Geochemical processes controlling the groundwater chemistry and fluoride contamination in the aquifer systems on the eastern, western and northern flanks of Mount Meru, Tanzania

UNIVERSITEIT GENT

George BENNETT

Introduction

Arusha volcanic region in northern Tanzania

- **Groundwater** – source of drinking water
    - ❖ High F^- conc.
- Dental and skeletal fluorosis

Location of Mount Meru in Arusha region, Tanzania.
(Source: modified after Wikimedia; commons.wikimedia.org)

Methods

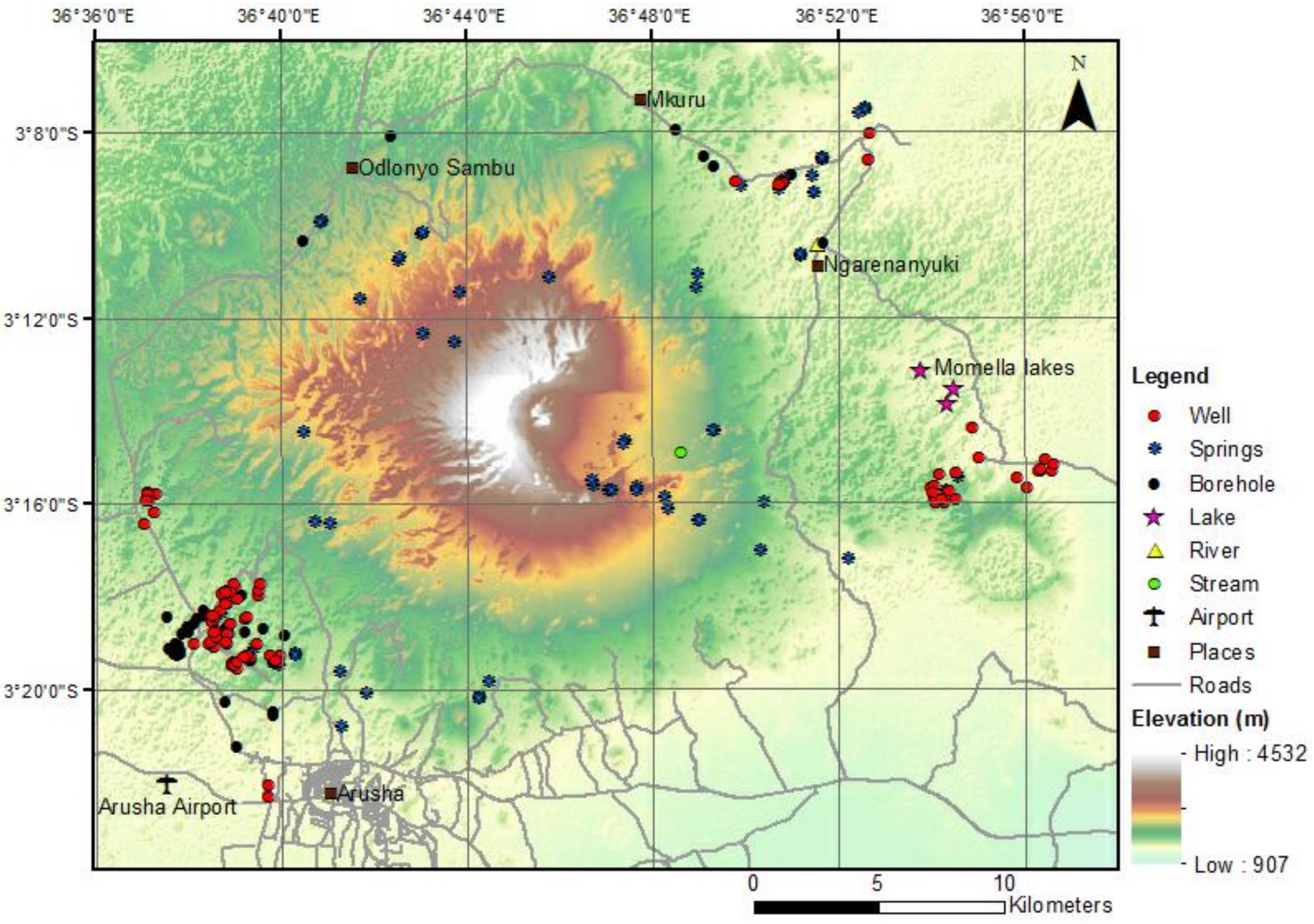
Two field campaigns;

