

# *Groundwater occurrence in hard rock and resources evaluation base on field observation in Sudetes (SW Poland)*

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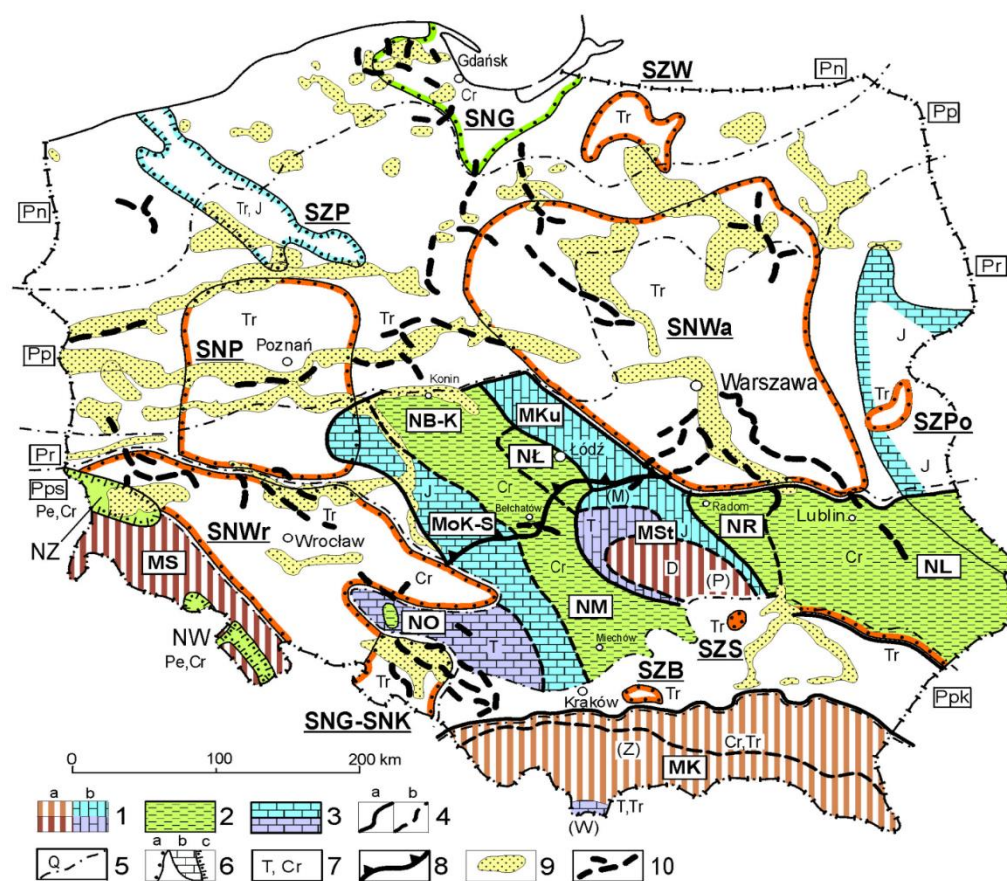
Hard rocks as a water bearing unit, rock's parameters and water quality

Field observation in Sudetes Mts.

Three- layers scheme of groundwater zone

Available resources

Conclusions



Groundwater occurrence in hard rock in Poland is limited to Sudetes Mts. and Carpathian Mts.

**Map of fresh groundwater classification and occurrence in Poland (after Kleczkowski, 1987, modified by Dowgiałło et al., 2002)**

