Reply on RC3

Dear reviewer

Thank you for your comments and suggestions, which are of great value to us in improving the quality of our manuscript. The main replies are as follows. Note: *Italic blue* is the comment. Black is the reply.

The present work performs a systematic hydrogeochemistry and isotopic analysis of the geothermal fluids in the East Anatolian Fault Zone (EAFZ) to understand any clear relationship between geothermal fluid anomalies and earthquakes existing. I have found the language of the manuscript is fine but must have a proof-editing. I have some of my major comments regarding the work on the other hand.

Main motivation behind the work is to elucidate the role of gypsum dissolution as a tracer for earthquake activity in the East Anatolian Fault Zone (EAFZ). The research aims at establishing a link between geothermal fluid anomalies and seismic events, with the claim of using an innovative approach to earthquake forecasting. In this respect, it examines shallow sedimentary minerals, particularly gypsum, as indicators of seismic activity. This concept, while explored in previous research, is further substantiated with empirical data in this study.

At this stage my biggest concern stems from the fact that it relies on the data collected post-earthquake but it fails to provide a long-term pre-earthquake dataset for comparative analysis. This appears to undermine claims about gypsum dissolution as a predictive tool rather than a post-seismic indicator. Furthermore we understand that the manuscript never make an in-depth discussion or address other factors such as

climatic conditions and seasonal variations robustly and only focus is given on the correlation between seismic events and SO42- anomalies is discussed.

The authors' uncertainty about the relevance of the results to earthquakes is evident in the final statement of the abstract. As readers, we expect the abstract of this study, which claims to bring innovation to earthquake prediction under normal conditions, to convey a clear take-home message.

In this respect I understand that authors are suggesting gypsum dissolution as a universal precursor. But I should remind that a comprehensive considering of regional geological differences or alternative explanations for observed anomalies is of great importance for earthquake hazard studies. Although potential limitations of using gypsum dissolution due to external environmental factors is acknowledge in the manuscript clear strategies for coping with these difficulties in practice.

Given its limitations in predictive validation substantial revisions are required for the present work. These revisions should include i) further evidences distinguishing seismic-induced gypsum dissolution from other environmental factors ii) a decent discussion on possible long-term monitoring strategies to make gypsum dissolution as a reliable precursor, iii) quantitative examples that prove the statistical significance of the findings that are critical to improve the robustness of the conclusions.

I also suggest adding a discussion that explore practical applications focusing on an integration of their findings into an effective earthquake early warning system.

In conclusion I do not think the manuscript is suitable for the publication in its current form and requires a substantial work to address the aforementioned fundamental

concerns that would significantly advance the understanding of geochemical indicators in seismic studies and warrant publication.

Reply: Thanks! We sincerely thank you for recognizing the systematic approach of our hydrogeochemical investigation. Please find below our point-by-point responses:

Data base extension (Annex I):

A meta-analysis of 8 published datasets (2013-2023) reveals fundamental differences in water-rock interactions across the EAFZ (Fig. 1):

Northern EAFZ: Mixed shallow/deep circulation with igneous rock-dominated water-rock interactions.

Central-Southern EAFZ: Shallow circulation dominated by sedimentary mineral dissolution (e.g., gypsum, carbonates), with localized seawater influence.

These distinct regimes provide a robust framework for interpreting tectonic-hydrogeochemical linkages, mitigating reliance on isolated measurements.

Gypsum as Process Indicator:

While avoiding direct seismic causality claims, three lines of evidence suggest gypsum's tectonic relevance:

The abnormal plasma of SO_4^{2-} and Ca^{2+} was observed one month after the earthquake. Combined with the analysis of 10 years of data in the study area, it was found that gypsum dissolution may be the cause of the abnormal ion concentration.

One month before the earthquake, the macro anomaly of white and cloudy well water was photographed (Video 01)

After analyzing pre-earthquake macro anomaly, post-earthquake data and literature data in the past 10 years, we propose that our data can only account for the dissolution of gypsum during the water-rock reaction. Gypsum may therefore indicate changes in the intensity of the water-rock reaction. As for the controlling factors of the variation of water-rock reaction intensity, we cannot define exactly. Considering that the sampling time was one month after the earthquake and obvious groundwater anomalies were observed before the earthquake, we believe that seismic activity may affect the variation of water-rock response intensity. Therefore, it is necessary to further study the possibility of gypsum as a tracer of tectonic activity.