- July – September 2017
- March – September 2018

Methods

181

groundwater points



Methods

158

water samples

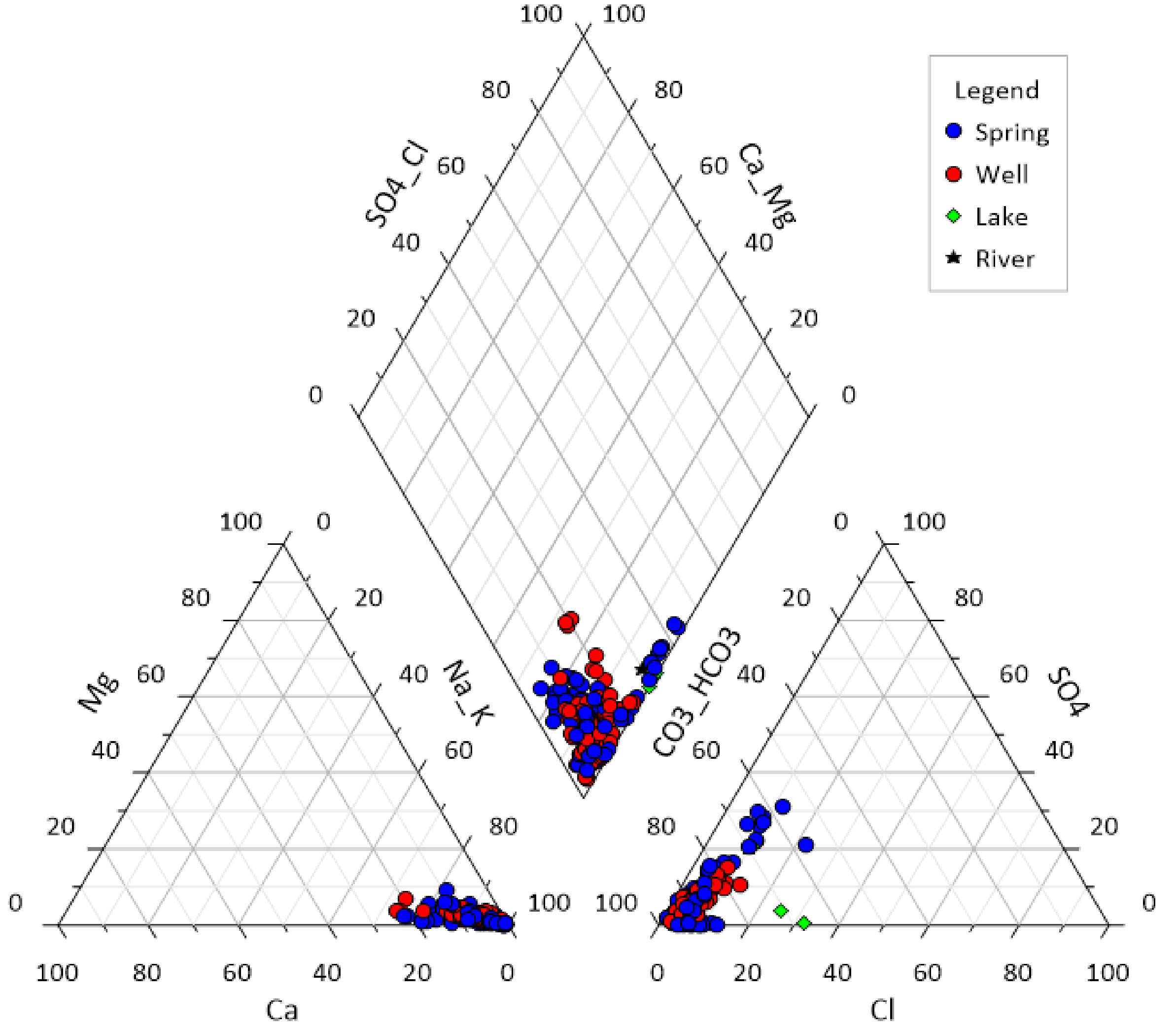
Results and Discussion

Dominant ions: **Sodium (Na^+)** and **bicarbonate (HCO_3^-)**

$NaHCO_3$ type water

Average pH value = **7.8**

Alkaline groundwater