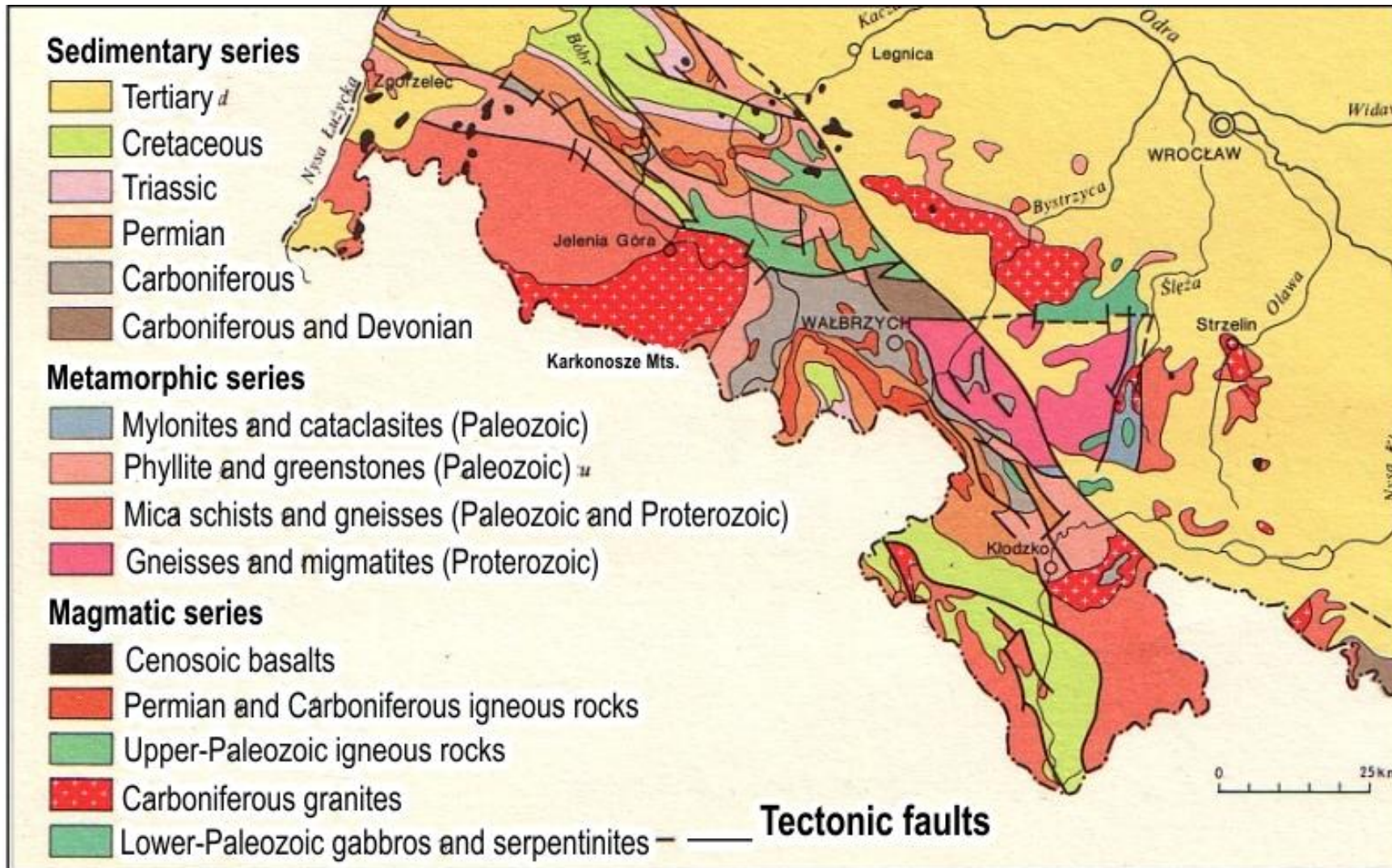
- 1 – massif formation *M*, 2 – basins (Cretaceous *K*, 3 – monocline structure of Krakowsko-Silesia *MK-S*,
- 4a – unit boundary, 4b – sub – unit boundary, 5 – limits of basins range in Quaternary aquifers,
- 6a – sub- basins *SN*, 6b – sub- unit *SZ*, 7 – stratigraphic names of aquifers system,
- 8 – limits of southern aquifers in massif, basin and monocline, 9. major Quaternary aquifers systems, 10. major buried valleys.





Poland

## Geological map of Sudetes Mts.



**Sudetes are built by**

- igneous and metamorphic rocks
- sedimentary rocks
- carbonates rocks ( limited area)

Limited vertical water well has been successfully drilled.

Shallow drilling well showed low discharge in range  $0.03\text{-}4.6\text{ m}^3/\text{h}$  (  $0.08\text{-}12\text{ l/s}$ ).

