

Interactive comment on “3-D reflection seismic imaging of the Hontomín structure in the Basque-Cantabrian Basin (Spain)” by J. Alcalde et al.

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The authors present the results of a 3D-seismic survey acquired over the Hontomin dome structure in the province of Burgos, Spain. Starting with an introduction, the manuscript covers the processing and a preliminary interpretation of these data. The carbonate Jurassic sequence in the Hontomin dome structure hosts a saline aquifer that is planned to be used as a storage reservoir within a forthcoming CO₂ injection experiment. Therefore, the presented investigation is of high relevance and it can be anticipated that its results will have an impact for a number of follow-up investigations. The authors give a decisive description on the data treatment and

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the encountered difficulties. Reasons for these difficulties comprise a rugged surface topography in the study area, the presence of local velocity inversions, as well as the complex and scattering-prone reflection characteristics of a folded geology that is composed of marine carbonates and continental siliciclastic sediments. Though some parts of the interpretation turn somewhat difficult to follow, the authors manage to present the material in a seamless and coherent manner throughout the manuscript. Overall, I think that the manuscript is making a good case for a seismic site characterization and that it warrants for publication after some minor revisions.

Major comments:

- Given several redundancies to Alcalde et al. (2013), the authors must specify more clearly what is essentially new here, e.g. which parts of the interpretation were exclusively available from the revised processing.
- Taking into consideration that the presented data (or at least portions of it) constitute the baseline for further time-lapse surveys, the value of the manuscript could be enhanced, if the authors point out what the encountered issues imply for repeat surveys? For instance, could the static corrections be improved by adding shallow refraction seismic surveys? Or, given the statement that the presented data are “final fully-processed” it should be indicated which parts of the workflow appear useful for a time-lapse processing. For example, the application of an AGC will compromise the utilization of the workflow for amplitude-based 4D analyses.
- Although the shots were just realized in relatively shallow holes, were uphole traveltimes recorded? If so, have they been considered for the static corrections?
- The interpretation closes with a figure on the storage capacity of the saline aquifer formation which is based on the formation’s areal extent, average thickness, and

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porosity. Although such a capacity estimate is reasonable in first order, it makes the assumption that the entire reservoir thickness can be exploited also in the edge regions. However, this is misleading for gently dipping structures. Hence, this figure should be supplemented by one for which the input volume is truncated by the deepest occurrence of the reservoir top. Further, it must be clarified whether the porosity of 8 % refers to the effective porosity.

- Remove inconsistencies between text body and bibliography. Improve the graphics quality in figures 8, 10, and 13.

Specific comments and stylistic recommendations:

Introduction

- 1577, 6-7: Replace „... the Hontomín area is a very heterogeneous folded structure...” by „... the geology of the Hontomín area comprises a very heterogeneous folded structure...”
- 1578, 23-24: Replace „Although the focus of this paper is the acquisition and processing of the 3-D dataset, the final 3-D seismic reflection image obtained for the Hontomín structure, as well as a preliminary interpretation, are presented.” by „Although the focus of this paper is the acquisition and processing of the 3-D dataset, also a preliminary interpretation is presented.”

Geological setting and seismic data acquisition

- 1579, 10: „Beneath the producing level ...” add comma
- Apart from the occurrence of oil in the structure, is there any evidence about the permeability characteristics of the faults obtained from the wells? At least the H-3
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well seems to penetrate the Ubierna-related Southern fault and the H-4 well the Central fault, respectively.

- 1580, 24: Move „The survey size was designed to cover the entire Hontomín structure.” behind „... provided overall information of the subsurface structures.”
- Table 1: Add the acquisition trace length and number of geophones per receiver station.
- Figure 4: Discard the high-cut filter in the spectrum of the Vibroseis data when presenting it as a result of “raw” data.