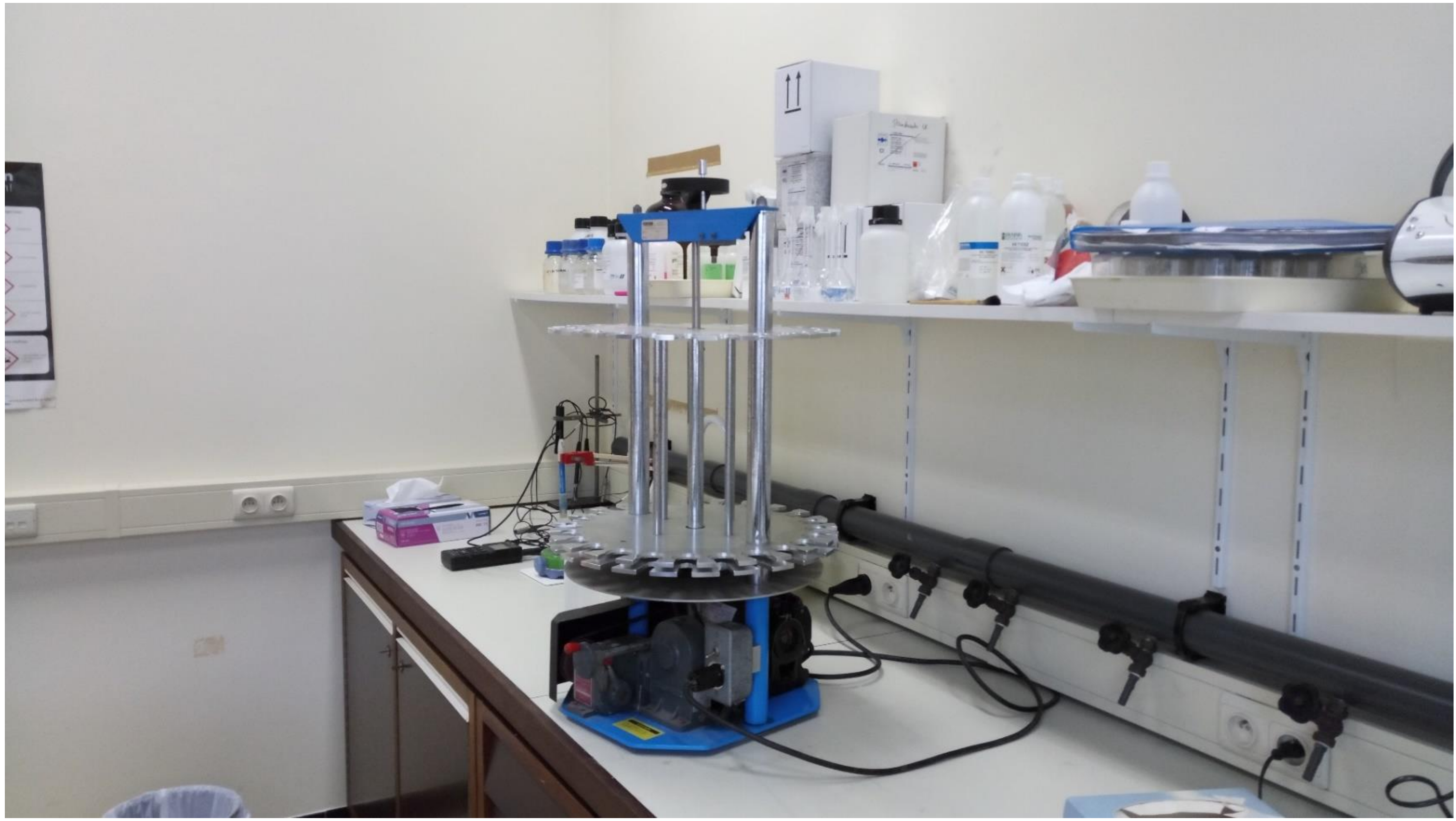
Results and Discussion

High values of **F^-** were recorded

Range: **0.15 – 301 mg/l**

Average value = **23 mg/l**

Median value = **10 mg/l**



Results and Discussion

F^- concentration

- **91%** of samples **(143** samples**)**
  - above 1.5 mg/l (WHO limit for drinking water)