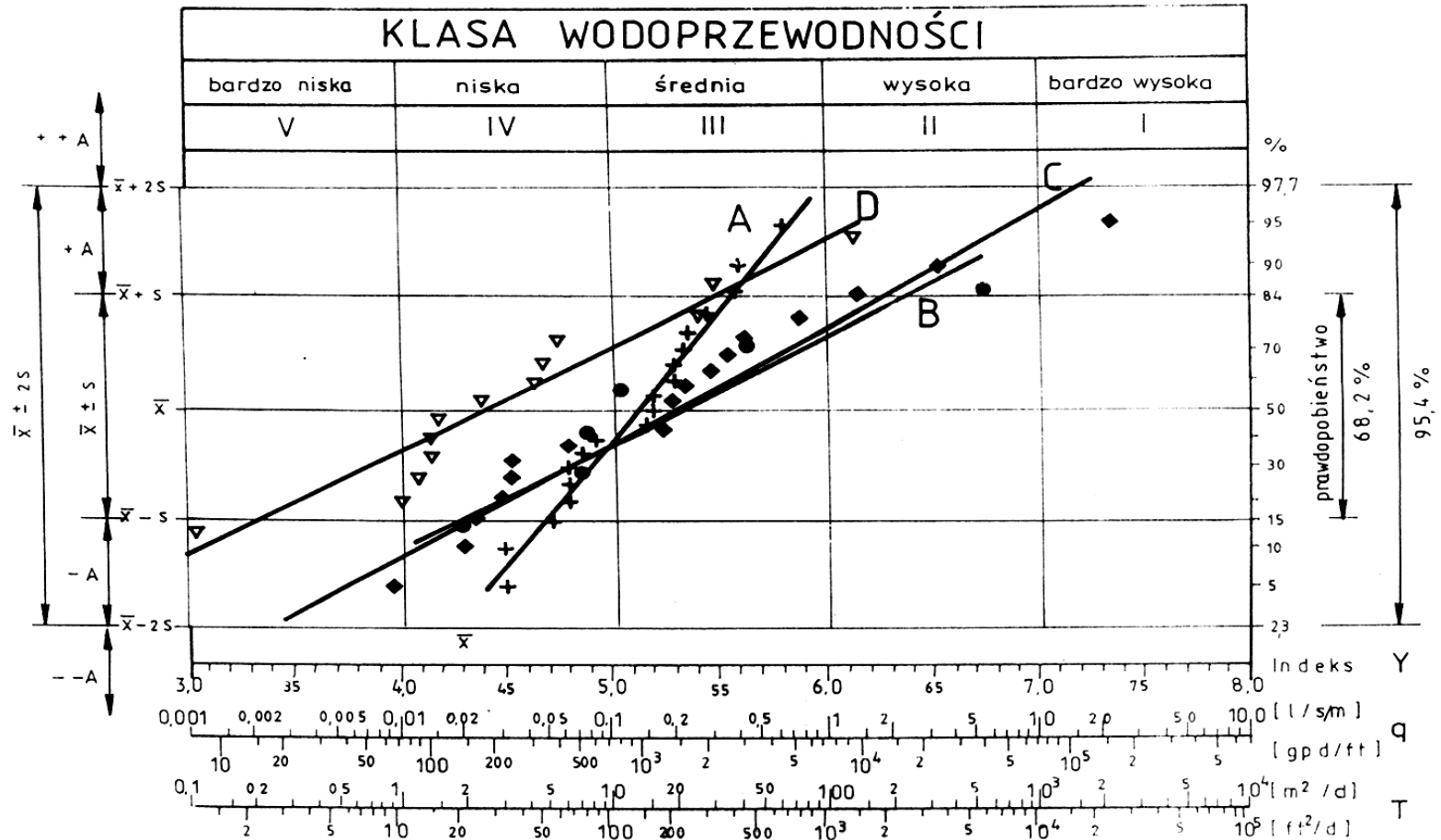
Some information available from deep well in Ladek Zdroj (Bad Landeck) is tapping mineral and thermal water on depth  $568\text{-}700\text{ m}$ .

Spring are frequent manifestation of groundwater and its average density equals  $5 / \text{km}^2$ .

Mainly they are characterized by low discharge in range  $0.1\text{ -}1.0\text{ l/s}$  however also these provided water in amount from  $1\text{ do }11\text{ l/s}$  are recorded.

