Short note: GPU accelerated 3D wave propagation and continuous coil shooting

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ABSTRACT

This short note discusses how continuous coil shooting for a synthetic VSP survey could lead towards more azimuth rich data whilst keeping the survey time below that of a conventional towed streamer survey.

INTRODUCTION

Throughout the history of reflection seismology, particularly since the large scale inception of 3D surveys, there has been a simultaneous desire to both improve acquisition geometries and also to reduce survey cost. At first glance these goals appear to be contradictory, and for the most case they are; however, this short note postulates that recent innovations in simultaneous source acquisition and in coil shooting could lead toward these stipulations.

Areas that exhibit complex salt geology, such as the North sea, the western Gulf of Mexico and offshore West Africa, are extremely petroleum-rich making the production of detailed, high resolution 3D images of these areas key in understanding and appraising such fields. Over the last 10 years there has been a proliferation of survey techniques that differ from or augment the usual single source streamer towed cable geometry. Methods such as multiple azimuth surveys (MAZ) (Manning, 2007) and wide azimuth surveys (WATS) (Verwest and Lin, 2007) are common. When compared to equivalent, traditional narrow azimuth surveys these images exhibit better illumination, more consistent amplitudes along reflectors and sub-salt coherency. However, whilst these methods improve image illumination they also greatly increase the cost the survey.

More recently, coil shooting has gained interest as a technique of acquiring more azimuth rich data without increasing survey costs as much as MAZ and WATS. It has been shown with synthetic data that over complex geologies coil shooting can provide more illumination and fill in gaps in 3D angle gathers (Buia (2009); Moldoveanu and Kapoor (2009)). Also recently the concept of simultaneous shooting (Aaron and Fromyr (2009); Ayeni and Biondi (2009); Tang and Biondi (2009)) within surveys has gained momentum, since this technqiue reduces acquisition time, which is generally

considered to be 80% of a survey's cost. The problem with the latter technique is that when cable towed streamers acquire simultaneously shot data, the waves recorded tend to be conical, rather than spherical, due to the motion of the source vessel. This gives reduced angular illumination compared to an equivalent, conventionally shot survey. We suggest that combining continuous shooting with coil shooting will help to both reduce acquisition costs and fill in illumination holes seen in 3D angle gathers.

PROPOSED METHOD

In order to simulate this problem synthetic data was produced using a 3D subsection of the SEAM velocity model. Initially a 2D VSP dataset was simulated using a parallelised, variable-density, two-way modelling CPU code. A VSP survey was chosen since reciprocity can be used to simulate the relevant surface geometries and this would require far fewer shot simulations. A total of 32 shots were simulated. To extend this to 3D modelling a constant density 3D GPU propagation kernel was written, and is in the process of being adapted to simulate a dataset of this size at an acceptable speed

SEAM DATASET AND 2D DATA

The model used to create the data was the latest iteration of the SEAM model, and for the 2D case a variable density two-way wave propagation algorithm was used. For the 3D modelling a constant density 3D GPU code was used, with the view of extending this to variable density. The SEAM model itself is extremely large, with over 20 billion samples, and so a small section of the data was windowed. A representative view of this windowed section can be seen in Figure 1.

Within this section, a salt body with an allochthonous arm extends into the sediments. Above the salt there is a carbonate layer, and the sediments are finely layered with an increasing velocity with depth.

Figure 2 shows an example of a simulated shot from the SEAM dataset.

3D GPU MODELLING AND FUTURE WORK

The next step in this concept is to extend the modelling to 3D. Thirty-two VSP shots are in the process of being modelled, with the entire surface wavefield saved every several time steps (such that the survey time sampling is 4ms.) From these densely

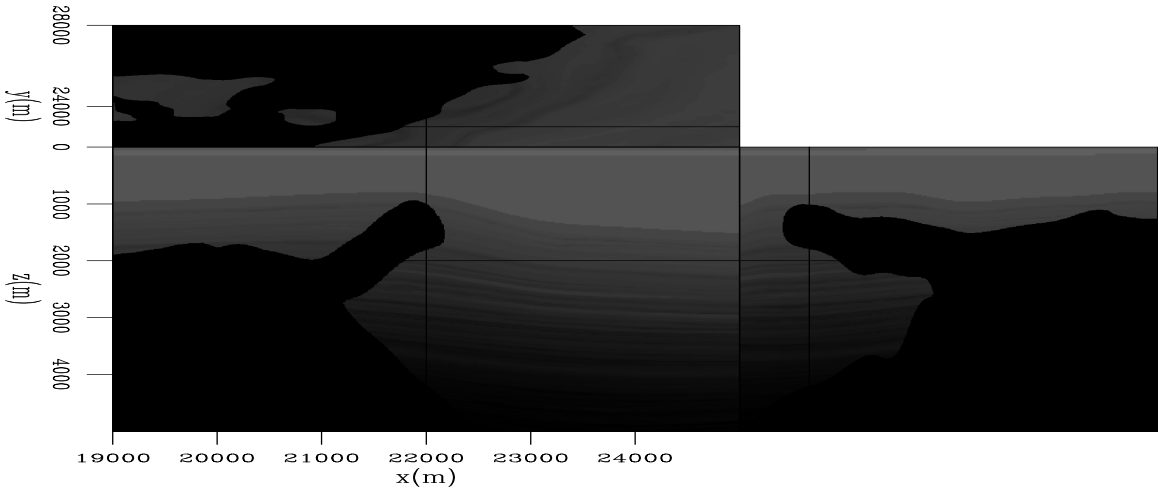

Figure 1: A cubeplot of the windowed section of the SEAM data. [**ER**]

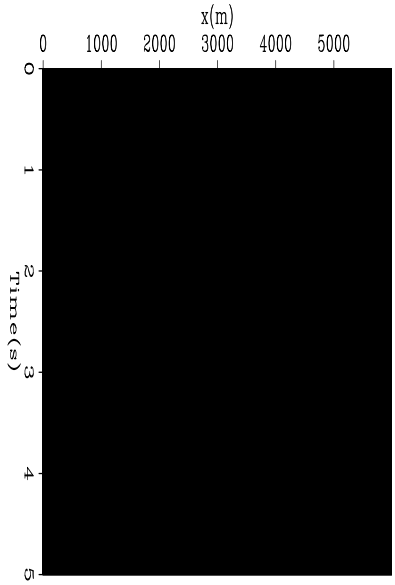

Figure 2: A subsurface shot at 1km depth. [**ER**]

sampled wavefields both continuous linear towed streamer and continuous coil shot streamer surveys will be modelled. These data can then be migrated (reverse time) and their images and 3D angle gathers analysed to see if better offset sampling per azimuth is observed, and if the survey type changes are noticeable in the final images.

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