

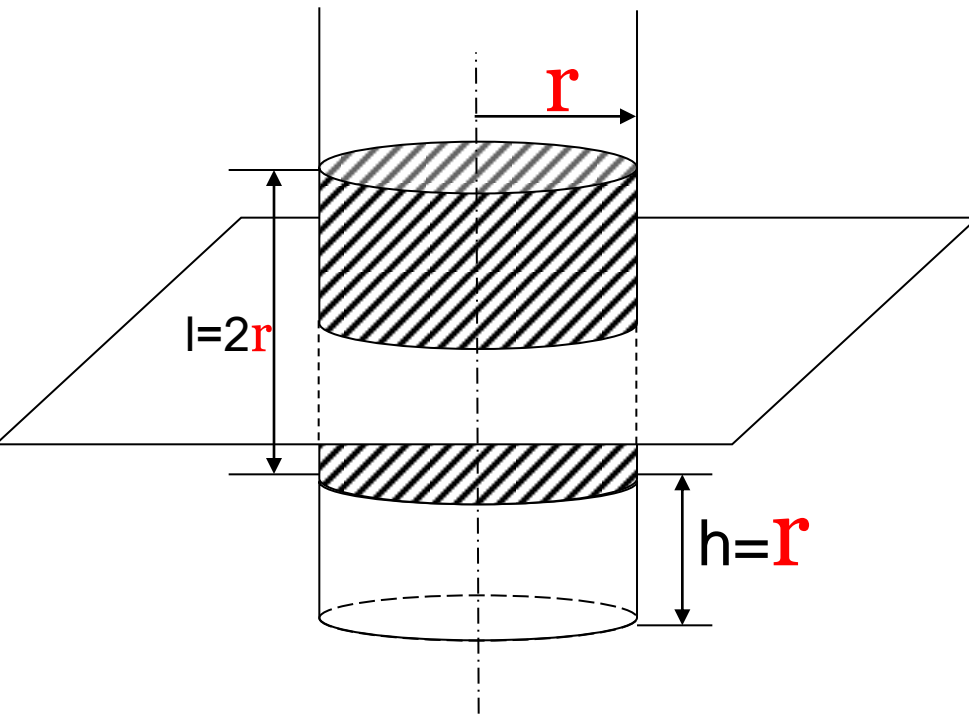
Operation Principle



- Water is pumped into a subsurface cavity, using cheap electrical power
- The is lifted by hydraulic forces
- The storage is discharged when the energy price is high, using a power converter



Physical Properties



mass $\sim r^3$

maximum height $\sim r$

storage capacity:

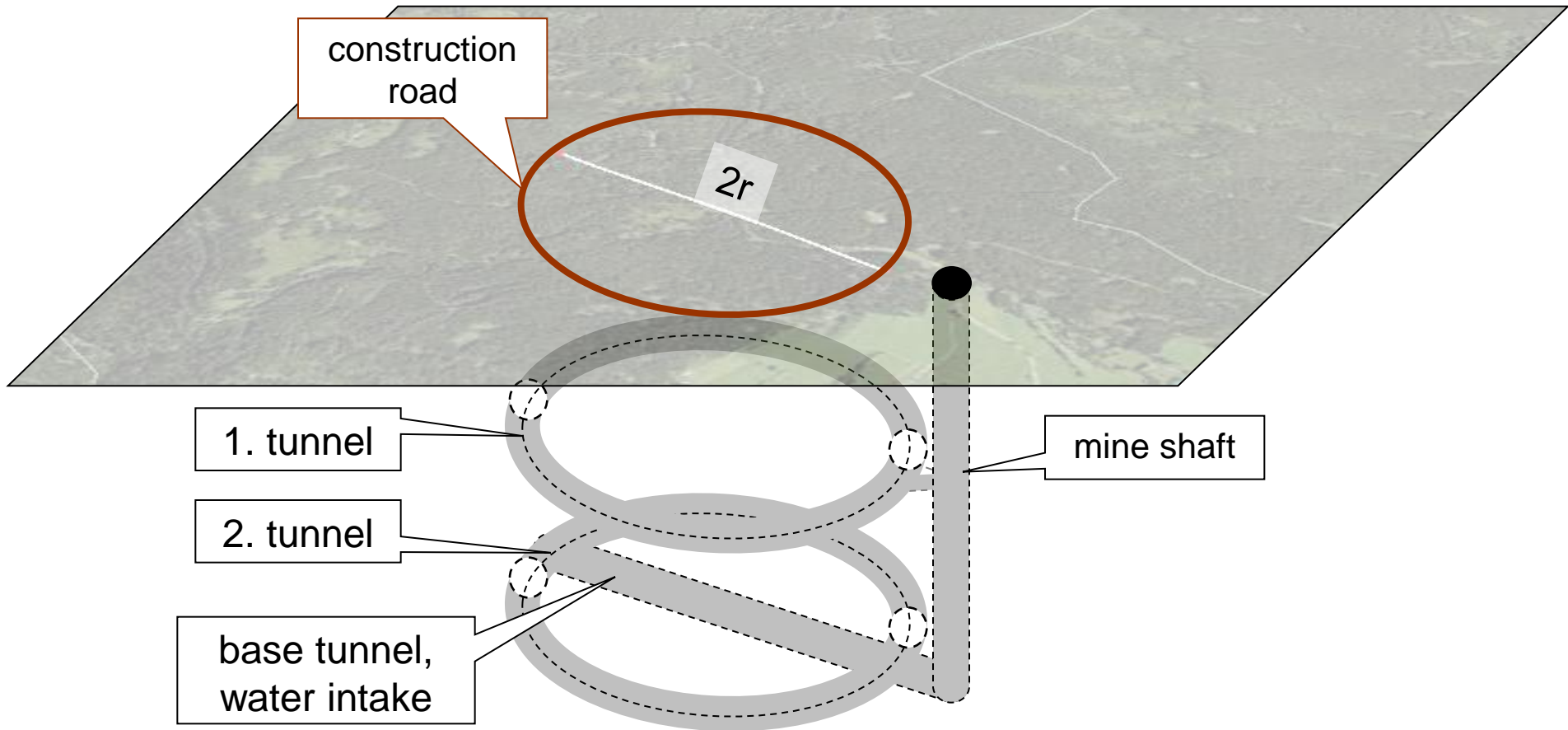
$$E = 2 \pi g \rho * r^4$$

surface \sim cost $\sim r^2$

advantage

cost per kWh capacity $\sim 1/r^2$

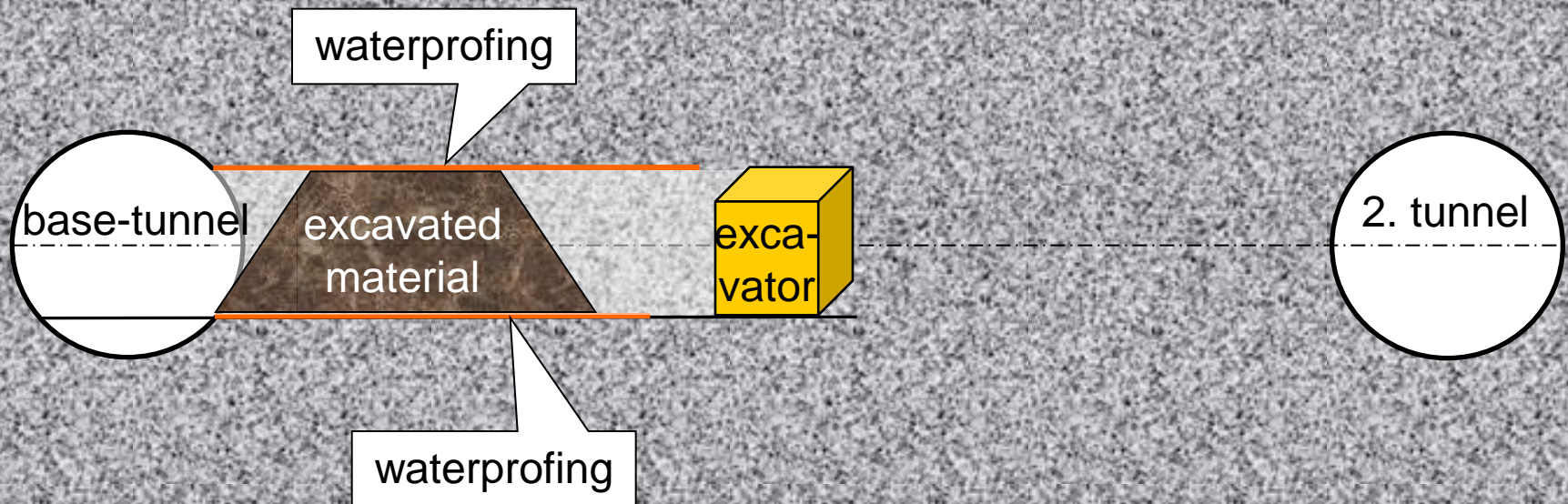
Construction