# Transmissivity of selected hard rocks formation –Sudety Mts.

A- gneiss Sowie Mts. , B- Śnieżnik massif , C- granites rocks Karkonosze Mts. , D- schist formation (Stasko 1996)



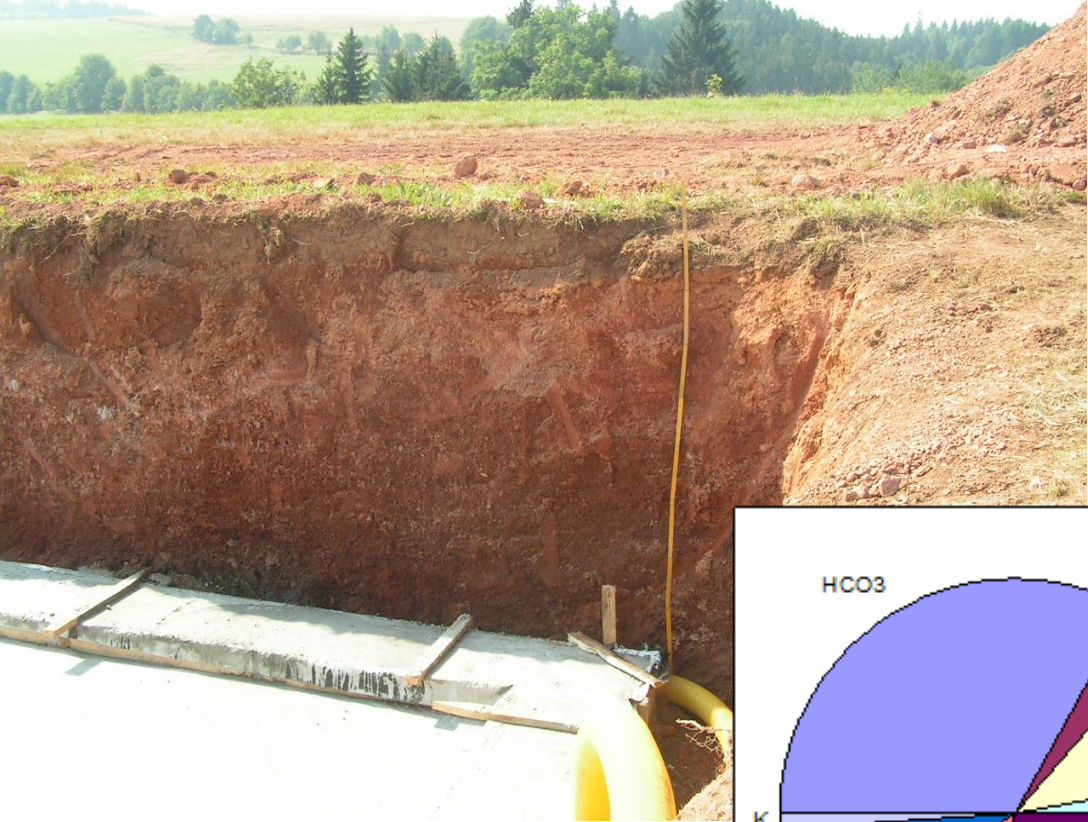
Based on 44 pumping well results

Q 0.2-67 m³/h , Q geom. mean.= 5.9 m³/h, S 6-84 m

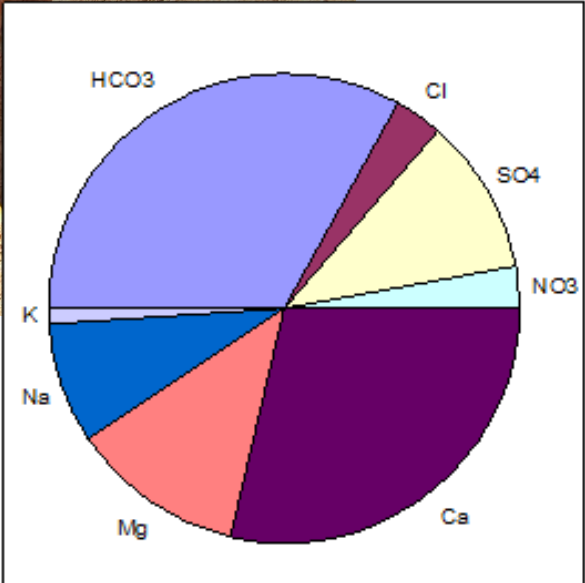
After Stasko i Tarka (1995)