- **9%** of samples **(15** samples**)**
  - below 1.5 mg/l
    - ❖ Springs at higher elevations on Mount Meru

Results and Discussion

F:Cl ratios

- **99%** of samples **(156** samples**)** – F:Cl **>** 0.10

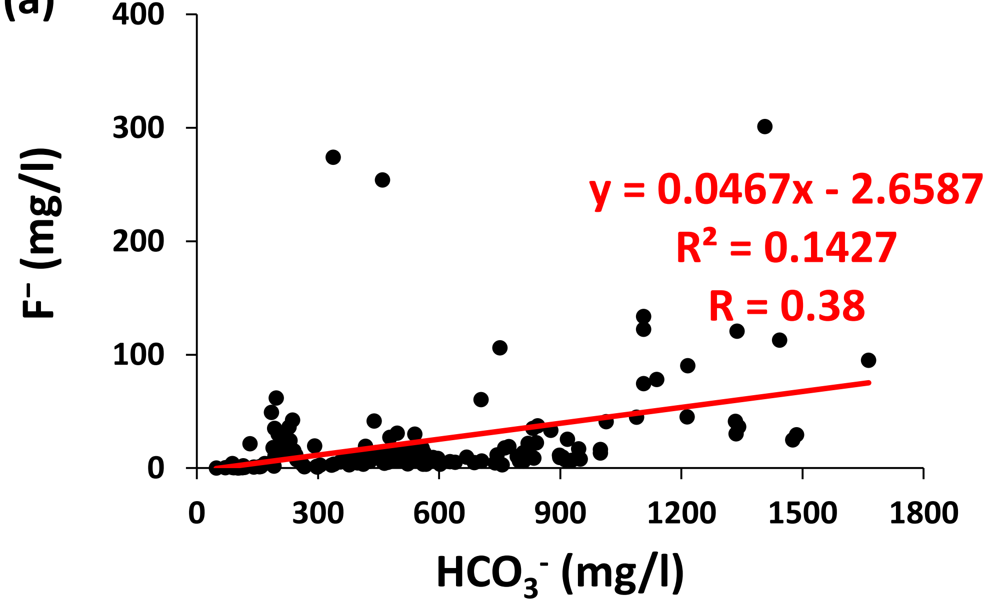
- **1%** of samples **(2** samples**)** – F:Cl **<** 0.10

