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Solid Earth Discussions

Interactive comment on "Seismic imaging of sandbox experiments – laboratory hardware setup and first reflection seismic sections" *by* C. M. Krawczyk et al.

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Review of SEISMIC IMAGING OF SANDBOX EXPERIMENTS – LABORATORY HARDWARE SETUP AND FIRST REFLECTION SEISMIC SECTIONS, by C.M. Krawczyk, M.-L. Buddensiek, O. Oncken, and N. Kukowski MS No.: se-2012-31 MS Type: Research Article

General Comments: This is an interesting, well written paper that is potentially suitable for publication in Solid Earth, after answering some specific comments (minor revisions).

Principal Criteria Excellent (1) Good (2) Fair (3) Poor (4) Scientific Significance: Does the manuscript represent a substantial contribution to scientific progress within the scope of Solid Earth (substantial new concepts, ideas, methods, or data)? 1 Scientific Quality: Are the scientific approach and applied methods valid? Are the results discussed in an appropriate and balanced way (consideration of related work, including appropriate references)? 1 Presentation Quality: Are the scientific results and conclusions presented in a clear, concise, and well-structured way (number and quality of figures/tables, appropriate use of English language)? 2

This paper represents a substantial contribution, both scientific and technical, trying to join and link together two different geophysical methodologies that indirectly reveal the Earth′s interior. One methodology is the simulation of the Earth′s subsurface by sandbox experiments (after this paper we could named also "glass beads" experiments). The other, the well-known multichannel seismic experiments, that estimates the properties of the Earth's subsurface from reflected seismic waves. This paper shows seismic imaging of sandbox experiments, trying to reproduce faults and channel structures that are structurally evolving in time, and explains step by step how to build the experiment.

Specific Comments:

Most of the questions of this reviewer arise from the translation of the seismic imaging of the sand box experiment scale to a real marine multichannel seismic experiment. 1. As in paragraph 2 (page 1321) is indicated by the sentence:

"Since 1 cm in the model scales to 1 km in nature, we want to test acquisition geometries in the lab on a tectonic scale first. Thus, our geometry simulates tectonic settings of up to 15km horizontal distance, where fault segments of a 100m width are present. This translates to 150mm offset and mm-width of structures to be investigated by the mini-seismic device."

The experiment scale between the real Earth′s subsurface and the experiment is 1cm = 1km. So, fault segments should be 100m long and source-receiver offsets less than 15 km. Instead of that, source-receiver offsets is 14 km and structures ranges from

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1.5-2.0 mm (150-200 m) in the abstract

Numbers must match in the abstract and manuscript.

2. Signal generator frequencies ranges from 0.05-1kHz, and receivers have a maximum sampling of 20 MHz (page 1322)

If the signal generator has a frequency between 50-1000 Hz (0.05-1kHz), the sampling frequency to avoid aliasing will be 0.05ms, that is, below Nyquist.

But authors use a receiver with 20 MHz sampling, equivalent to 0.00025 ms sampling. Is there any reason to use a 1000 times lower sampling?

This is what the text suggests as it is written.

3. Transducers (page 1323)

If signal generator ranges between 0.05-1kHz, may you explain why transducers with a bandwidth between 250-675 kHz have been elected for the experiment?

4. with incidence angles below 35° (page 1323)

In a marine multichannel seismic experiment with a typical 1000 m depth water, a maximum 35° angle incidence means a maximum 1400 m distance between source and receiver for the first reflection (seafloor). Present-day experiments at sea includes 12 km long streamer, meaning source-receiver distances almost 10 times bigger as the calculated before. This angle limitation, and therefore maximum source-receiver offset, in the current sand-box experiments has to be considering for future experiments and a reference to that could be included in the main text by the authors.

5. Test experiments (page 1323)

"The maximum source frequency of 1MHz allows for a very high resolution in the mm-range"

Following the emission signal indications for the generator in page 1322 (0.05-1kHz)

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seems impossible to generate a source frequency of 1 MHz. Please indicate or explain with more details this wavelet generation in the text. As it is written is confusing.

6. Test experiments (page 1323)

“The acquisition geometry is based on 18 to 150mm shot-receiver spacing, 12mm receiver spacing, 3mm shot spacing and 100mm water depth”

This point is not critical for publication, because the experiment of seismic imaging a sand box is still feasible, but in my opinion some of the values of the acquisition geometry should be revised in future experiments and at this stage, should be discussed in this revision.

