Hydrogeochemical processes and groundwater evolution in Lake Tana basin, Ethiopia

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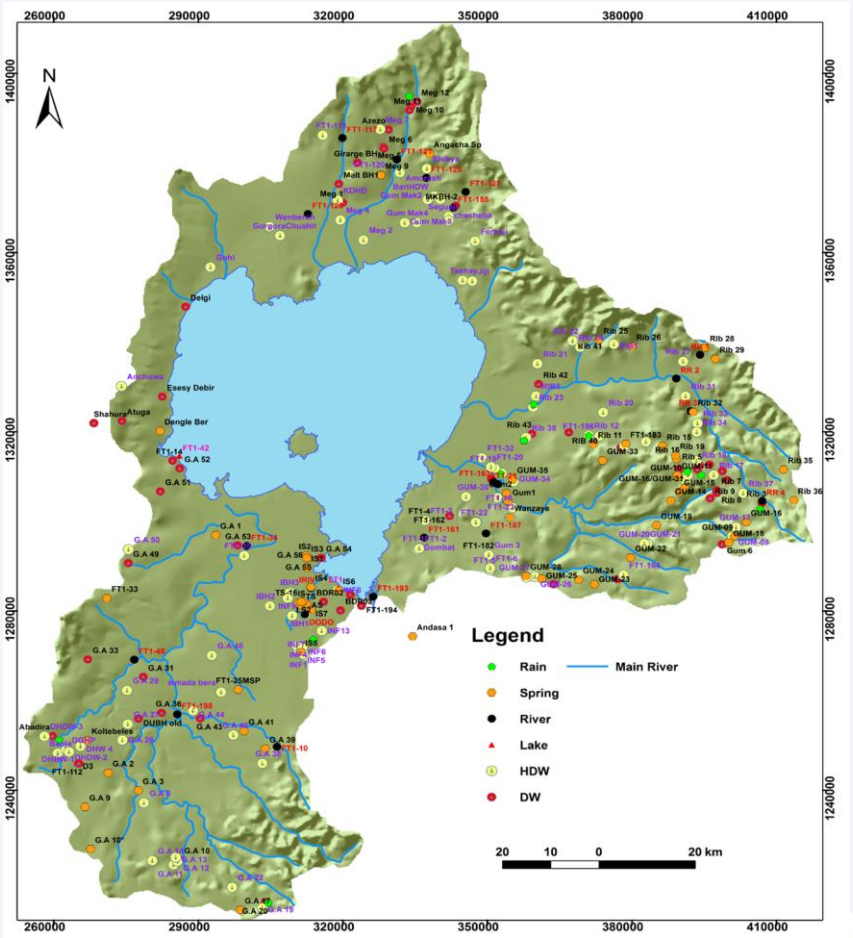
Location

Lake Tana basin:

- Entire basin area: 15,000 km^2
- Lake area: 3060 km^2
- Source of Blue Nile
- Annual rainfall: ca 1400mm
- Rainfall type: mono modal



