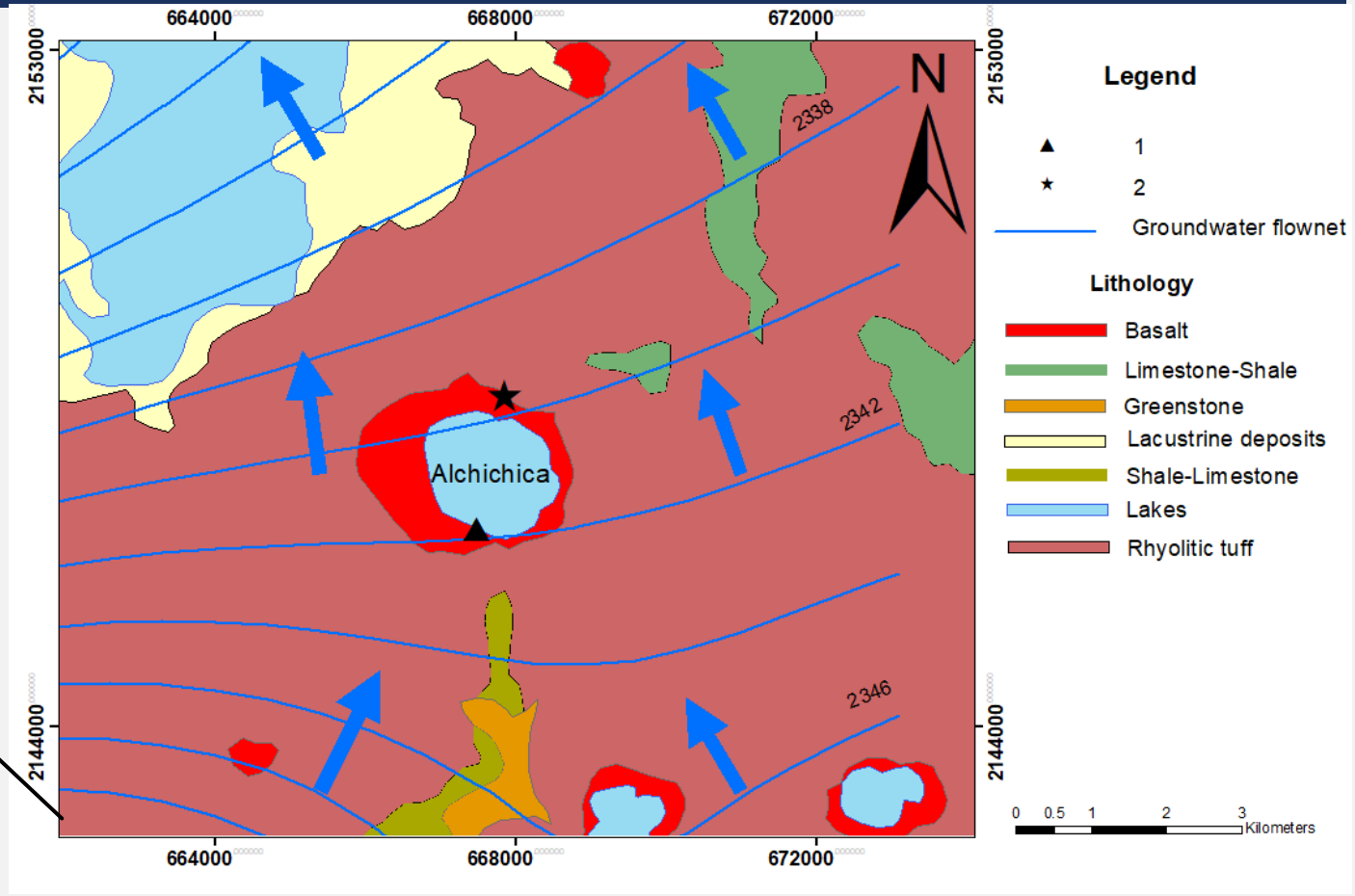
"GEOCHEMICAL MODELS HELP TO UNDERSTAND THE INFLUENCE OF CLIMATE CHANGE AND INTENSIVE GROUNDWATER EXTRACTION IN THE CHEMICAL COMPOSITION OF A TROPICAL, MAAR LAKE IN CENTRAL MEXICO"

SELENE OLEA-OLEA[1], JAVIER ALCOCER[2], RAÚL SILVA-AGUILERA[3], OSCAR ESCOLERO[4], AND LUIS A. OSEGUERA[2]

[1]Postdoc de DGAPA asignado al Grupo de Investigación en Limnología Tropical, FES Iztacala, Universidad Nacional Autónoma de México, Av. de los Barrios 1, Los Reyes Iztacala, C.P. 54090, Tlalnepantla, Estado de México, México
[2]Grupo de Investigación en Limnología Tropical, FES Iztacala, Universidad Nacional Autónoma de México, Av. de los Barrios 1, Los Reyes Iztacala, C.P. 54090, Tlalnepantla, Estado de México, México.
[3]Programa de Posgrado en Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, Ciudad Universitaria, 04510, Ciudad de México, México.
[4]Departamento de Dinámica Terrestre y Superficial, Instituto de Geología, Universidad Nacional Autónoma de México, Ciudad Universitaria, 04510, Ciudad de México, México.