Hydraulic Hydro Storage System

base plate Separation

mined space

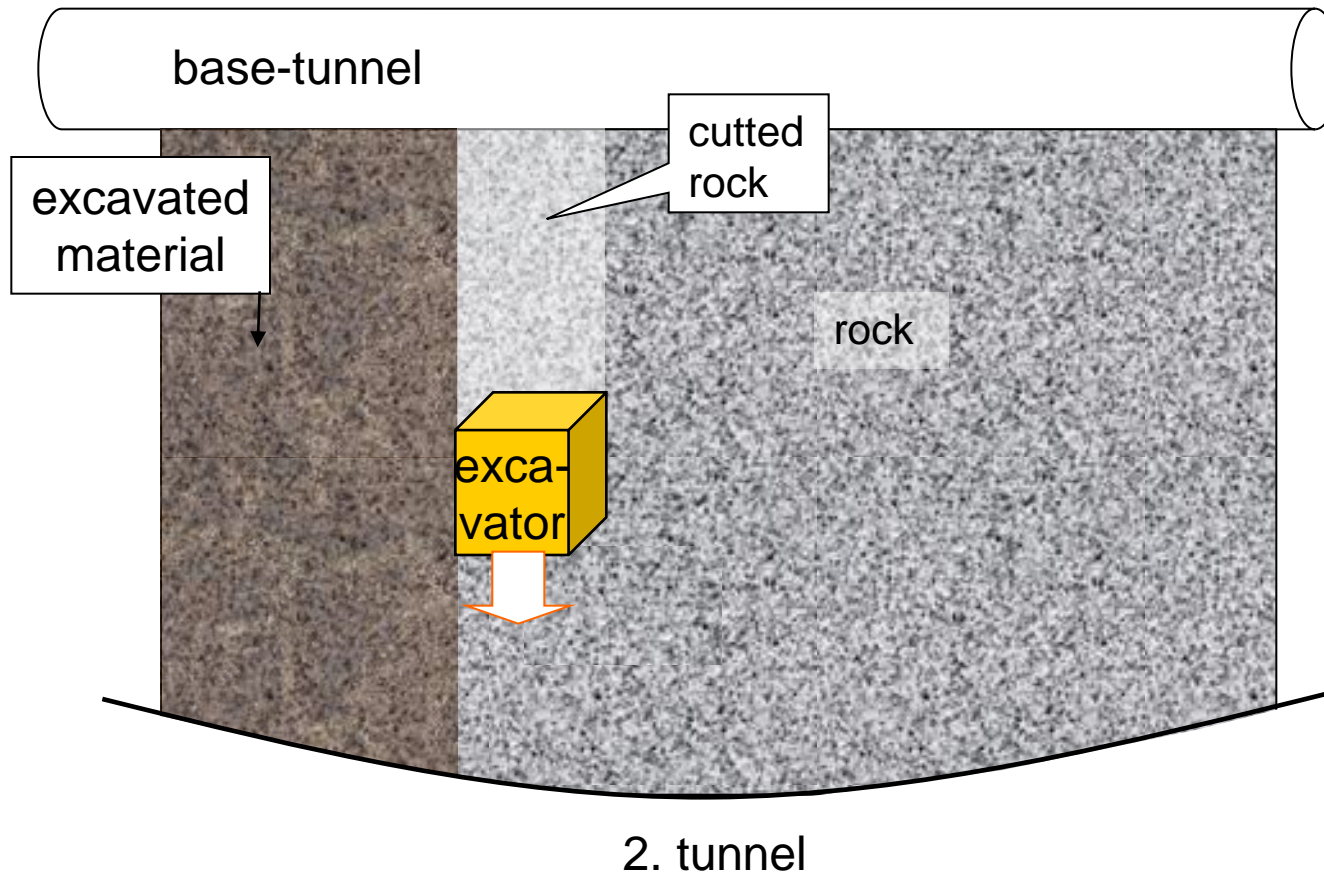


side view



Hydraulic Hydro Storage System

base plate separation

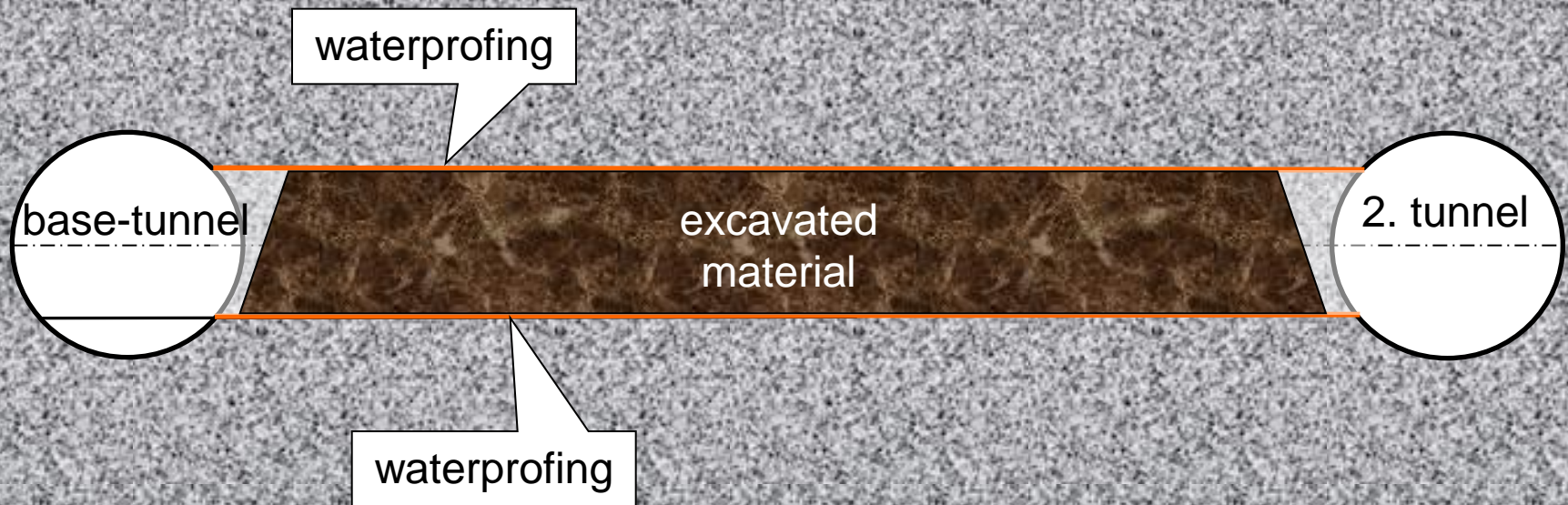


top view!