Methods

Data collection

273 samples from DW, SW, SP, HDW, rivers and rainwater

43 samples -> secondary data

Water sampling

pumping before sampling

→either submersible pump or surface pump

→ bailer

pH, Eh, EC, To and DO content using multi-parameter AQUAREAD

Samples for cation analysis

Filtration through 0.45-µm membrane

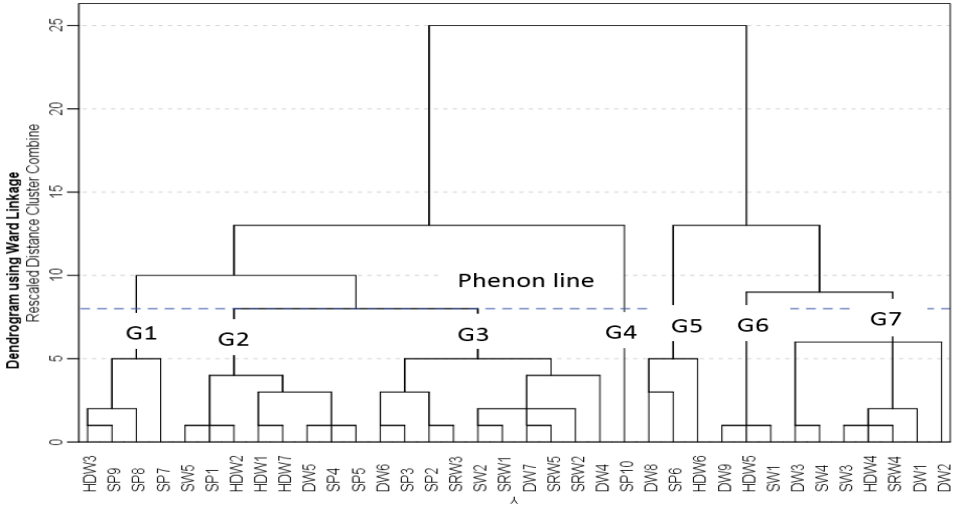
Acidified with HNO3

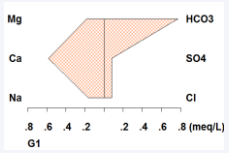
Bottles were rinsed three times before sampling

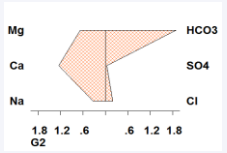
Clean polyethene bottles used for chemistry and isotope samples

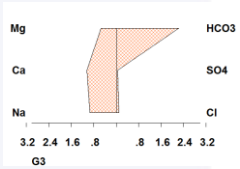
Results and discussion

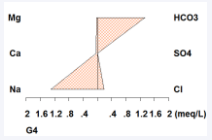
	pH_lab	EC_lab	TDS	Na^+	K^+	Ca^{2+}	Mg^{2+}	HCO_3^-	Cl^-	SO_4^{2-}	NO_3^-
pH_lab	1.00										
EC_lab	0.22	1.00									
TDS	0.21	**0.97**	1.00								
Na^+	0.31	**0.84**	**0.84**	1.00							
K^+	0.01	0.29	0.38	0.40	1.00						
Ca^{2+}	0.13	**0.82**	**0.81**	0.46	0.22	1.00					
Mg^{2+}	0.12	**0.88**	**0.91**	**0.66**	0.23	**0.77**	1.00				
HCO_3^-	0.21	**0.95**	**0.98**	**0.84**	0.32	**0.76**	**0.91**	1.00			
Cl^-	0.01	0.43	0.34	0.19	0.21	0.50	0.29	0.17	1.00		
SO_4^{2-}	0.06	0.39	0.36	0.28	0.15	0.45	0.27	0.25	0.47	1.00	
NO_3^-	-0.16	0.16	0.13	0.03	0.34	0.31	0.12	-0.04	**0.78**	0.29	1.00

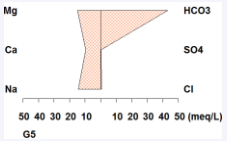


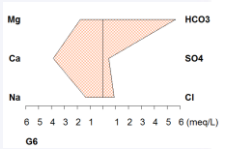


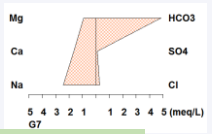












Water types

- $CaHCO_3$
- Ca-Mg-HCO_3
- Ca-Na-other cations-HCO_3
- Mg-Na-Ca-HCO_3
- $Na\text{-}HCO_3$