# Hard rocks as a water bearing unit, rock's parameters and water quality



Groundwater are typical fresh water with low TDS (8-180 mg/l), low pH (5.5-7.5) value and locally high radon concentration up to 220 Bq/l

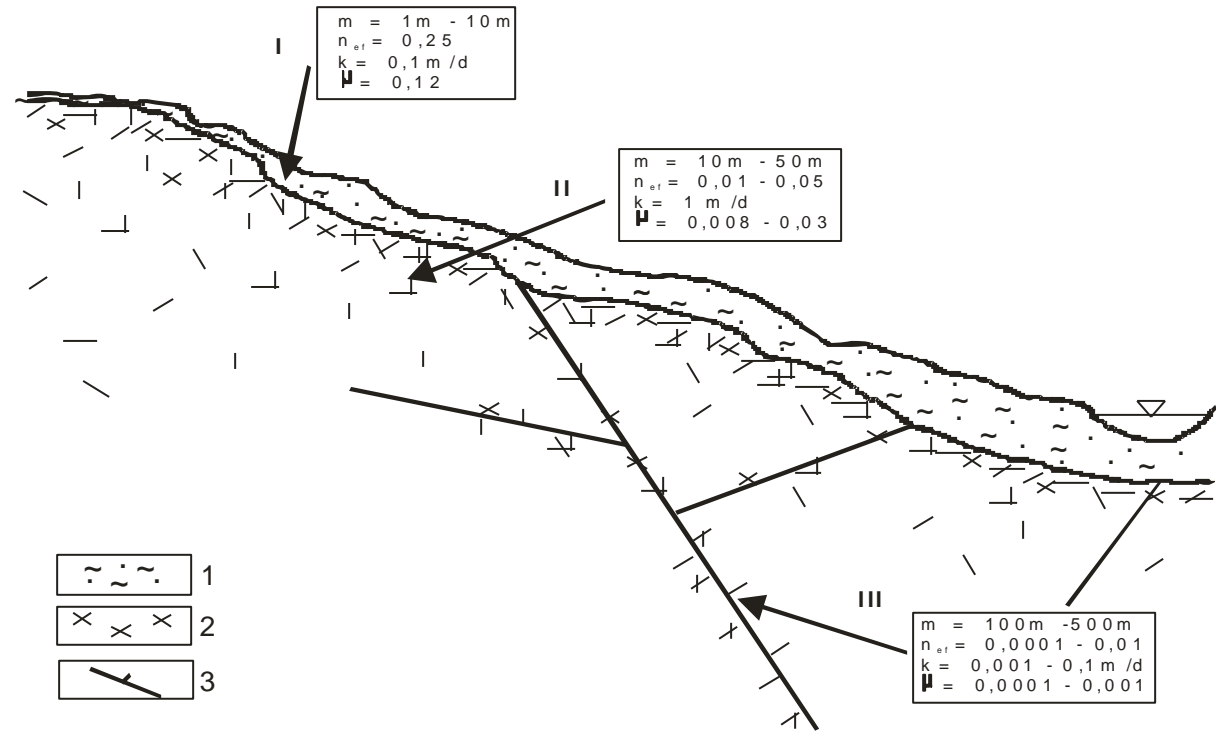


# Hard rock of the Sudetes Mts . hydrogeological parameters

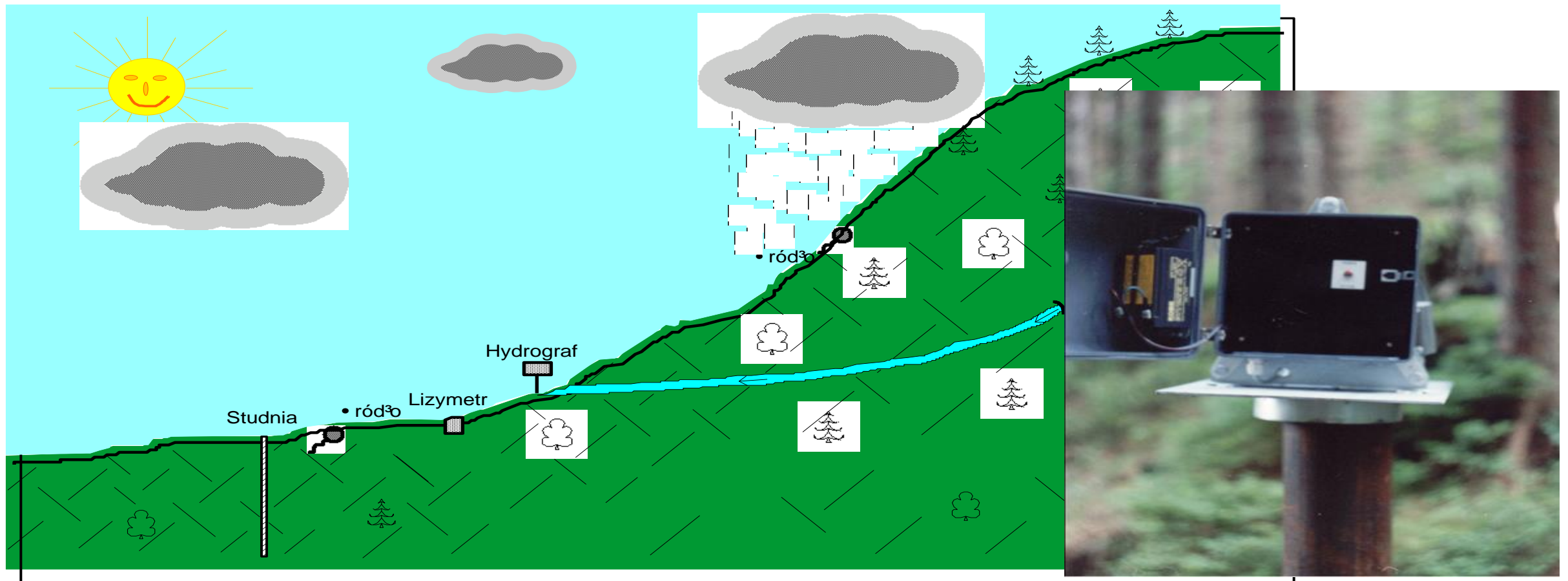
Hydrogeological parameter	Value Min- Max. Average	Author/year	Sub-region
<b>Groundwater runoff modulus</b> [ l/s km <sup>2</sup> ]	> 7 2.8-17.4 1.3- 11.9 av. 5.08 0.6-20.3 2.5-24.5 6.48-14.17 1.1-6.15 1.4-7.2	Jokiel (1994) Paczyński (1995) Kryza H, Kryza J.(1986) H.Kryza (1986) Staśko i Tarka (1994) Marszałek (1996) Bocheńska i inni (1994) Staśko (1996)	Sudetes Sudetes Sudetes Śnieżnik massif  Karkonosze Mts., Izerskie Mts. Kaczawskie Mts. Sowie Mts.
<b>Springs</b> <b>Spring density</b> Sd [1/km <sup>2</sup> ]	Sd 2.92 Q 0.05-6.0  Sd 5.6-18.6 Q 0.1-11.0 R 2.3-31.9	H.Kryza (1983)  Staśko i Tarka (1994) Staśko (1996)	Śnieżnik massif