base plate separation

base plate separated

cylinder is mounted on a ballast bed



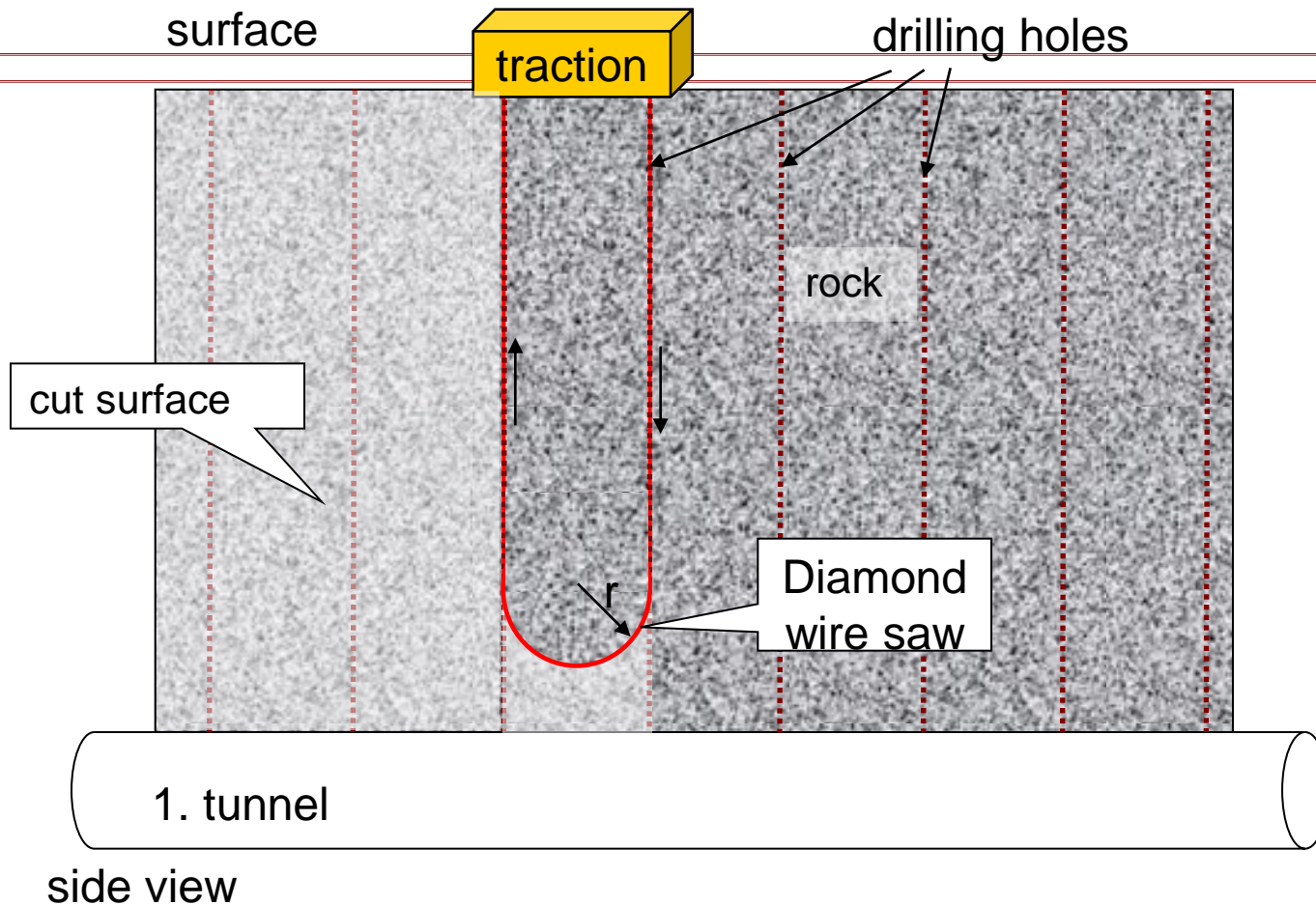
side view

Drilling

drilling guide holes for the wire saw

