

1 Dear Giovanni Martinelli

2 Thank you for your recognition of our work and valuable suggestions, which are  
3 very helpful for us to improve the quality of our manuscripts. Your two comments are  
4 exactly where we are lacking. At your suggestion, we plan to add a subsection to the  
5 discussion section for assessing the contribution of mantle degassing to EAFZ  
6 geothermal fluids. The supplementary content is as follows:

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8 *Contribution of Mantle Degassing to EAFZ Geothermal Fluids*

9 Mantle degassing occurs extensively along fault zones, and the amount of volatile  
10 release can sometimes be comparable to the degassing associated with volcanic activity  
11 e.g. (Fischer and Aiuppa, 2020; Zhang et al., 2021). Sulfur-containing volatiles (such  
12 as SO<sub>2</sub> and H<sub>2</sub>S) ascend along these fault zones and, upon reaching the shallow  
13 subsurface, mix with groundwater, where they are oxidized and migrate in the form of  
14 SO<sub>4</sub><sup>2-</sup> in geothermal fluids. Therefore, the contribution of mantle degassing to the SO<sub>4</sub><sup>2-</sup>  
15 content in geothermal fluids cannot be overlooked. To better assess the contribution of  
16 mantle degassing to SO<sub>4</sub> in EAFZ geothermal fluids, we need to consider the sources  
17 and modifications of geothermal fluids.

18 The deep-origin geothermal fluids in EAFZ are significantly diluted by shallow  
19 groundwater, masking the chemical signature of deeper fluid components. This dilution  
20 process introduces a large amount of dissolved oxygen, which facilitates the oxidation  
21 of H<sub>2</sub>S to SO<sub>4</sub><sup>2-</sup>. Lacking O<sub>2</sub> was detected in EAFZ geothermal gases suggested that the  
22 dissolved oxygen may have been consumed (Italiano et al., 2013; Yuce et al., 2014).

23 However, it is important to note that H<sub>2</sub>S, H<sub>2</sub>, and CH<sub>4</sub> can all react with oxygen.  
24 Thermodynamic calculations indicate that CH<sub>4</sub> is more favorable than H<sub>2</sub>S in oxidation  
25 reactions ( $\Delta G^\circ$  CH<sub>4</sub> = -818.1 kJ/mol,  $\Delta G^\circ$  H<sub>2</sub>S = -494.2 kJ/mol, at 298 K and 1 atm). In  
26 actual geothermal systems, however, the depletion of H<sub>2</sub>S is more commonly observed  
27 than the depletion of CH<sub>4</sub>, suggesting that H<sub>2</sub>S may be oxidized before CH<sub>4</sub>. To resolve  
28 this apparent contradiction, we propose the following possible explanations: 1)  
29 Oxidation of H<sub>2</sub>S: While thermodynamic calculations predict CH<sub>4</sub> oxidation first, a  
30 small amount of H<sub>2</sub>S might still be oxidized simultaneously with CH<sub>4</sub>. Due to the much  
31 lower concentration of H<sub>2</sub>S in geothermal systems compared to CH<sub>4</sub>, H<sub>2</sub>S is consumed  
32 more quickly, leaving CH<sub>4</sub> with a higher residual concentration. 2) Exogenous CH<sub>4</sub>  
33 Supply: In addition to mantle-derived CH<sub>4</sub>, other sources of CH<sub>4</sub>, such as biogenic CH<sub>4</sub>  
34 and thermogenic CH<sub>4</sub> (e.g., serpentinization), may contribute to the geothermal system.  
35 These external sources could increase the concentration of CH<sub>4</sub> in the geothermal fluids.

36 In the EAFZ, we observed significant contributions of biogenic and  
37 serpentinization-derived CH<sub>4</sub> but did not detect significant levels of H<sub>2</sub>S (Italiano et al.,  
38 2013; Yuce et al., 2014). Therefore, we proposed that although H<sub>2</sub>S may contribute to  
39 the geothermal system, its impact is likely limited due to its relatively low concentration.  
40 Inversely, the notable increase in SO<sub>4</sub><sup>2-</sup> concentrations following seismic events is likely  
41 primarily controlled by the dissolution of shallow evaporitic layers (such as gypsum).  
42 All in all, while the oxidation of H<sub>2</sub>S may contribute to SO<sub>4</sub><sup>2-</sup> formation, distinguishing  
43 between H<sub>2</sub>S oxidation and sulfate dissolution requires additional geochemical  
44 indicators, such as S isotopes and Ca isotopes, for more accurate assessments.

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46 **References**

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