

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

J. Alcalde et al.

juan.alcalde.martin@gmail.com

Received and published: 9 December 2013

Dear Anonymous Referee #2,

Thank you for reviewing our paper and for your positive and useful comments. Please find enclosed the answers to your comments on behalf of all the co-authors and myself. Kind regards,

Juan Alcalde

-Referee's comments are italicized, bold and addressed; manuscript text follows with changes tracked; new text added to the manuscript is attached in red for the discussion-

C647

1) Numerous structures in the study area and their link to tectonics are mentioned. To what extent are these structures (still) assumed to be active, and what are their implications in relation to future CO₂ storage? The tectonic stability of the site is one of the pre-requisites for the selection of the site for the Pilot Plant according to the standard selection criteria for this kind of CO₂ storage project (e.g., Bachu, 2000; Pérez-Estaún et al., 2009). Although the Hontomín site has undergone a number of tectonic events during the Mesozoic and Cenozoic, it is believed to be tectonically stable at present time. Ugalde et al. (2013) confirmed this interpretation by searching through the Spanish National Geographic Institute (<http://www.ign.es>) seismic catalogs up to September 2012. They report in their article that “less than 10 earthquakes with magnitude 2.5 or greater have been recorded within a radius of 50 km from Hontomín over the last 100 years, the largest being a 4.3 magnitude event that occurred in 1939 at a distance of about 40 km from the site”. This is consistent with the Hontomín area being a low seismicity area. This information was added to the text as follows: The existing data indicate that the reservoir and seal formations are Jurassic in age, and form a slightly elongated dome-like structure with an overall aerial extent of 5x3 km². The area features low natural seismicity as stated in Ugalde et al., (2013). The discussion of the implications of Geological Storage of CO₂ in a seismically active area is out of the scope of this article.

2) CO₂ storage is mentioned both in the abstract and the conclusion part of the paper, but the CO₂ storage potential of the rocks are in fact only briefly discussed in the body of the paper. The authors calculate a maximum storage capacity of the structure, but how do the authors expect the CO₂ to react with the surrounding rock? Will the CO₂ have the potential to e.g. dissolve the rock, and what are the potential implications? Since this manuscript aims to provide a seismic image of the subsurface of the Hontomín site, it is not our purpose to discuss the effects of the CO₂ injection in a carbonate reservoir. Several authors deal with this issue and there are a number of examples of this topic in the literature (e.g., Czernichowski-Lauriol et al., 2006; Izgec et al., 2008; Gaus, 2010; Liu et al., 2012; amongst others). In the Hontomín

C648

project, García-Ríos et al. (2013) are conducting the laboratory experiments aimed to describe the interaction of the CO₂ with the caprock. A reference to their work has been added to the manuscript as follows: In spite of this lack of internal definition, we have calculated a theoretical CO₂ capacity of the reservoir unit within the Jurassic structure. We do not take into account the possible interactions of the CO₂ with the reservoir formation since this is outside of the scope of this article. Further information about geochemical and rock physics interactions, conducted inside the Hontomín project, can be found in García-Ríos et al. (2013) and Canal et al. (2012), respectively. Canal, J., Falcón, I., Barrientos, V., Juncosa, R., and Delgado, J., (2012). Injection of reactive fluids in geological reservoirs: The coupling between rock reactivity, hydrodynamics and petrophysics. DHI/Fluid Consortium Meeting Fall 2012. Colorado School of Mines. Abstract paper. García-Ríos, M., Luquot, L., Soler, J. M., and Cama, J., (2013). Laboratory-scale interaction between CO₂-rich brine and reservoir rocks (limestone and sandstone). *Procedia Earth and Planetary Science*, Volume 7, 2013, Pages 109-112