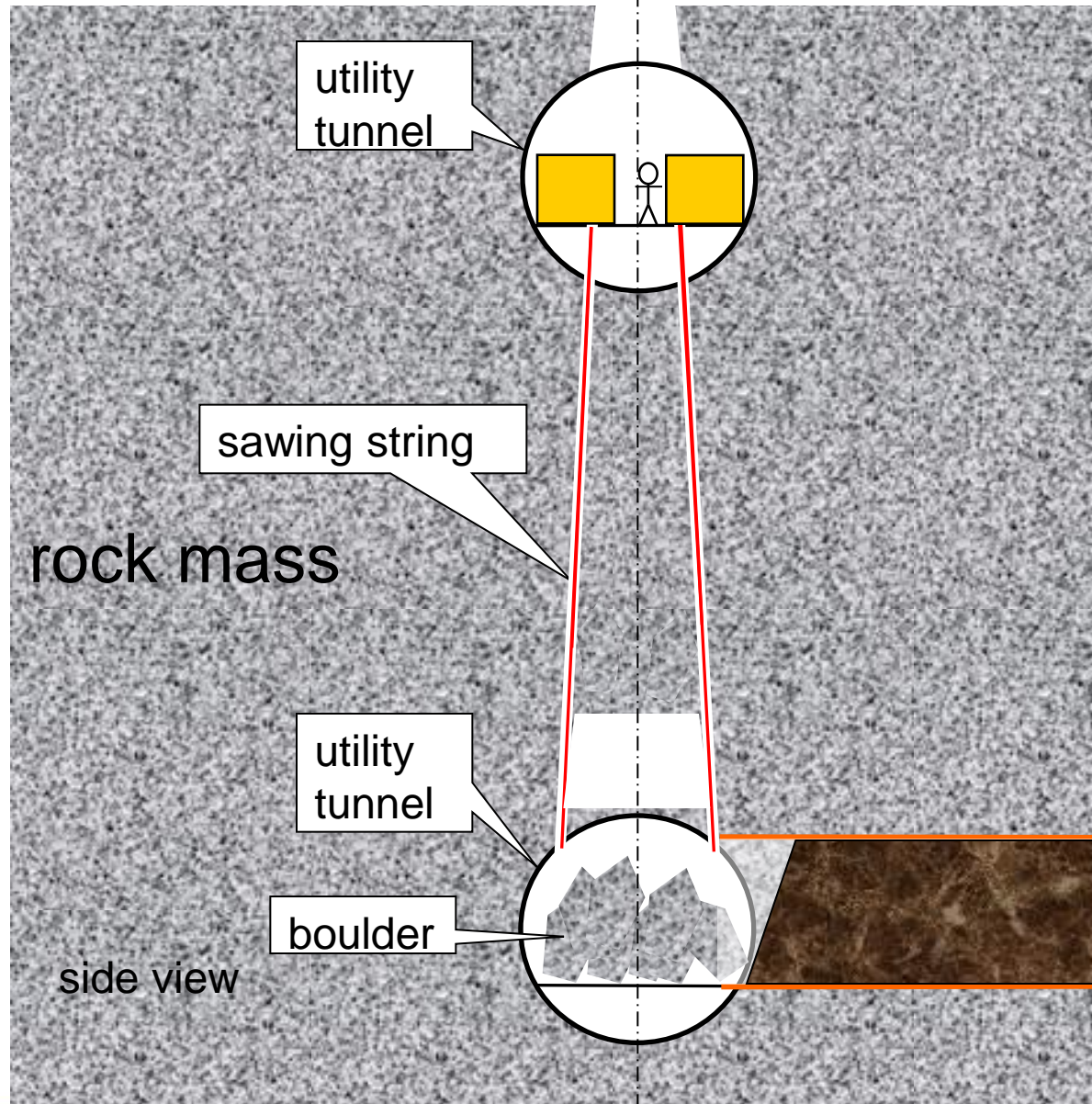


Diamond wire sawing



Hydraulic Hydro Storage System

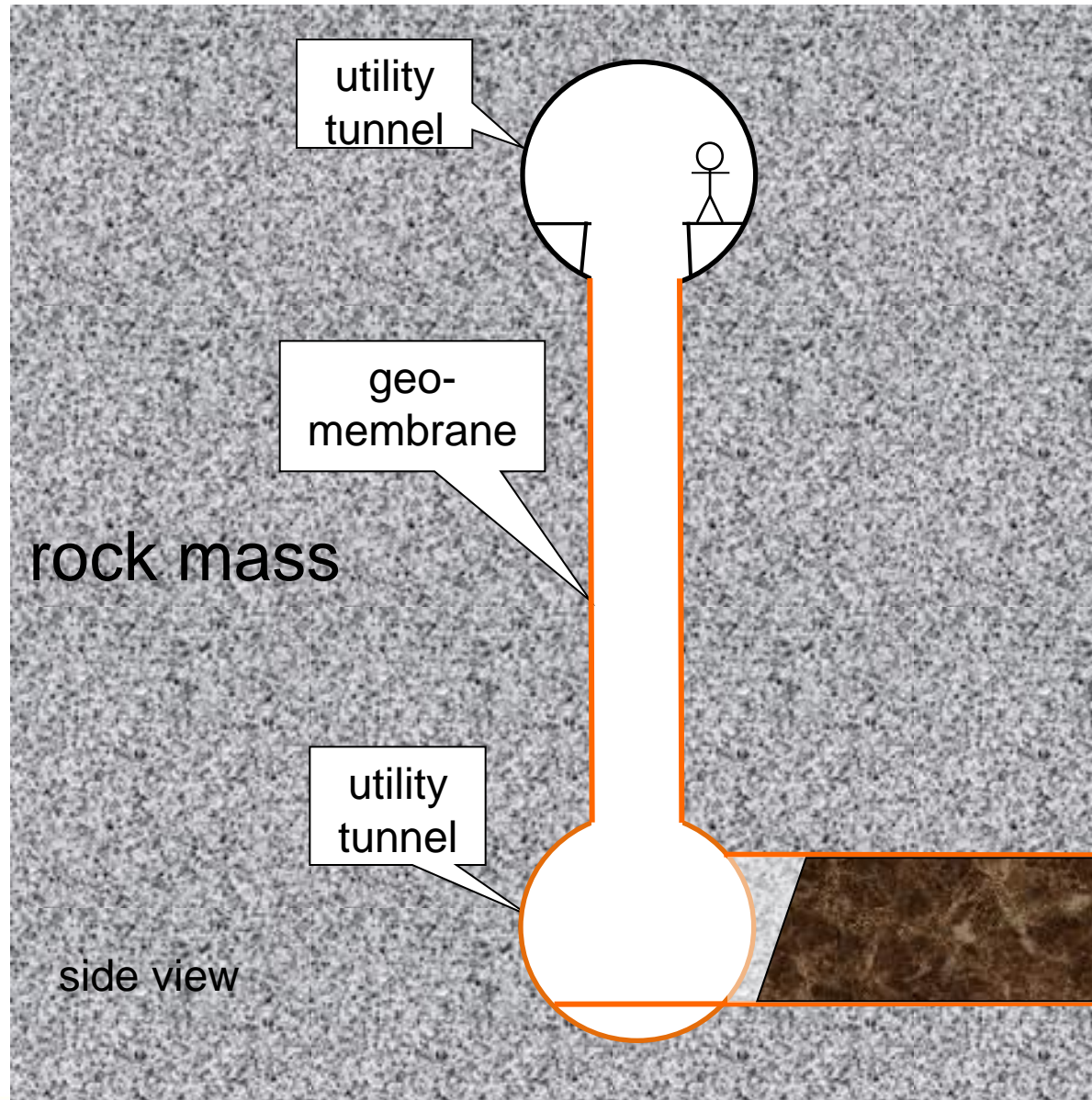
Due to rock mechanics, it is necessary to cut a V-shaped trench



