Aquifer parameter estimation for the Zhagu subcatchment (Tibetan Plateau) based on geophysical methods

Geo-ecosystems in Transition on the Tibetan Plateau (TransTiP)

Photography encouraged

This presentation participates in OSPP

Outstanding Student Poster & PICO Contest

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Motivation

- Aquifers on the Tibetan Plateau (TP) are the origin of important water supplying rivers all over Asia. *Population* and tourism activities are growing, especially on the Asian continent, resulting to a higher water demand.
- Climatic change in the recent decades (increasing trends of precipitation, melting of glaciers and degradation of permafrost) have led to rising lake levels on the TP and therefore causing changes in the *water cycle*.
- To ensure future *water supply*, *aquifer characterisation* is therefore an important issue on the TP.
- However, due to the *remote* character of the TP, hydrogeological aquifer information is *scarce*.
- **The *two aims* of this study are to** *(I) calculate **porosity** out of Archie's Law* **and to** *(II) estimate **hydraulic conductivities**.*

#TP #hydrogeology #ERT #hydraulic conductivity #climatechange

Study area

Location

- Zhagu 30°52'-30°56' N, 91°00'-91°07' E
- Lake elevation 4718 m
- Area 46 km² (3% of Nam Co basin area)

Climate

- Indian monsoon dominated during rainy season (June – October).
- Westerly controlled during dry season (November – May).
- $P_{mean\ annual}$ = 406 mm
- $T_{mean\ annual}$ = -0.6°C

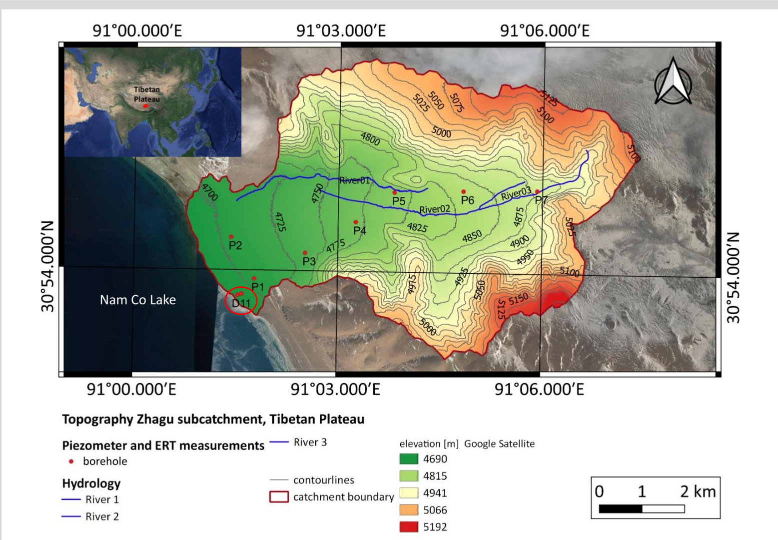

Figure 1: Study area Zhagu subbasin in the Nam Co lake basin, Tibetan Plateau.

Methods

(I) Archie's law for saturated conditions

- Practical application of resistivity measurements
  - determination of water saturation
- Archie's Law (2) inserted into Formation factor (1) and rearrange for porosity ϕ leads to (3)

$$F = \frac{\sigma_w}{\sigma_0} \quad (1)$$

$$\sigma_0 = \phi^m \cdot \sigma_w \quad (2)$$

$$\boxed{\phi[-] = F^{\frac{-1}{1.3}} \quad (3)}$$

(II) Hydraulic conductivity calculation after Barr

- Hydraulic conductivity calculation based on measureable characteristics of soil (grain size analysis)
- Built on Barr (2001)

$$\boxed{K = 3 \cdot 10^{-3} \frac{\rho g}{\mu} \frac{\phi^3}{(1-\phi)^2} d_{10}^2 \quad (4)}$$

- bulk conductivity σ_0 : measured with ERT
- conductivity of pore water σ_w : measured with conductivity plus measurement device
- Tortuosity factor $a = 1$
- cementation factor $m = 1.3$
- water saturation $S_w = 1$: fully saturated aquifer
- saturation exponent $n = 2$
- Formation factor F

Figure 2: ERT measurement and borehole drillling during Field Work in July 2018

Results

Electrical Resistivity Tomography (ERT)