→ **F^-** is derived from **chemical weathering of rocks**

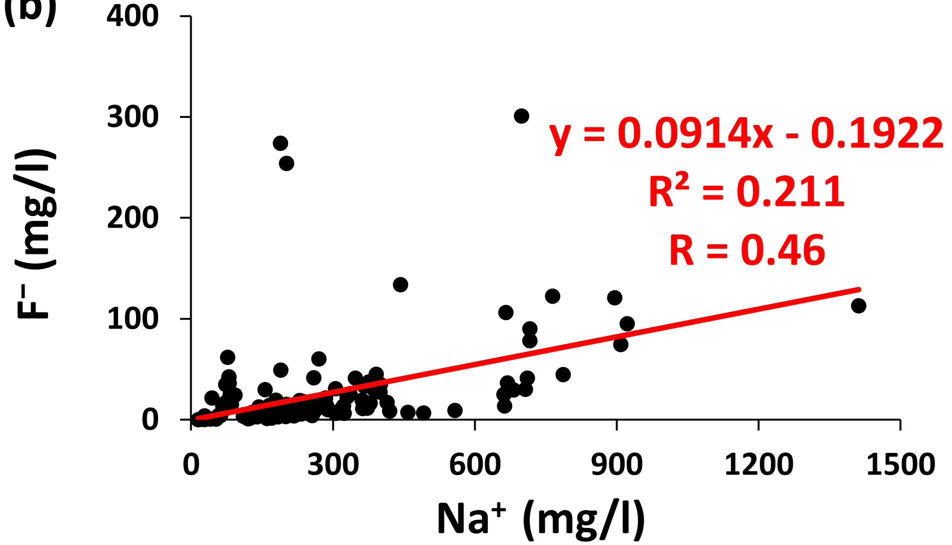
Results and Discussion

Correlation analysis

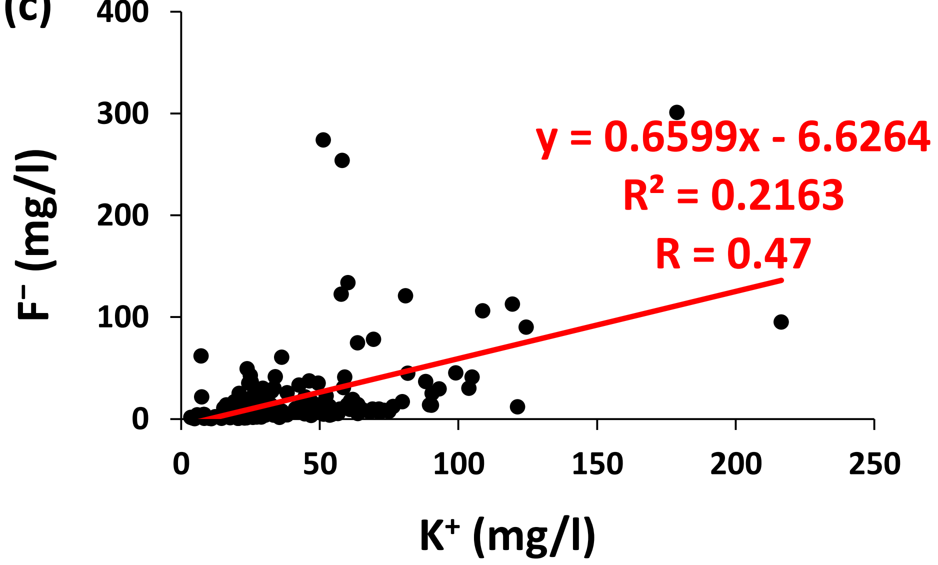
(a)



(b)



(c)



Results and Discussion

Significant **positive linear correlations** of F^- with HCO_3^-, Na^+, K^+ and pH

- ***Weathering of silicate minerals***
  - ❖ ***Na-K-rich volcanic rocks***

α = 0.05; r- correlation coefficients; n=158

	r	p-value
HCO_3^-	0.38	9.97E-07
Na^+	0.46	1.27E-09
K^+	0.47	7.45E-10
pH	0.33	2.00E-05