1. STUDY AREA

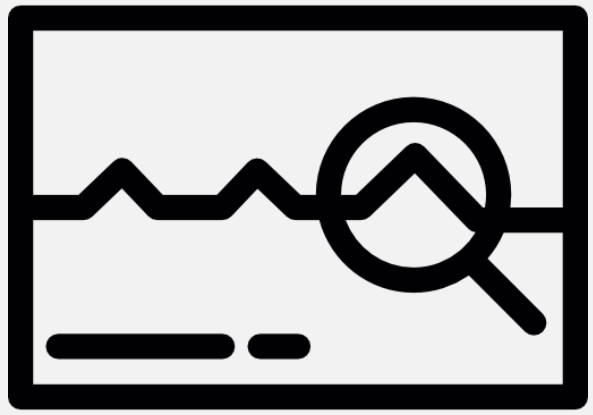
- Volcanic field
- Crater lakes (maars)
- Semiarid climate
- Intensive groundwater extraction



2. RESEARCH QUESTIONS

What factors condition the increases of HCO_3, Mg, and Cl in the lake water?

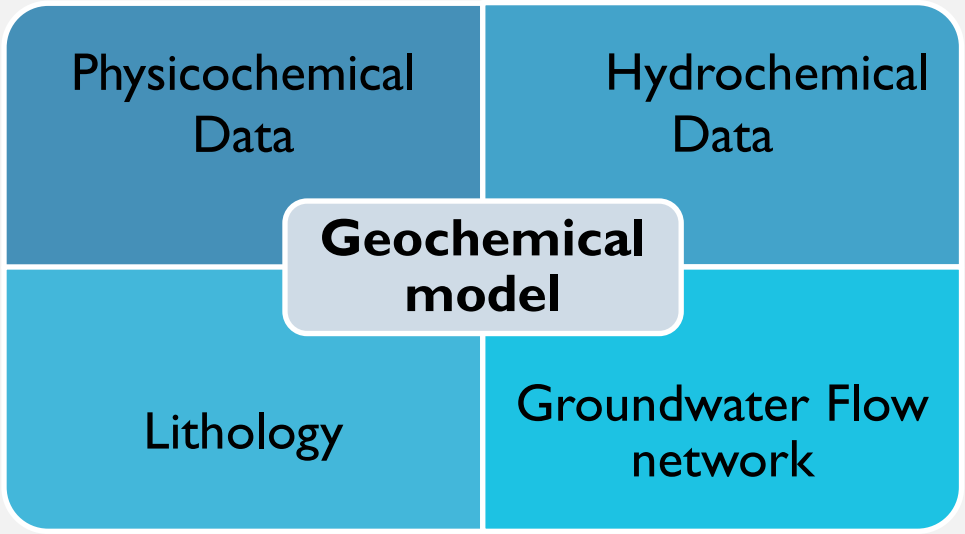
What are the relationships between the ions increase, groundwater, and climate change?

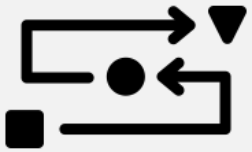


WATER-ROCK VS CLIMATE CHANGE AND ANTHROPIC CAUSES

2. METHODOLOGY

The **inverse geochemical model** predicts the possible **reactions** between **water** and **rock**





Climate change	• Temperature increase
Intesive groundwater extraction	• Since the 1980s
Evaporation	• Increasing of salinities
Dissolution Precipitation	• Mass transfers in groundwater
Groundwater flownet	• Hydrochemical evolution

4. RESULTS AND DISCUSSION

Model I

Phase	Chemical formula	Mass transfer
$CO_2(g)$	CO_2	2.06E-02
Calcite	$CaCO_3$	5.15E-04
Halite	NaCl	1.70E-03
Olivine	$Mg_{1.86}6Fe_{0.14}SiO_4$	4.51E-03
Gypsum	$CaSO_4{:}2H_2O$	-4.18E-04
$SiO_2(a)$	SiO_2	-3.02E-03
Plagioclase	$Na_{0.62}Ca_{0.38}Al_{1.38}Si_{2.62}O$	-4.07E-05
Pyroxene	$CaFeSi_2O_6$	-6.57E-04
$Fe(OH)_3$	$Fe(OH)_3$	-4.85E-06

moles per kilogram H2O

- **Dissolution** of CO_2, Calcite, Halite and Olivine
- **Precipitation** of Gypsum, SiO_2 (a), Plagioclase, Pyroxene and $Fe(OH)_3$
- Increase of **Mg** is relate to **dissolution of Olivine**
- Increase of **HCO_3** relate to **dissolution of Olivine**

$$Mg_2SiO_4(olivine)+4CO_2+4H_2O \longrightarrow Mg^{2+} + 4HCO_3^- + H_4SiO_4$$

- Increase of **Cl** is related to **weathering of hydrosilicate** minerals (phyllosilicates)

5. CONCLUSIONS

- **Water-rock** interaction processes **influence** the **groundwater** and **lake chemistry**
- **Evaporation** in the lake **increases** due to the temperature increment (since 1966-2018)
- Intensive **groundwater extraction alters** the **water input** to lake and **lake chemistry**
- The **climate change** and intensive **groundwater extraction** modify the original conditions of this maar lake reflected in the **decreasing levels** and **increasing salinities**