Solid Earth Discussions

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Comment on se-2021-132

Nicholas T. Arndt (Referee)

Referee comment on "Ambient seismic noise analysis of LARGE-N data for mineral exploration in the Central Erzgebirge, Germany" by Trond Ryberg et al., Solid Earth Discuss., https://doi.org/10.5194/se-2021-132-RC2, 2021

This is a very well written and comprehensive description of a passive seismic and airborne electromagnetic survey of a zone of greisen mineralisation in Germany. The descriptions of the geological setting, the methods used to acquire the data are complete and accurate. I do not have the background to comment on the processing of the data and I hope this will be done by another more qualified reviewer. I will instead focus on the interpretation of the results, and here I have many questions.

The first question is whether the seismic velocities of the rock types being imaged are sufficiently different that they can be distinguished from one another. And more specifically, can the mineralised greisens be distinguished from surrounding unmineralized rocks? In the manuscript there is considerable discussion about anomalies, both seismic and electromagnetic, and whether they can be related to real geological features. I am not entirely convinced that this has been done. The rocks in the region are all quartzo-feldspathic (mica schists, felsic gneisses and granitoids) and, from literature data, strong differences in velocity are not to be expected. The authors refer to data from Müller-Huber and Börner collected from a near-by area and conclude that greisens might be seismically faster than the surrounding rocks. Yet Müller-Huber and Börner state 'bulk density, however, is critically influenced by porosity and is therefore not suitable to distinguish the Austrian greisen rocks from the surrounding two-mica granites, 3 despite the greisens' comparably high grain density (mean: 2.74 g/cm³). Their higher porosity (mean: 5.7%) also results in lower elastic wave velocities (mostly < 2900 m/s)." The last sentence suggests that the more porous greisens might slower, not faster, than surrounding rocks, but there is not enough information to decide whether this difference is significant.

The authors have identified anomalies in both the seismic and electromagnetic data and they combine the two using an interesting clustering approach. They derive 9 clusters, which they relate to geological features. Unfortunately, I also found these results to be rather unconvincing.

- The anomaly SA1 is clearly expressed in the seismic models, and in section 3.1 (Ambient noise inversion results) it is related to a contact between a "two-mica schist (high velocities) in the NW and more quartzite-rich mica schist and gneiss (lower velocities)". This contact is not shown on the geological map but there seem to be some discrepancies between the orientation of this anomaly (ca. 045°) and the principal geological structures (ca. 030° to 010°, and ca. 090° south of the Greifenbach fault). In the authors' discussion of the clusters (section 3.3 "Integration and geological significance"), instead of associating the anomaly SA1 with a change in lithology of the metasedimentary units of the basement, this cluster is attributed to the Quaternary cover. Given that the anomaly aligns with topographic features (see line 221), the latter interpretation seems more likely.

- the contact between the granite intrusion and surrounding metamorphic rocks, where there might be a seismic contrast, is poorly resolved. The position of the contact inferred from mapping and drilling cuts obliquely across the boundary between high and low-velocity zones in Figure 10.

- the greisens are related to cluster 8, which is described as an anomaly "at depth having a width of up to 750 m, a length of 1350 m and a thickness of 200 m". This anomaly broadly coincides with most of the "greisen markers" shown in Figure 9 and this may be a useful result, but the size of the anomaly and its boundaries are not well constrained.

- the seismic study has picked out the Greifenbach Fault, but only in the horizontal slice near the surface where it matches the location defined by the geological mapping and drilling. The fault is not evident at depth in the vertical slices – Figs. 7 and 10.

In the introduction it is said that the study demonstrates the great potential of the cost-efficient and low-impact ambient noise technology for mineral exploration. How valid is this statement? It is true that an anomaly that might correspond to the greisens has been identified, but the distribution and margins of the zone are very poorly described. The anomaly SA1 seems better related to Quaternary deposits and, if so, has little relevance to the primary lithologies. The Greifenbach fault is imaged close to the surface but not at depth. It is difficult to see how these results could be a much help in mineral exploration.

What could be done to remove some of these uncertainties? It would be useful for the reader to have better information about the seismic velocities of the different lithologies. The results of Müller-Huber and Börner could be summarised in a table, giving the mean, the range and the uncertainties of the data. This information would help estimate whether the velocity of a two-mica schist is indeed significantly higher than that of quartzite-rich mica schist and gneiss (line 218). In addition, the uncertainty concerning the velocity of the greisen should be resolved – does it have higher porosity that would decrease its velocity below that of the surrounding rocks, as suggested by Müller-Huber and Börner? Would this difference be large enough that the greisens could be imaged in a passive seismic survey? In the present manuscript, this has not been demonstrated.

It would also be useful to superimpose the seismic results on the geological map, as I have tried to do in the attached document.

If this type of information could be provided and the probable limitations of the method were discussed, the manuscript should be suitable for publication.

Some minor points

Why wasn't the Quaternary layer imaged with ANSWT? Determination of the thickness and distribution of this cover sequence would be useful information for mineral exploration companies.

The profile labelled A-A' in the geological map (Fig 1) is oriented NW-SE but in Figure 7, the one labelled A-A' is oriented NE-SW. Please re-label the lines to eliminate this source of confusion.

Nicholas Arndt

Grenoble, 22/11/2021

Please also note the supplement to this comment:
https://se.copernicus.org/preprints/se-2021-132/se-2021-132-RC2-supplement.pdf