Results and Discussion

Significant **negative linear correlation** of F^- with Ca^{2+}

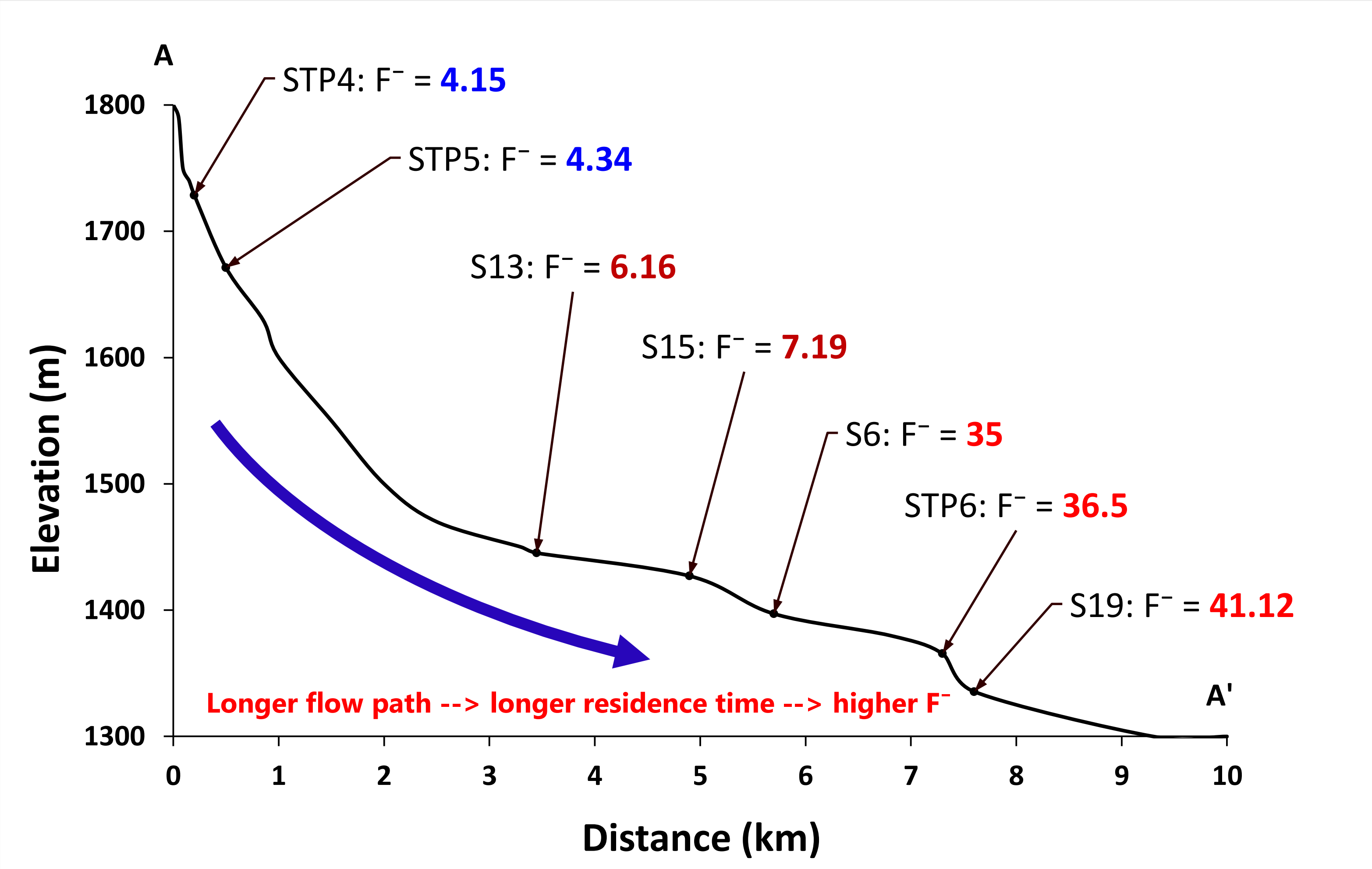
- ***Calcite precipitation***
- ***Dissolution of fluorite (CaF_2)***

