

Review of "Joint interpretation of magnetotelluric, seismic and well-log data in Hontomín (Spain)" by X. Ogaya, J. Alcalde, I. Marzan, J. Ledo, P. Queralt, A. MArcuello, D. Martí, E. Saura, R. Carbonell, and B. Benjumea

The manuscript describes a valuable and interesting comparison of seismic velocity and resistivity data in the area of the Hontomín CO₂ sequestration site. Three-dimensional velocity and magnetotelluric (MT) resistivity models are described and compared, and these data are compared with well-log information. Statistical relationships between the velocity and resistivity are derived from the well-log data and used to convert the 3-D MT resistivity model into equivalent velocity models. These results are then compared with the actual well-log data and near-surface seismic models. The manuscript is well written and illustrated and appears to be scientifically correct. It will be of interest to a wide range of readers of Solid Earth.

I have only one significant comment on the scientific aspects of the manuscript and that is that although the relationships between the well-log seismic and velocity data are established for subsequent empirical use I think there should be a little discussion of their physical basis and a more critical assessment of their significance. There are also a number of small editorial scale corrections that would enhance the manuscript.

General Comments

1. The results of the study will be valuable to many readers. The intercomparison of the seismic and MT results provides new results meaning that the overall geophysical data set provides more information than the sum of the results obtained from the individual methods. For example, the differences between the data sets provide information at depth on fluid distributions relative to the fault locations and in shallow areas on the possible contribution of clay to the resistivity variations.

2. The comparison of the MT 3-D resistivity model with the well-logs was also of valuable and demonstrated that the surface method provided remarkably good resolution of the sub-surface resistivity.

3. I think that the aspects of the study dealing with the correlation of the well-log resistivity and seismic data could be strengthened in places.

(a) The manuscript cites other studies that have considered this correlation but it would be useful for it to include some level of discussion of the physical basis for the regressions used. What is the basis for considering different depth ranges (empirical observation or accounting for the influence of confining or fluid pressures on velocity, pore connectivity)? How do the two relationships accommodate the effect of porosity expressed in the standard Archie's Law (with or without a surface conductivity contribution from clay minerals) for resistivity and Reuss average (time-average) or other physical mixing models? What is the relationship between the observed relationships and the various lithologies? The manuscript attributes differences in the near-surface velocity models in Figure 10 to the role of clay. However, I assume that the mean clay content is already accommodated in the two regression models so it is really spatial variability in clay content that is involved. What percentage contribution of clay to the bulk conductivity is required to explain the observations?

(b) There is partial circularity in the results that has not been explicitly noted in the manuscript. For the ER1 models there are a number of fitted relationships in which the constant a appears to be not statistically significant (e.g., for S4, S5, D1, D6, D7, and D11 in Table 1) In these depth ranges the velocity is effectively independent of resistivity so the regression line essentially provides only the mean value of the seismic velocity for that depth range. The resistivity has virtually no capacity to predict the velocity in these depth ranges. When the fitted relationship is used to predict the velocity from the 3D

resistivity model all it is doing is returning the mean value of the velocity for that depth range. This result will of course provide a good representation of the seismic results because it is based almost entirely on seismic constraints. The comments on the quality of prediction of the seismic results should focus to a greater extent on those depth ranges in which there is a strong resistivity-velocity correlation. I think it would also be valuable to include an assessment of the statistical significance of the regression results in Table 1 in order to address this issue. It may be hard to use a standard statistical test as the true number of degrees of freedom is unclear because of the spatial correlation of the well-log data. However, perhaps an analysis of the proportional decrease in variance could be used.

(c) The display of data in Figure 6b and c and the results in Table 2 are perhaps a little artificial. Much of apparent excellent fit of the data in Figure 6b is due to the presence of R in both variables and disguises the true level of correlation. Re-arrangement of (the second) equation 1 suggests that the underlying linear relationship is of the form:

$$\frac{1}{V} = c + \frac{d}{R} \quad \text{Equation 1}$$

so I think a regression of $1/V$ against $1/R$ would provide a truer indication of the fit of the underlying model. It is presently difficult to use the results in Table 2 to see if there are any similar issues to those noted in point (b) above.

Specific Comments

p. 1, line 23-24. Perhaps "... model for the near-surface is compared..."

p. 2, line 7. Perhaps "..., for example, the magnetelluric method ..." (Unless you specify this is for the scale of the sequestration site investigation most electromagnetic methods can provide similar constraints on fluid characterization.)

p. 3, line 14. Perhaps "The mixed lithologies (siliciclastic..."

Line 16. Perhaps "... together with moderate..."

Line 26. Perhaps "...regional geological information...", "...identification of 39 subunits..."

p. 3. Line 29. I was not fully sure what "prognosis" meant in this context. It is a little unusual use of the word so it may be worth adding a few extra words of clarification.

p. 4. Line 17. Perhaps "The BBMT sites were..."

p. 5. Line 1. "...which has an aerial extent of circa..."

p. 5. Line 9. It was bit unclear what "unfold in different faults" means.

Line 29. It is also not entirely clear what "bend of the resistive body" means. In the vertical plane or in the horizontal plane?

p. 6. Line 4. Perhaps "... seems to indicate .."

p. 7. Line 21. "noisier", Perhaps "...are large (>2000 m/s)."

Line 28. "... ones observed ..."

p. 10. Line 26. "Although the level..."

p. 19. "... thicknesses of the sedimentary units."

p. 23. Perhaps "... velocity for the GW1 and H4 well logs"

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