Hydraulic Hydro Storage System

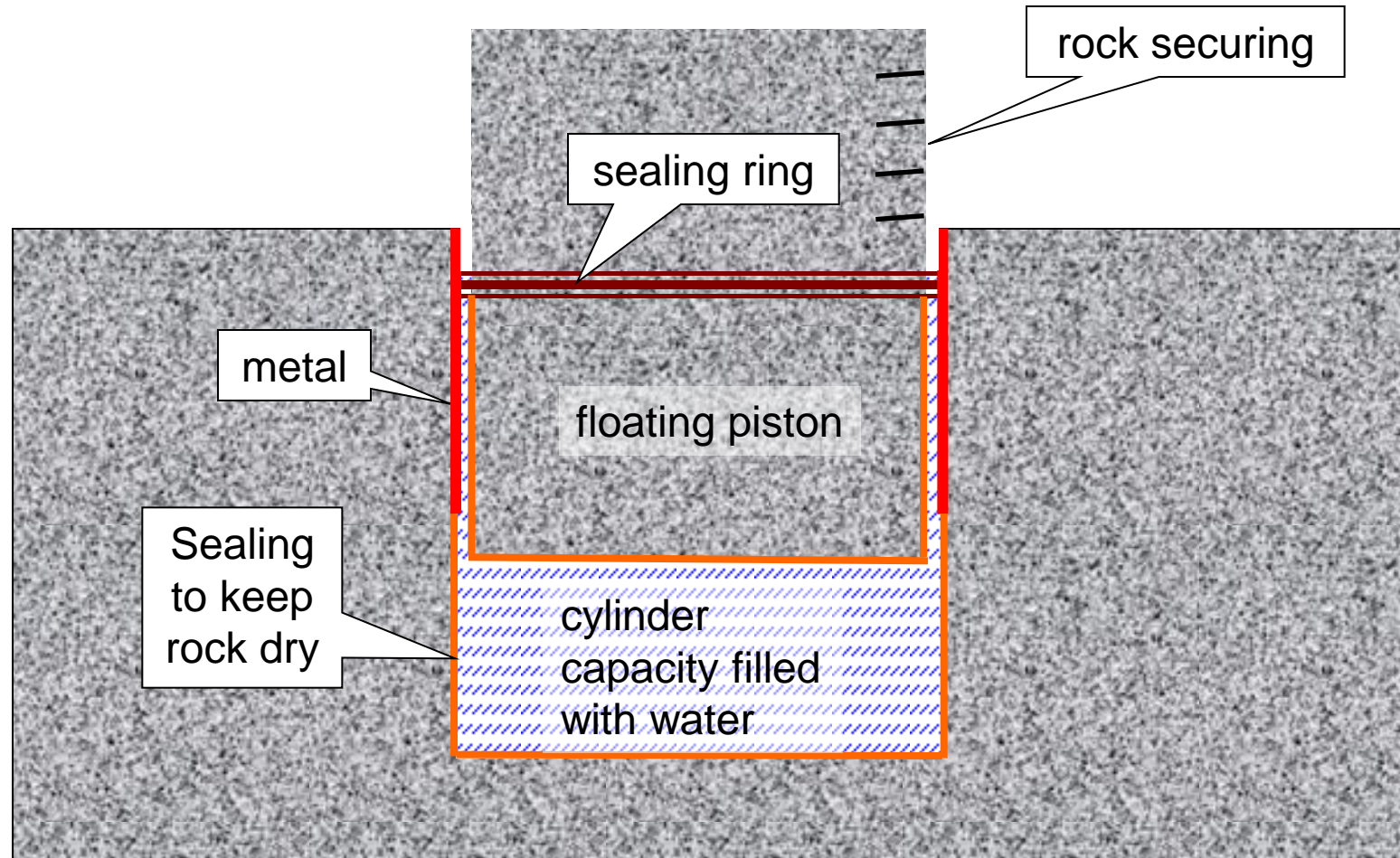
trench will get smaller
due to rock pressure