α = 0.05; r- correlation coefficients; n=158

	r	p-value
Ca^{2+}	$\boxed{-0.21}$	6.84E-03

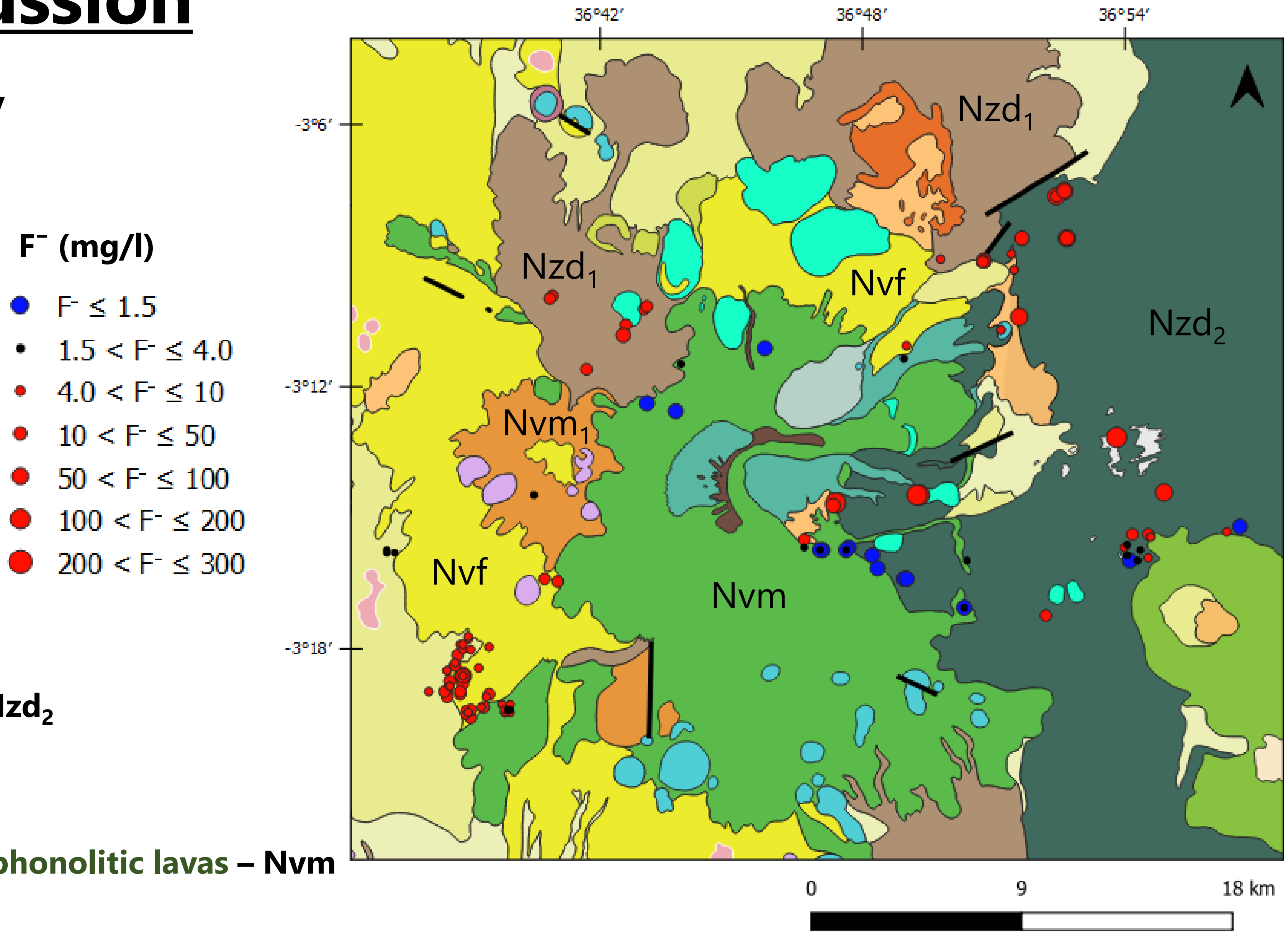
Results and Discussion

F⁻ (mg/l) **increase** with a **decrease** in elevation



Results and Discussion

F⁻ conc. vs Geology



Geological formations

- **Debris avalanche deposits - Nzd_1, Nzd_2**
- **Mantling ash – Nvf**
- **Pyroclastics with nephenelitic and phonolitic lavas – Nvm**
- **Nephelinite lavas and breccias - Nvm_1**

Results and Discussion

F^- conc. vs **Geology**

- **Lower F^- values**
  - Pyroclastics with nephenelitic and phonolitic lavas
  - Nephelinite lavas and breccias
- **Higher F^- values**
  - Debris avalanche deposits
  - Mantling ash deposits

Conclusion

Chemical evolution of groundwater;

- **Weathering and dissolution of silicate minerals**
  - **Chemical weathering of Na-K-feldspars**
- **Calcite precipitation and dissolution of fluorite (CaF_2)**

Conclusion

Factors controlling **F^-** concentrations in groundwater;

- **Nature of the geological formations**
- **Long residence time**

Recommendation

For **safe drinking water**

- Tapping water from the **springs** with **lower F^- values**

Thank You

Email: George.Bennett@UGent.be

Ash cone, Mount Meru (Picture by George Bennett)