<b>Discharge Q</b> [l/s]	Sd 2.06-7.3 Q 0.05-18.7 R 3.7-32.7	Marszałek (1996)	Karkonosze Mts., Izerskie Mts.
<b>Variability R</b>	Sd 0.11-1.11 av. 0.57 Q 0.1-2.0 R 1.04-11.0 Q 0.09-6.49 * R 3-429** Sd 1.8 Q 0.01-2,7 R 3-90	Bocheńska i inni (1994)  Wojtkowiak (2000)  Staśko (1996)	Kaczawskie Mts.  Western Sudety  Sowie Mts.
<b>Well discharge ,</b> <b>Q [m<sup>3</sup>/h]</b> <b>Depression S</b> [m]	Q 0.75 -67. Q av 5.2 S 3.0-56.3  Q 0.2-3.6 S 2-24	Staśko (1996)  Zaleska i inni (1999)	Łądeka-Kamienica region , Gór Sowich ,Jeleniej Góry  Karkonosze , Jelenia Góra- Cieplice



# Three –layer (zones) model of groundwater occurrence in Sudetes Mts.



Explanation : 1- weathering zone ( sandy clay), 2-dense fractured massif rocks, 3-deep faults zone m- thickness ,  $n_{ef}$  – effective porosity, k-hydraulic conductivity,  $\mu$ - specific yield