Seismic data processing

- 1582, 4: Add „tw” after „... 1150 ms ...” and introduce abbreviation already here.
- 1582, 21: Add „cross-correlated” before „Vibroseis wavelet”.
- 1583, 2-3: Replace „co-efficient” by „coefficient”
- 1583, 4-6: „It was observed that, based on tests performed with synthetic data, the effects of noise could be overcome by stacking the correlation coefficients across many dynamite-Vibroseis trace pairs.” Make clear whether this refers to the noise originating from the wavelet processing or environmental noise.
- 1584, 19-20: “New velocity analysis was performed after every major processing step...” Table 1 shows just one occurrence for velocity analysis.
- 1584, 22: Specify the velocity reduction inferred for the velocity inversion.
- Table 2: Make clear whether the 140000 traces were eliminated and the fraction they make relative to the total amount of traces. Further, does “iterative” residual

statics indicate that the statics were alternated with velocity analyses throughout several passes? Make the meaning of “iterative” in the table clearer or cross-reference the text body.

Processing result and interpretation

- 1585, 17-19: „The lateral continuity of the reflections is limited in the whole seismic volume, due to the influence of the shallow velocity inversion, as well as to the existence of heterogeneities associated with small scale fracture zones.“ (1) Point out an example for this in Figure 11 or 12. (2) If the velocity inversion is jointly responsible for the lateral reflector discontinuity, it should be relatively variable in a lateral sense. Provide a comment whether this was inferred from the velocity analyses. (3) Provide details on the occurrence and characteristics of these “small scale fracture zones”.
- 1585,14 : Change “...improved definition of defining structures...” to something like “...improved identifiability of defining structures...”.
- 1585, 26: Add „generally“ into „The first domain contains low amplitude, discontinuous reflections (A).“, otherwise it will be compromised by (B).
- 1586, 6 and 10: Communicate the thickness of „300 ms“ just once.
- 1586, 16: If so, add that this bound of (E) is acting towards the overburden.
- 1586, 16-17: At least from Fig. 12, it is not obvious that (F) has more continuous parallel reflections than (E).
- 1586, 18: Clear up “In Fig. 12, Fig. 12A, ...”
- 1587, 14-16: „Surface and borehole data show a non-uniform, gradual change from anhydrite to carbonate, interpreted as resulting in a diffuse seismic response.“ Where is this change and its characteristics shown by the surface data?

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It appears that the reflection response seen in the surface data fits such a change, but does not provide this evidence by itself.

Discussion

- 1588, 2: Merge “sub horizontal”
- 1588, 4-5: This list contains more than two faults
- 1588, 16-17: “However, it was unexpected to find a sharp velocity inversion so close to the surface.” Have there been no indications from the vintage data?
- 1588, 19-23: The geometrical arrangement behind this thought is not clear. Provide a better explanation or schematic illustration.
- 1589, 16: Add a comma before „both were“
- 1589, 24-25: I generally agree with this statement, because the reflector definition is visibly enhanced and the overall noise level is lower. However, there seem to be some portions where the previous workflow performed better, e.g. in Fig. 11 halfway between H2 and beta’ at 700-800 ms twt. Discuss this and add a distance scale to the horizontal axis of Fig. 11.
- 1590, 9: Outline the extent of this area in Fig. 15. Label axes with inlines and crosslines. Add negative signs to the lower colorbar.
- 1591, 21-23: It appears sensible to take also wave-equation datuming into consideration.
- 1591, 25-26: I presume that this is referring to locations where the Jurassic outcrops rather than the surface geology at the site. Please, clarify.

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- 1592, 1-4: Add also a capacity estimate where the depth of a hypothetical spill point is set by the deepest occurrence of the reservoir top in the inferred dome area (see major comment above).
- 1593, 15: Correct "Lowre Hutt"

Bibliography

- Soto et al. (2011), Martinez-Torres (1993), Beroiz and Permanyer (2011) are missing in the bibliography.
- Arts et al. (2004), Elío et al. (2013), Ivanova et al. (2013), Koperna et al. (2012), Lumley (2010), Martens et al. (2012), Pérez-Estaún et al. (2009), Pruess and García (2002), White et al. (2004) have no occurrence in the text body.
- In case Quintà and Tavani (2012) and Quintá (2012) refer to the same person, check spelling.

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