Evolution

Silicate dissolution

Calcite precipitation

Silicate weathering, hydrogeochemical processes and groundwater evolution

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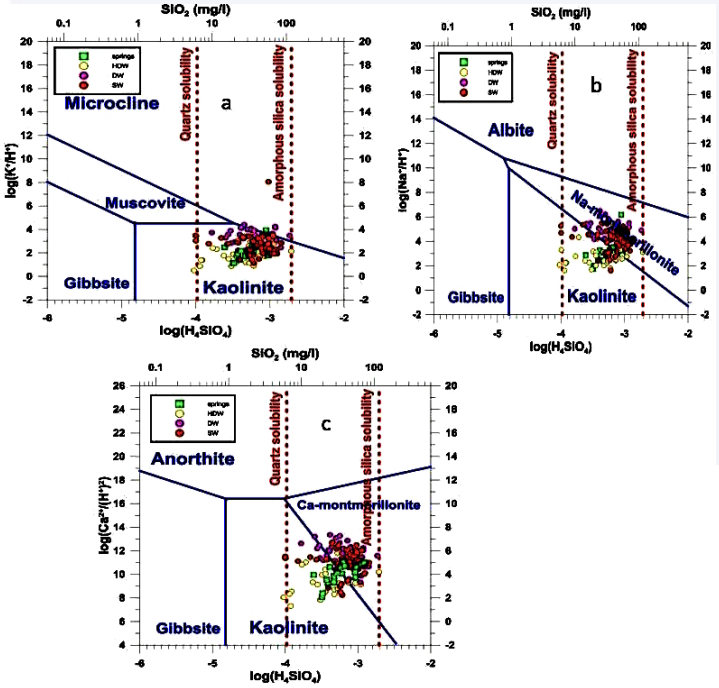
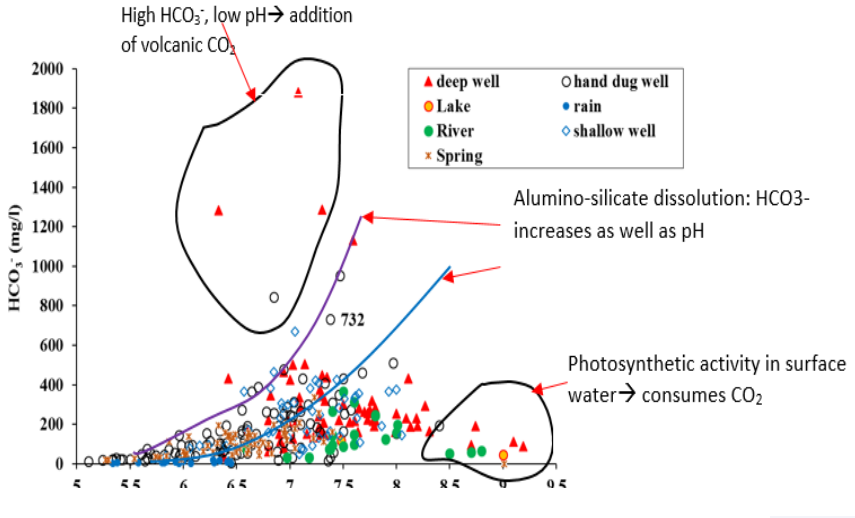
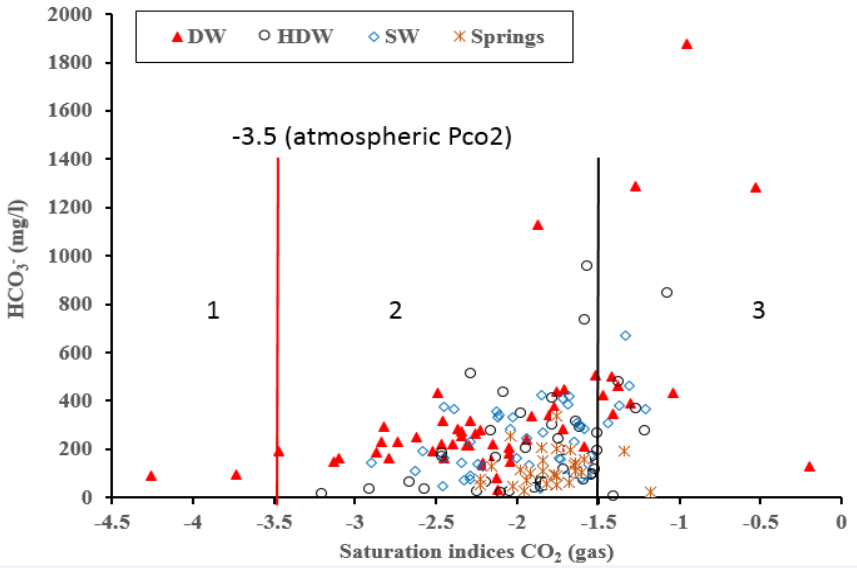
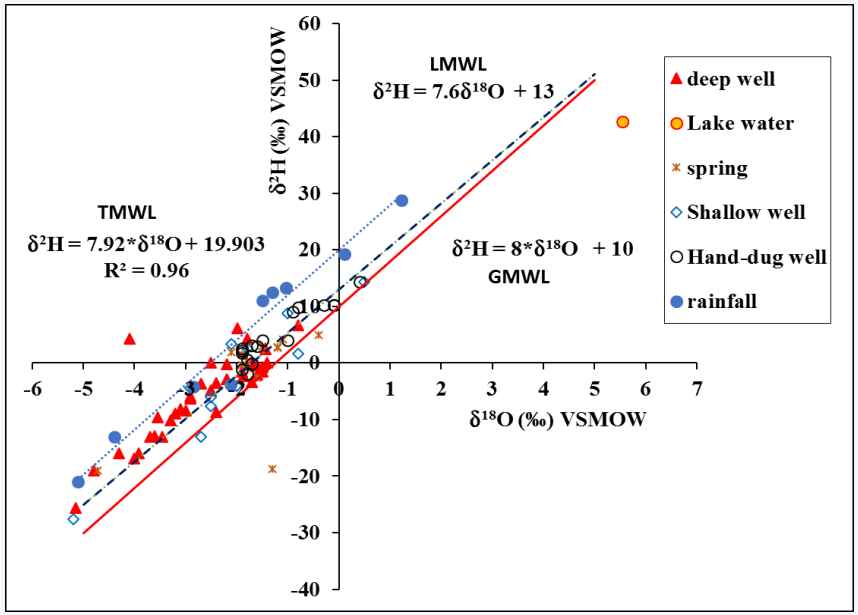
Saturation index and stability diagram