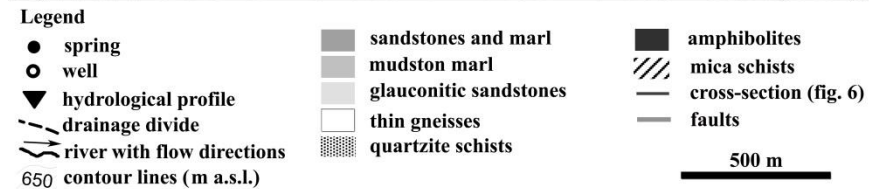
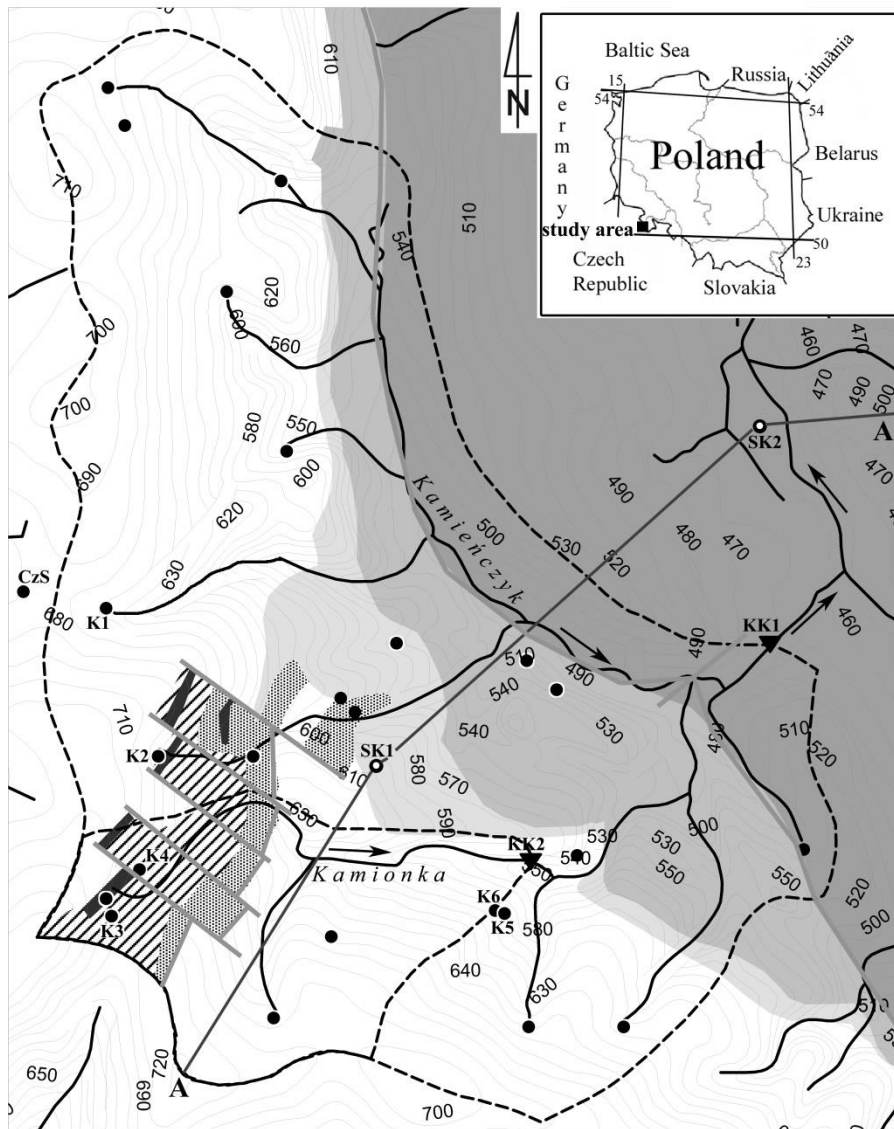
**-Field experimental station – Snieznik massif showed**