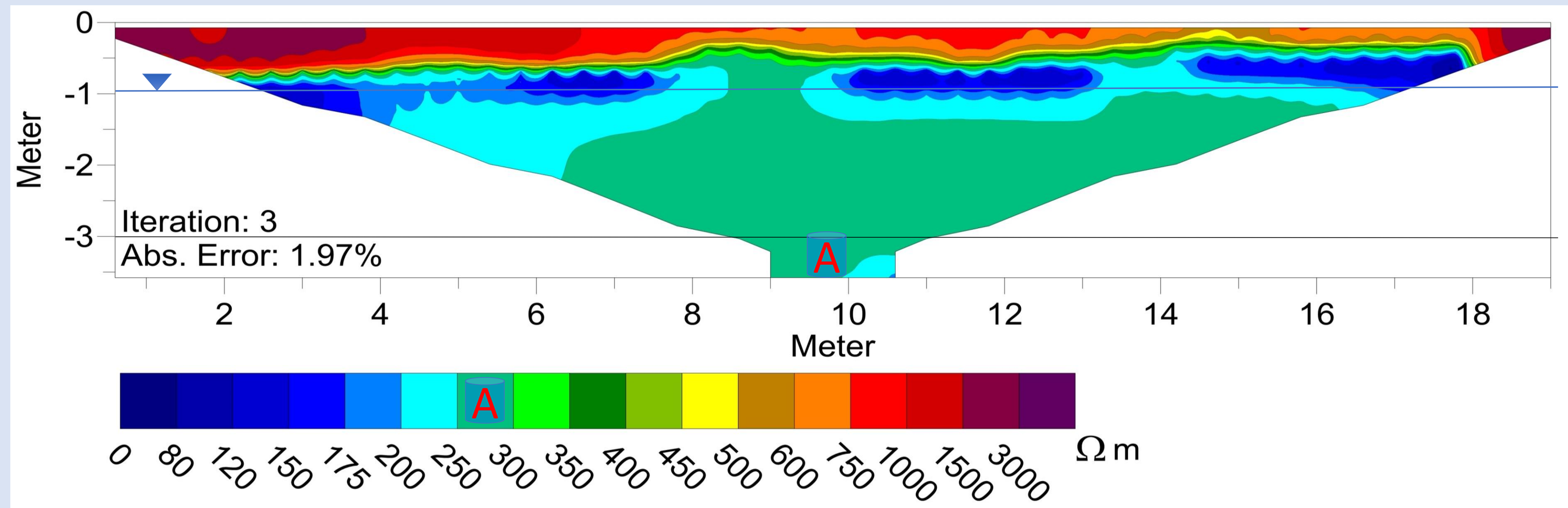

Figure 3: ERT measurements for D11 3 iteration abs. error 1.97% (RES 2 DINV - Software).

Table 1: ERT values at point A.

ERT Profile	Date	ρ_0 [Ωm]	σ_0 [S/m]
D11	17.05.2019	275	3.64×10^{-3}

Table 2: Measured conductivity of pore water σ_w during field campaign in May 2019.

Piezometer	Date	σ_w [S/m]
$D11_1$	16.05.2019	1.97×10^{-2}
$D11_2$	19.05.2019	2.46×10^{-2}

Sediment Profiles

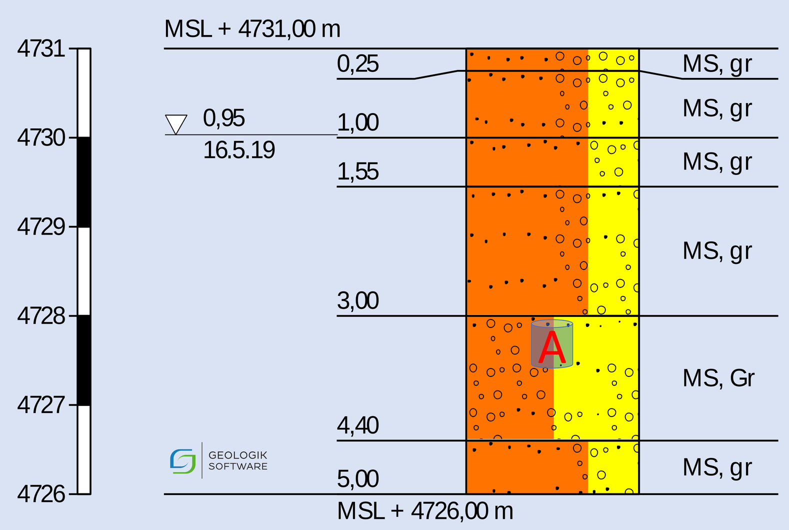

Figure 4: Grain size analyses of sediment layers from borehole D11 (a) with MS = medium sand, gr = gravel.

Medium Sand	Gravel [%]
44.90	26.52
33.27	39.55
40.87	22.03
44.88	23.50
32.04	45.28
49.00	16.61

Table 4: Medium sand and gravel percentage overview.

Table 3: Parameter from grain size analysis.

Piezometer	d10 [mm]	$\varphi_{grainsize}$ [-]
D11	0.123	0.26

$$\rightarrow \quad K_{\phi grainsize} \approx 1.5 \cdot 10^{-5} [\frac{m}{s}]$$

Aim (I) Porosity calculation (Archies Law)

$$\phi_{D11_1}[-] = (\frac{1.91 \cdot 10^{-2}}{3.64 \cdot 10^{-3}})^{\frac{-1}{1.3}} \approx 0.27$$

$$\phi_{D11_2}[-] = (\frac{2.46 \cdot 10^{-2}}{3.64 \cdot 10^{-3}})^{\frac{-1}{1.3}} \approx 0.23$$

- deviation of 5% and 12% from $\varphi_{grainsize}$

Aim (II) Hydraulic conductivity (Barr)

$$K_{D11_1} \approx 1.7 \cdot 10^{-5} [\frac{m}{s}]$$

$$K_{D11_2} \approx 9.3 \cdot 10^{-6} [\frac{m}{s}]$$

- deviation of 18% and 55% from $K_{\phi grainsize}$

Outlook

- Further analysis of remaining ERT measurements will be carried out.
- Results will be compared to hydraulic conductivities gained by field test.
- Other geophysical methods will be chosen to calculate hydraulic conductivity.

Conclusion

- Porosity values calculated based on geophysical measurement compare well with grain size analysis .
- Geophysical methods potentially useful to constrain hydraulic conductivities.
- Deviation in porosity calculation influences further process and lead to larger discrepancy in the results.
- Possible source of errors
  - Neglection of surface conductivity in Archie's Law.
  - Measurement during field work (disturbed samples).
  - Estimation of porosity based on grain size analysis.

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