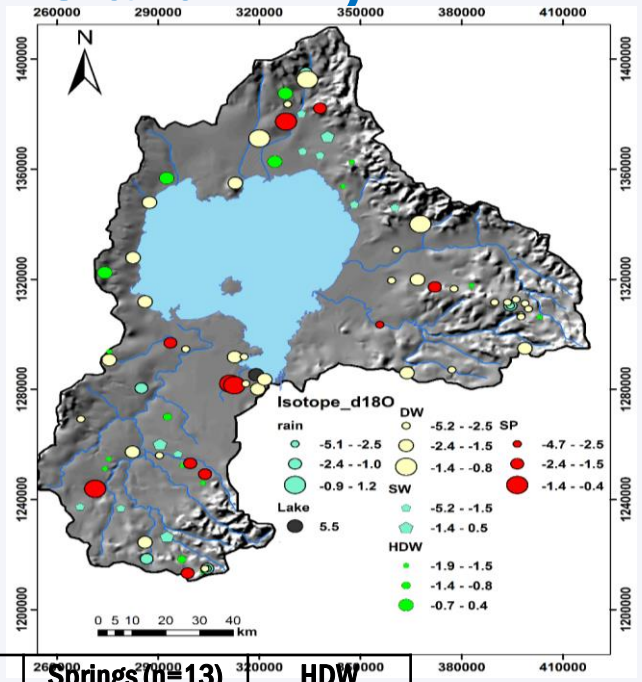






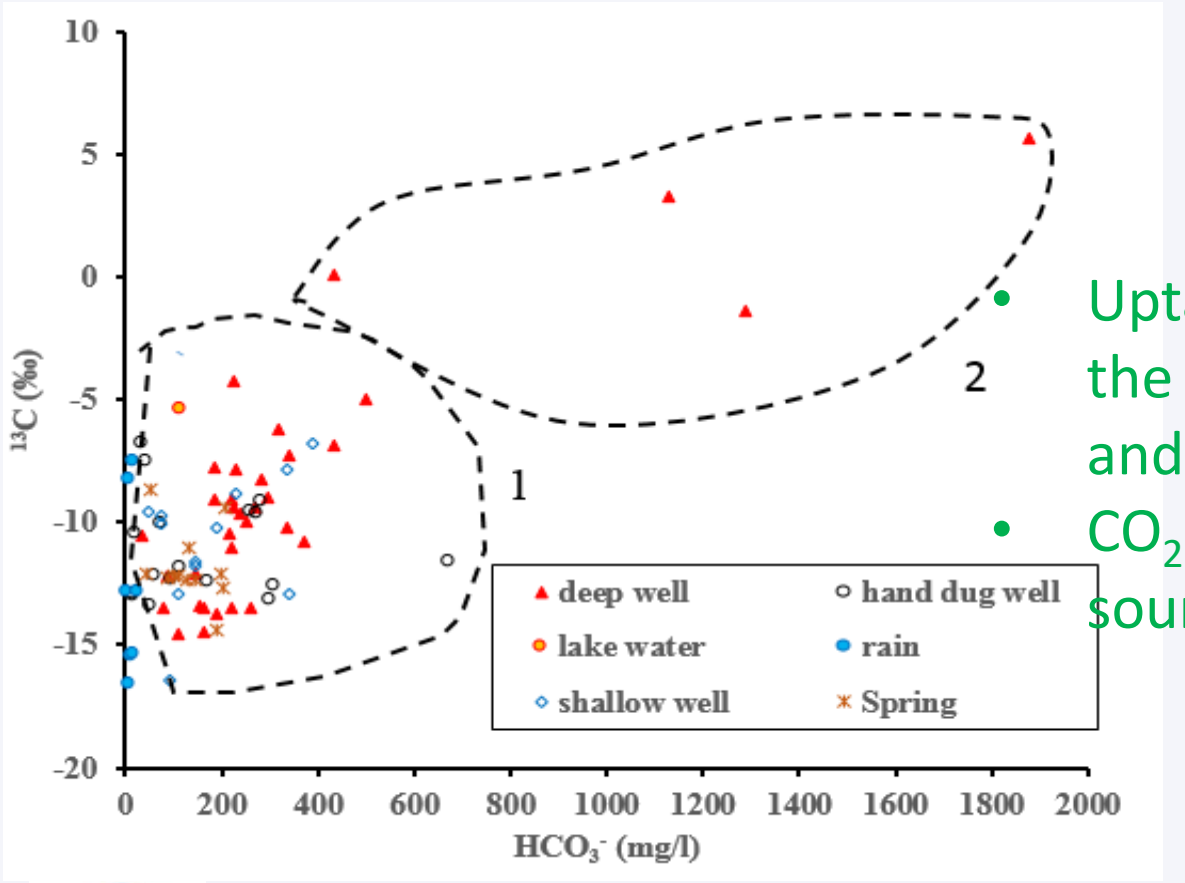
Stable isotopes signatures (δ18O and δ2H)





Parameters	DW (n=38)		SW (n=11)		Springs (n=13)		HDW (n=17)	
	δ18O	δ2H	δ18O	δ2H	δ18O	δ2H	δ18O	δ2H
Mean	-2.68	-5.7	-2.1	-2.9	-1.5	0.0077	-1.2	4.8
Median	-2.5	-3.6	-2.1	-4	-1.6	1.5	-1.6	3.1
Standard Deviation	1.06	7.33	1.44	11.28	0.47	6.02	0.77	4.84
Minimum	-5.15	-25.6	-5.2	-27.6	-2.1	-18.8	-1.9	-1.9

Carbon-13 (13C) isotope signatures



- Uptake of CO_2 from the soil-atmosphere and
- CO_2 from magmatic sources

Summary

(1) Recharge water: consists of fresh Ca-HCO_3 - Ca-Mg-HCO_3 – Ca-Na-Mg-HCO_3 with TDS values < 600 mg/l. The isotopic compositions of these waters fall near to LMWL

Suggests recharge is modern precipitation, without significant evaporation,
low rock-water interaction
short residence time

$\delta^{13}C$ isotopic data indicate that the principal source of CO_2 is from combination of atmospheric CO_2 and soil CO_2 (-16.4 to -7.5‰)

(2) Discharge waters

- (a) brackish Mg-Na-Ca-HCO_3 type (TDS > 3000 mg/l)
  - depleted with respect to $\delta^{18}O$ (-4‰ to -3‰)
  - enriched $\delta^{13}C$ values (-1.4‰ to 5.6‰)

➔ deep system is open to the influx of CO_2 other than atmospheric and soil CO_2 => magmatic sources

→ the enriched $\delta^{13}C$ and depleted $\delta^{18}O$ indicate highly evolved groundwater,

→ strong rock-water interaction and having long residence time

- (b) groundwater samples with fresh Na-Ca-HCO3 and Na-HCO3 types
  - δ18O -2.5‰ to -5.15‰
  - δ13C varies from -13.8‰ to +3.26‰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THANK
YOU!