Thus, following the comparison between the sand-box experiment and a real marine multichannel seismic survey, because 1cm in the model scales 1 km (1mm= 100m) nature, authors should include a few sentences justifying the choice of the current acquisition geometry values before publication. For instance:

a) Shot-receiver spacing 18-150 mm in the experiment is equivalent to 1.8 km-15 km. 15 km is ok for large offsets, but near offsets in marine MCS experiments are about 200 m.

b) 12 mm receiver spacing is equivalent to 1.2 km in marine MCS experiment. Streamers typically are built with a 6.25m / 12.5 m receiver spacing. When receiver spacing is large as in this paper, spatial aliasing occurs and f-k filtering must be included during processing. Alternatively, to avoid spatial aliasing, traces can be interpolated reducing the trace distance during processing.

c) 3mm shot spacing.

Usually shot spacing is a multiple of receiver distance (12.5m, 25 m 37.5m, 50 m,. . ..) in order to account for a constant fold before nmo correction. 3mm shot rate is equivalent to 300m in a real seismic experiment.

d) 100 mm water depth = 10 km water depth, which is almost the maximum on Earth

For future experiments could be interesting to use 37 mm water, equivalent to 3700 m, the average submarine depth on Earth, although this data seems not to be critical for the experiment.

7. Page 1324 “Here, the source frequency varied systematically between 100 kHz and 1 MHz”

Again, could you explain how to generate a source frequency between 100 kHz and 1 MHz if signal generator frequencies ranges from 0.05-1kHz?

8. Page 1325, “Due to data acquisition very near to the model surface, only this trace provided enough sensitivity and a clear signal”

As commented before, if near offset distance used in the sand-box experiments can be reduced to values similar to those used during multichannel seismic acquisition, sensitivity will increase and clear signals will be recorded in a larger amount of near traces.

9. Page 1328, “The shear zone images by disruptions of the very strong bounding reflectors in the upper part”

As written, is difficult to understand the meaning of this sentence.

10. Page 1328 and Figure 8

Before and after the migration, would be interesting to perform a time variant frequency analysis of the reflections to know exactly the high frequency loss and the content of the bandwidth in reflection signals. This analysis could be included as a third column in Fig 8. This decrease of the high frequency due to the succeeding reflections could also explain the “wormy” shape, increasing in time, of the seismic images that we observe in Fig. 8, below the interface between 0.16-0.18μs, notably after migration. Migration parameters used during processing must also be included in the main text. In some cases, in order to reduce the migration PC time consuming processing, a reduced signal bandwidth is used instead of a Nyquist maximum frequency. Is this the case? Could you check migration parameters?

11. Page 1329 "Because of the required resolution of 1 to 3 mm"

i) Vertical resolution of a signal is calculated by $\frac{1}{4}$ the wavelength (λ). And the wavelength is calculated by λ= V/F, v= seismic velocity and F= seismic frequency

For 1mm resolution, λ/4=4V/F=1mm, then F=4V/1mm = 6*106Hz = 6 MHz. For 3mm resolution, F= 2 MHz

But during processing, a band-pass filtering of 75-125-750-800 KHz was applied.

Are you sure that the resolution of the features that you are imaging is 1 to 3 mm?

ii) In the reflection seismic sections of Fig. 8, 1mm vertical spacing at 1500 m/s velocity corresponds to 1.3 μs two way travel time (twtt). Time=Displacement/velocity= 10-3 / 750 = 1.3 μs

In other words, 1 mm vertical spacing corresponds to 1.3 μs twtt. But vertical scale of Fig. 8 goes from 0.12-0.20 μs, that is, 0.08 μs thick. Could you explain why the vertical resolution (1 mm) is larger than all the vertical section?

May be you should distinguish between horizontal and vertical resolution in the manuscript.

12. Page 1330, discussion about grain surface texture and saturation. Because I am not an expert in saturation, could there be any reason to use salt water instead of fresh water in your models? Could salt water increase sand saturation? In other words, salt water behaves like freshwater in terms of saturation? This point will be more realistic to nature (because salty sea water), although as the authors commented in the paper, algae and other organic growth is a time depending problem during the saturation process.

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13. Figure 4

Bottom-right panel vertical scale (0-0.25 μs) is different from the rest of pictures in the Figure (0-0.30 μs)

14. Table 1 PC control unit, signal generator max. output 125 MHz. This 125 MHz is confusing because in the main text, max. output is 0.05-1 KHz.

Interactive comment on Solid Earth Discuss., 4, 1317, 2012.