**-groundwater recharge equals 22-55% of total precipitation**

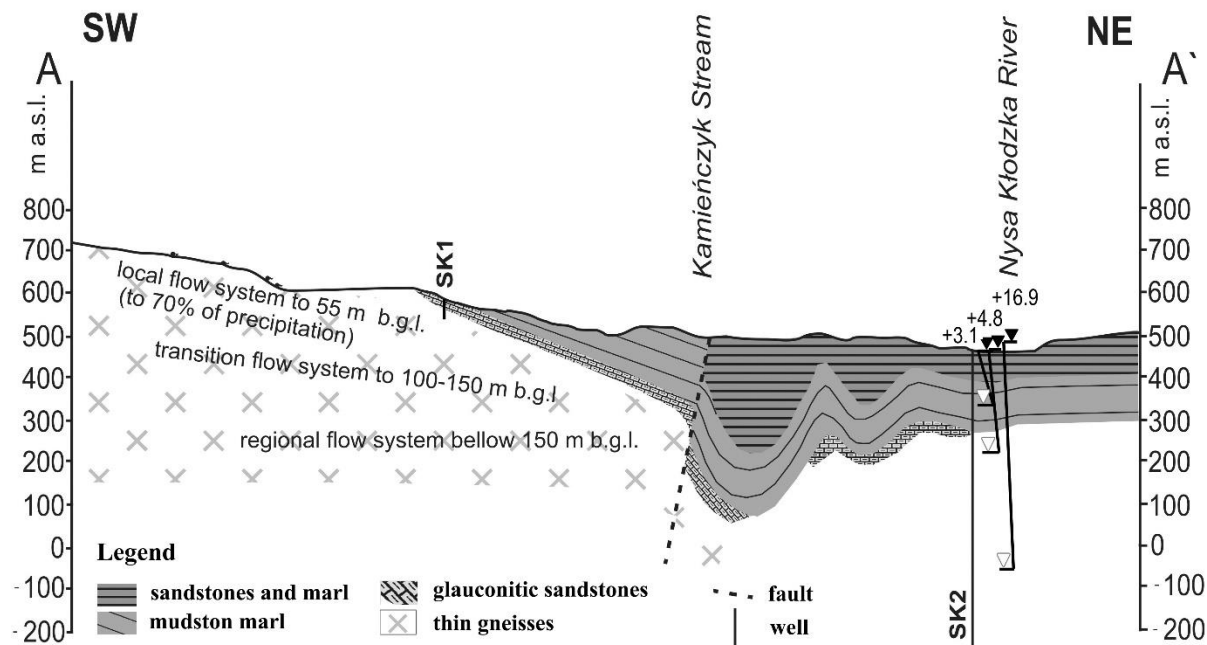
**- groundwater occurrence in significant amount is connected with weathering cover zone and dense fracture part of the massif rock and is manifested in preferential zones –**

**discharge of horizontal mine gallery  $Q = 17.4 – 26.6 \text{ l/s}$  ( $62.6\text{-}95.7\text{m}^3\text{/h}$ )**

**- Base on tritium contents the average water resident time is 7.5 -30 year**



## Field observation in Bystrzyckie Mts.



	Total runoff (m <sup>3</sup> /s)	Groundwater runoff (m <sup>3</sup> /s)	Precipitation (mm)	Total runoff (mm)	Groundwater runoff (mm)	Modulus of total runoff (L·s <sup>-1</sup> /km <sup>2</sup> )	Modulus of groundwater runoff (L·s <sup>-1</sup> /km <sup>2</sup> )
KK1	0.124	0.049	736.6	500.6	196.7	15.87	6.24
KK2	0.019	0.009	819.6	488.7	226.0	15.50	7.17

Base on stream and springs measurements calculated modulus of groundwater runoff was in range 6.24-7.17 L·s<sup>-1</sup>/km<sup>2</sup>



# Conclusions

***Results of field measurements and study on groundwater occurrence in Sudetes Mts. in hard rock showed :***

- ***groundwater occurrence in significant amount is connected with the weathering cover zone and dense fracture part of the massif rock and is manifested in preferential zones***
- ***groundwater runoff evaluated with base flow method in rivers and creeks, showed value in upper part of catchment ( 3.5-6.5 l/s km<sup>2</sup>), when in lower part, higher value ( 6.5 -7.5 l/s/ km<sup>2</sup>) due to direct drainage to river valley.***
- ***methods and technique of field survey should include complete characteristic (wells, spring, hydrograph separation, chemical composition, isotopic study etc. )***
- ***best methods of water intake and supply is horizontal drainage intake***

Thank you for your attention

