TIME-LAPSE MODELING AND INVERSION OF CO2 SATURATION FOR SEQUESTRATION AND ENHANCED OIL RECOVERY

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ABSTRACT

In this quarter we have continued our development of the inversion procedure for Phase III, in which time-lapse changes in seismic attributes are inverted to yield changes in CO_2 fluid properties over time. In order to extract seismic attributes from the Sleipner North Sea CO_2 time-lapse data set, a new, detailed interpretation was performed and multiple horizons were picked for the 1994 and 2002 vintages. Traveltime difference maps were constructed at several levels within the Sleipner CO_2 injection zone, and were quantitatively analyzed. No traveltime change was seen in the overburden, as expected, while significant changes were seen in the upper half of the CO_2 injection zone. Evidence of thin-bed tuning and undershooting was also found. A new semi-automated, quantitative method for estimating time sag anomalies was developed, and was used to calculate the amount of time sag along a selected horizon. The resulting time sag estimates matched those seen in the traveltime difference maps. Such a method will be useful for obtaining rapid, accurate quantitative measurements of traveltime changes in the Sleipner data cubes. The traveltime changes will be combined with other attributes, such as amplitude and frequency changes, for input into the real-data inversion.

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I. EXECUTIVE SUMMARY

In this quarter we have continued our development of the inversion procedure for Phase III, in which time-lapse changes in seismic attributes are inverted to yield changes in CO_2 fluid properties over time. In the last quarter, traveltime difference maps from three horizons of the 1994 and 2002 Sleipner North Sea CO_2 data sets were shown. In this reporting period, a new, detailed interpretation was performed and multiple horizons were picked. Traveltime difference maps were constructed and quantitatively analyzed at several levels within the CO_2 injection zone. No traveltime change was seen in the overburden, as expected, while significant changes were seen in the upper half of the CO_2 injection zone. Evidence of thin-bed tuning and undershooting was also found. A new semi-automated, quantitative method for estimating time sag anomalies was developed, and was used to calculate the amount of time sag along a selected horizon. The resulting time sag estimates matched those seen in the traveltime difference maps. Such a method will be useful for obtaining rapid, accurate quantitative measurements of traveltime changes in the Sleipner data cubes. The traveltime changes will be combined with other attributes, such as amplitude and frequency changes, as input to the real-data inversion.

II. EXPERIMENTAL

No experimental methods were used during this reporting period.

III. RESULTS AND DISCUSSION

In this quarter we have continued our development of the inversion procedure for Phase III, in which time-lapse changes in seismic attributes are inverted to yield changes in CO_2 fluid properties over time. In order to extract seismic attributes from the Sleipner North Sea CO_2 time-lapse data set, a detailed interpretation was performed and multiple horizons were picked for the 1994 and 2002 vintages. One of the attributes that we will use in our inversion procedure is the time-lapse change in event arrival times from different vintages. Traveltime difference maps were constructed at several levels within the Sleipner CO_2 injection zone, and their characteristics were noted, as described in Appendix A. No traveltime change was seen in the overburden, as expected. Significant changes were seen in the upper half of the CO_2 injection zone due to the accumulation and spreading of CO_2 in the upper part of the reservoir. Evidence of thin-bed tuning and undershooting was also found.

A semi-automated technique was developed to calculate traveltime differences in a more detailed, robust manner than horizon picking and analysis. The technique works by quantifying the amount of traveltime change, or time sag, that occurs between pairs of traces from different vintages. As shown in Appendix A, the method is able to reproduce the time sags seen in the traveltime difference maps, but in a more detailed manner. Such a method will be useful for obtaining rapid quantitative measurements of traveltime change attributes in the Sleipner data cubes. The traveltime changes will be combined with other attributes, such as amplitude and frequency changes, as input to the real-data inversion

IV. CONCLUSIONS

In this reporting period, a new, detailed interpretation was performed and multiple horizons were picked. Traveltime difference maps were constructed and quantitatively analyzed at several levels within the CO_2 injection zone. No traveltime change was seen in the overburden, as expected, while significant changes were seen in the upper half of the CO_2 injection zone. Evidence of thin-bed tuning and undershooting was also found. A new semi-automated, quantitative method for estimating time sag anomalies was developed, and was used to calculate the amount of time sag along a selected horizon. The resulting time sag estimates matched those seen in the traveltime difference maps. Such a method will be useful for obtaining rapid, accurate quantitative measurements of traveltime changes in the Sleipner data cubes. The traveltime changes will be combined with other attributes, such as amplitude and frequency changes, for input into the real-data inversion. Further analysis of the Sleipner data set will continue in the next quarter will the goal of obtaining quantitative, volumetric estimates of time-lapse changes in these various attributes.