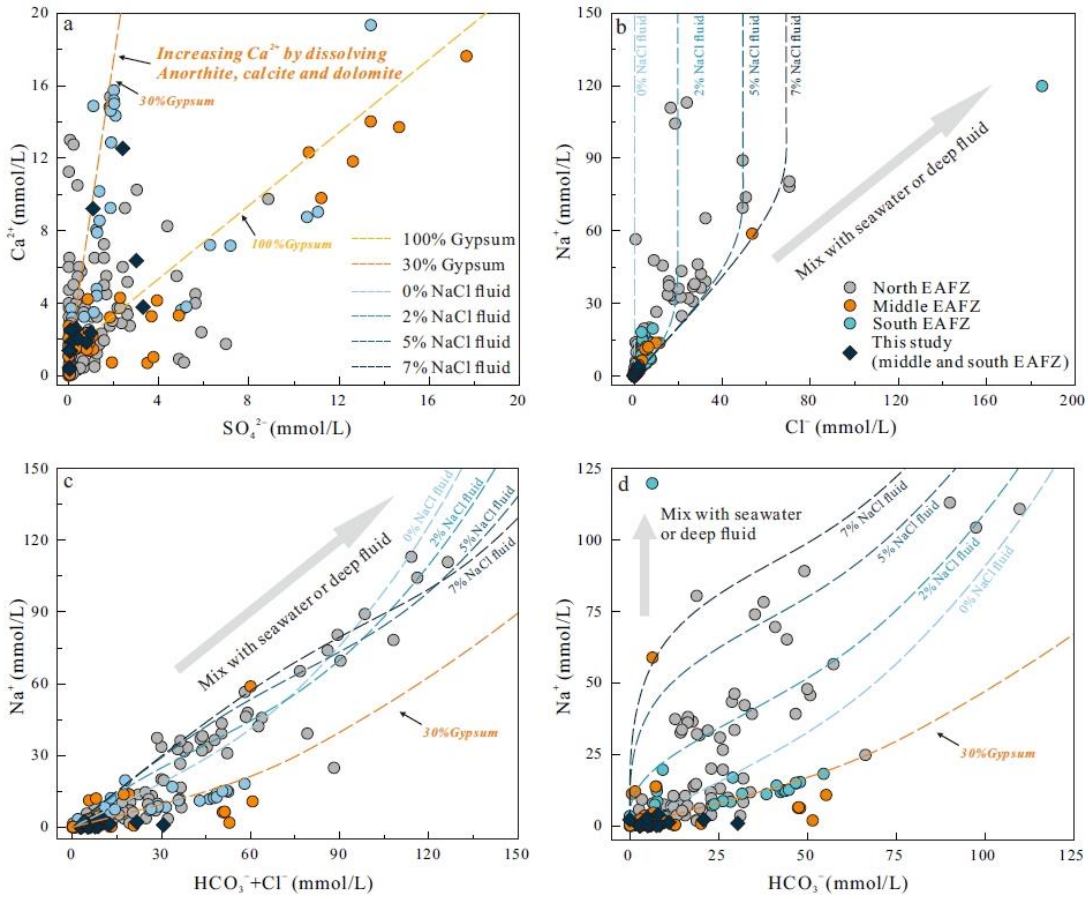

Fig. 2 Characteristics of chemical components of geothermal waters in the EAFZ, during water-rock interaction. The diamond is the measured value of geothermal waters. The dashed line is the

numerical simulation result of PHREEQC. a: Ca^{2+} vs SO_4^{2-}, b: Na^+ vs Cl^-, c: Na^+ vs HCO_3^-+Cl^- and d: Na^+ vs HCO_3^-. The sources of literature data and the simulation calculations are detailed in Annex I.

Clear research orientation:

Delete all references to "earthquake prediction". This study focuses on the analysis of EAFZ groundwater circulation process and attempts to establish the relationship between water-rock reaction intensity and tectonic activity. This study will provide a new research idea for the subsequent exploration of gypsum as a tracer of tectonic activity.