3) It is mentioned on page 1582 that based on an internal report and the paper of Ogaya et al. (2013) "...dipping events steeper than 16 degrees are rather unexpected, and therefore, quasi-horizontal dips were assumed in the processing." To me that is a bit surprising given the structural complexity in the area in general. Moreover, what are the risk and potential implications of having overlooked steeply-dipping events? The Hontomín area has undergone different periods of sedimentation and a number of tectonic events have configured its current state. The study area has experienced different sedimentary environments and deformation episodes through its evolution (e.g. García-Mondéjar, 1996; Pujalte et al. 2004; Tavani et al., 2011; Quintà and Tavani 2012; Tavani, 2012; Tavani et al., 2013). The stratigraphic formations deposited in the study area have, thus, been affected by a wide range of stress regimes. However, the resultant deformation is relatively low intensity because, among other reasons, the Hontomín area is away from the main deformation. Ogaya et al. (2013) does not find steep dips. These are only found locally in the surface of the study area in a small

C649

scale structure above the Southern fault. Besides, the wavelength of this structure is almost sub-seismic. These dips, in any case, are not considered important enough to modify the data processing.

4) On page 1591, I would have given rounded numbers for the estimated lateral resolution. The values given here indicate (unrealistic) high precision of these estimates. We totally agree with Referee #2 and we have rounded up the numbers of the capacity estimation following his suggestion.

REFERENCES Bachu, S., 2000. Sequestration of CO₂ in geological media: criteria and approach for site selection in response to climate change. *Energy Conversion and Management*, Volume 41, Issue 9, 1 June 2000, Pages 953-970, DOI: 10.1016/S0196-8904(99)00149-1. Czernichowski-Lauriol, I., Rochelle, C., Gaus, I., Azaroual, M., Pearce, J., Durst, P., 2006. Geochemical interactions between CO₂, pore-waters and reservoir rocks: lessons learned from laboratory experiments, field studies and computer simulations. In: Lombardi, S., Altunina, S.E., Beaubien, S.E. (Eds.), *Advances in the geological storage of carbon dioxide: international approaches to reduce anthropogenic greenhouse gas emissions*. Springer, Dordrecht, Netherlands, pp. 157–174. Gaus, I., 2010. Role and impact of CO₂-rock interactions during CO₂ storage in sedimentary rocks. *International Journal of Greenhouse Gas Control* 4, pp. 73-89. García-Mondéjar, J., 1996. Plate reconstruction of the Bay of Biscay. *Geology*, 24, 635–638. Izgec, O., Demiral, B., Bertin, H., and Akin, S., 2008. CO₂ injection into saline carbonate aquifer formations I: laboratory investigation. *Transp Porous Med*, 72, pp. 1-24. DOI 10.1007/s11242-007-9132-5 Liu, F., Lu, P., Griffith, C., Hedges, S. W., Soong, Y., Hellevang, H., and Zhu, C., 2012. CO₂-brine-caprock interaction: Reactivity experiments on Eau Claire shale and a review of relevant literature. *International Journal of Greenhouse Gas Control*, 7, pp. 153-167. Pérez-Estaún, A., Gómez, M. and Carrera, J., 2009. El almacenamiento geológico de CO₂, una de las soluciones al efecto invernadero. *Enseñanza de las Ciencias de la Tierra*, (17.2), 179-189. Pujalte, V., Robles, S., García-Ramos, J. C. and Hernández, J. M., (2004),

C650

El Malm-Barremiense no marinos de la Cordillera Cantábrica. *Geología de España* (J.A. Vera, Ed), SGE-IGME, Madrid, pp 288-291. Tavani, S., 2012. Plate kinematics in the Cantabrian domain of the Pyrenean orogen. *Solid Earth*, 3, 265-292. Ugalde, A., Villaseñor, A., Gaité, B., Casquero, S., Martí, D., Calahorrano, A., Marzán, I., Carbonell, R., Estaún, A.P., 2013. Passive seismic monitoring of an experimental CO2 geological storage site in Hontomín (Northern Spain). *Seismological Research Letters*, 84 (1), pp. 75-84.

Please also note the supplement to this comment:

<http://www.solid-earth-discuss.net/5/C647/2013/sed-5-C647-2013-supplement.pdf>

Interactive comment on *Solid Earth Discuss.*, 5, 1575, 2013.