every surface is sealed
using geomembrane

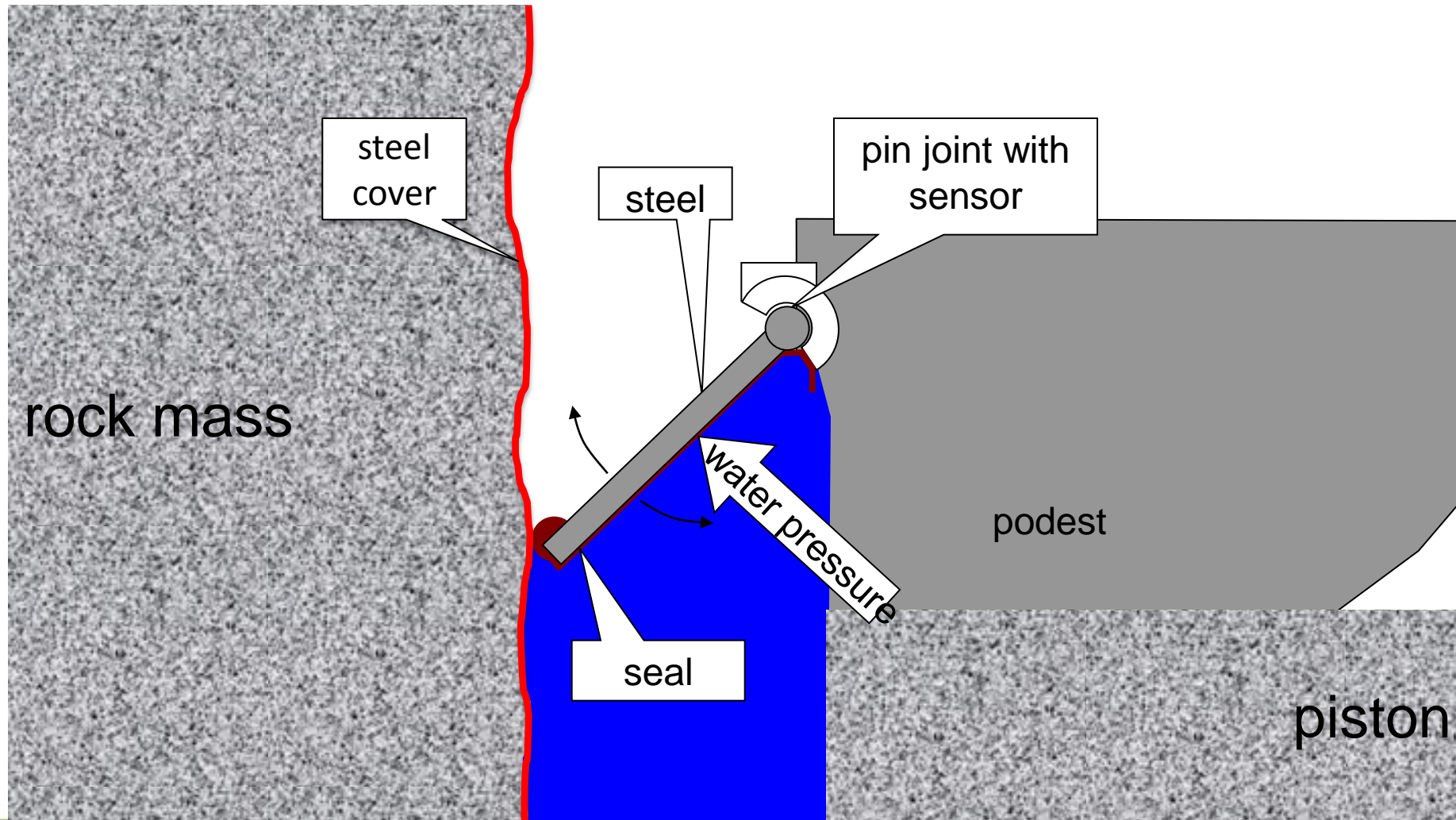


Hydraulic Hydro Storage System

Sealing and Securing

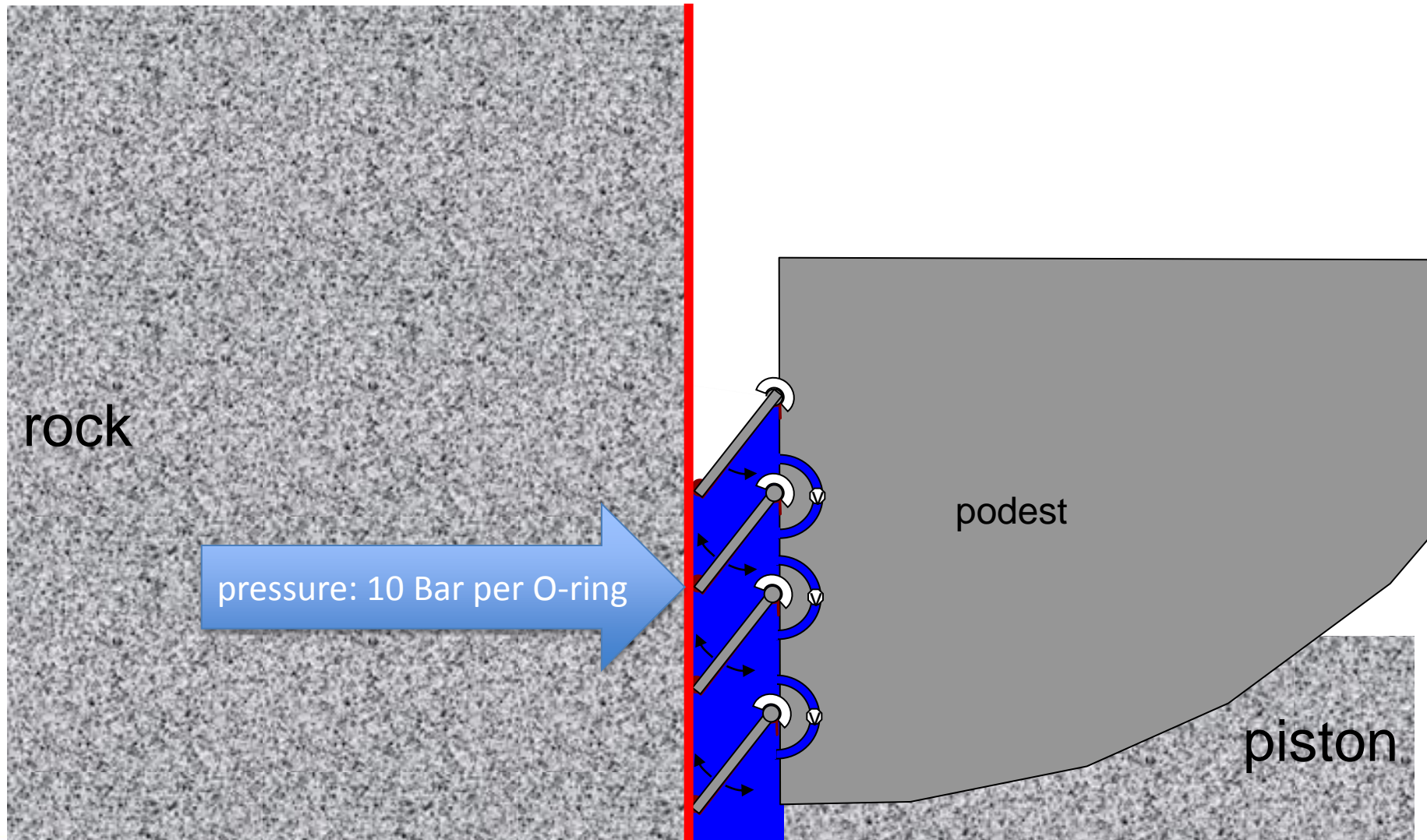


Sealing O-ring



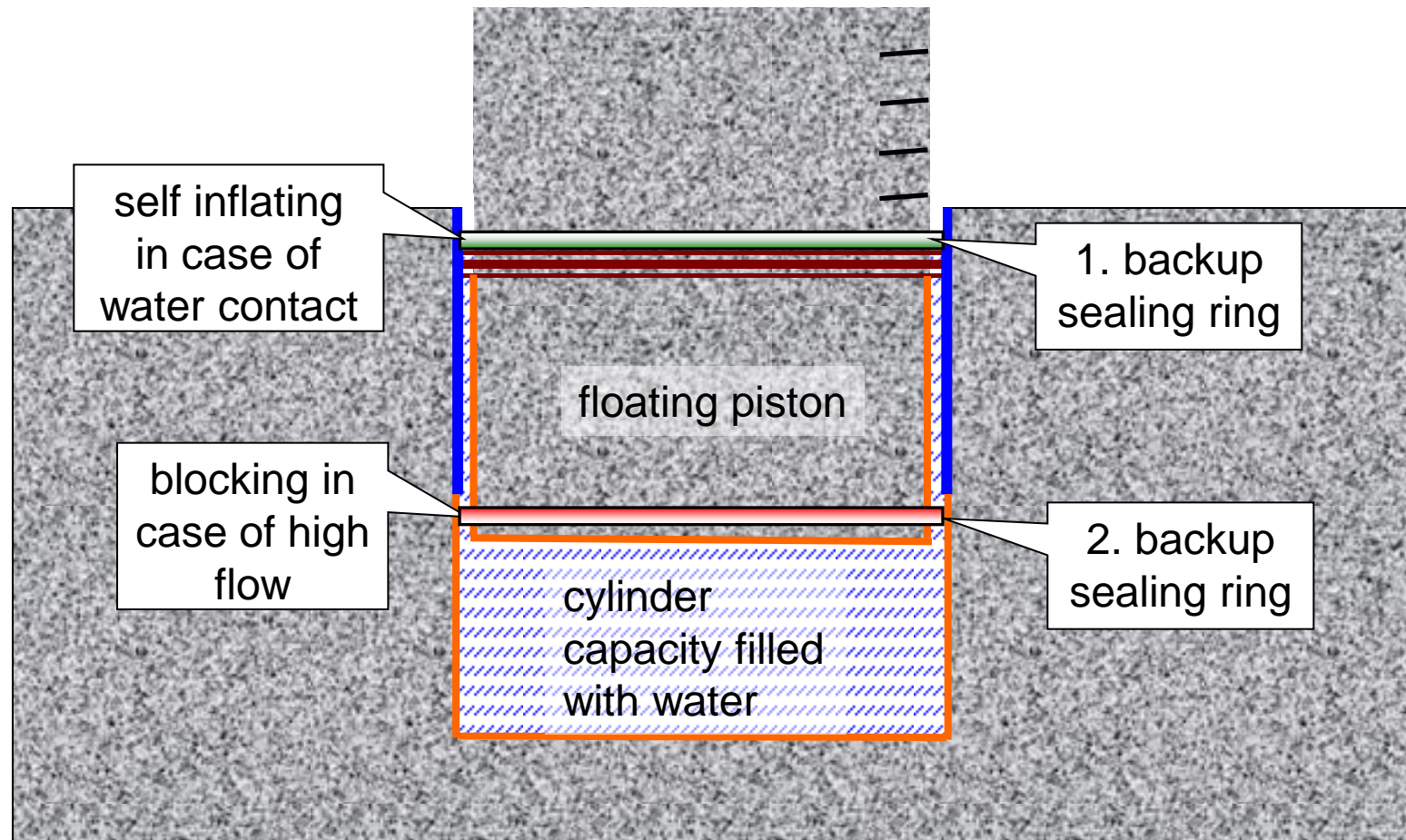
Hydraulic Hydro Storage System

Setup: multi O-ring sealing



Safety

There should be systems, that stop a leakage by physical means



Investment for r=500 m HHS

tunnel	10.000 €/m	73 Mio. €
drilling	500 €/m	157 Mio. €
wire saw	10 €/m ²	63 Mio. €
overburden	20 €/m ³	126 Mio. €
base separation	1.000 €/m ²	785 Mio. €
seal (stainless steel)	200 €/m ²	157 Mio. €
seal geomembrane	100 €/m ²	393 Mio. €
O-ring	10.000 €/m	31 Mio. €
Summe		1.785 Mio. €



Technical and Financial Data*

Radius [m]	62,5	125	250	500
storage capacity [GWh]	0,5	7	100	1600
pressure [Bar]	25	50	100	200
Investment ² [Mio. €]	40	112	400	1800
Investment per kWh [€]	80	16	4	1
value of one loaded system 100€/MWh [Mio.€]	0,05	0,800	12	200
ROI [# of cycles]	800	140	33	9

*figures rounded

²invest does not include pumping system



Advantage

- ✓ **storage capacity** beyond 1000 GWh visible
- ✓ **efficiency**: 80% known value
- ✓ no resource problem
- ✓ no mountains necessary
- ✓ no environmental problems
- ✓ only small **footprint** (up to 2 MWh/m²)
- ✓ less water consumption than PHS (~1/4)
- ✓ known **technologies**
- ✓ **price** drops with $1/r^2$



Hydraulic Hydro Storage System

Europe 2012

12 - 14 June

Rome

Hotel Quirinale



Thank you!



www.Hydraulic-Hydro-Storage.com



Kontakt

Furtwangen University

Prof. Dr. Eduard Heindl

Robert Gerwig Platz 1

78120 Furtwangen

Germany

+49 177 2183578

hed@hs-furtwangen.de

www.hydraulic-hydro-storage.de

