Geophysical characterization of the Devonian Nisku Formation for the Wabamun Area CO_2 Sequestration Project (WASP), Alberta, Canada

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SUMMARY

• Seismic characterization of the Nisku Formation has delineated two groups of anomalies:

1. The first is interpreted to be due to contrasts in lithology (porosity).
2. The second is interpreted to be footprints of geological discontinuities induced by dissolution in the overlying Wabamun Formation.

• The analysis has identified favourable low-impedance high-porosity locations that could be developed for a CO_2 injection site.

• These locations exhibit a good correlation with favourable sites derived from wireline data and core analysis through petrophysical analysis.

• Fluid replacement modelling suggests that changes in seismic response due to CO_2 injection will most likely be subtle but within the lower threshold of seismic detectability.

STUDY AREA AND GEOLOGY

• The proposed CO_2 sequestration area is located in the central plains of Alberta, approximately 50 km southwest of the capital Edmonton (FIG. 1).

• The injection target is the Devonian brine-bearing dolomitic Nisku Formation, which is a carbonate saline aquifer confined between two shale aquitards.

• The Nisku Formation average depth, thickness, temperature, pressure, porosity and permeability are 2000 m, 60 m, 50C°, 15 MPa, 9%, and 20 mD, respectively.

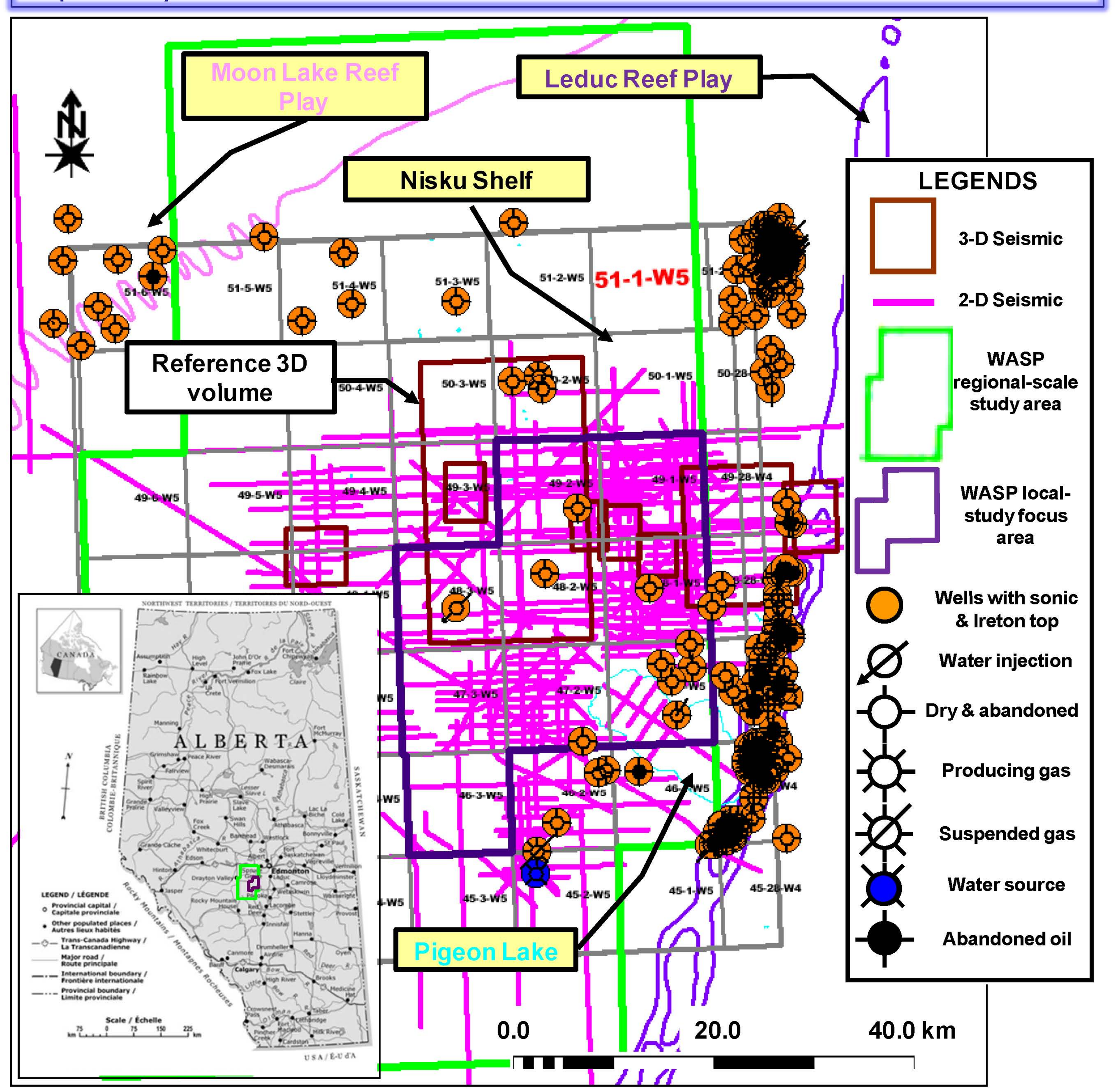

FIG. 1. Study area location and base map showing the distribution of the seismic and borehole data as well as the main geological and hydrocarbon trends in the area, namely Leduc Reef and Moon Lake Reef. Alberta map at the bottom-left corner is courtesy of Natural Resource Canada.

ACKNOWLEDGEMENTS

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RESULTS

I. Seismic Attributes:

• FIG. 2 shows some of the seismic attributes. Of particular interest, are the low-amplitude, low-impedance zones identified in FIG. 2 (b) and (c).

II. Numerical Modelling:

• The convolution modelling results in FIG. 3 indicate that lithology rather than tuning effect is the main force responsible for observed low-amplitude, low-impedance anomalies in FIG. 2; beside discontinuities footprints.

III. Petrophysics:

• FIG. 4 shows a good correlation between the porosity derived from seismic inversion and that constructed from wireline data using sonic and resistivity logs (Eisinger and Jensen, 2009).

• The permeability map (FIG. 4 (c)) derived from core analysis is indicative of flow capacity and it, also, shows a good agreement with seismic attributes.

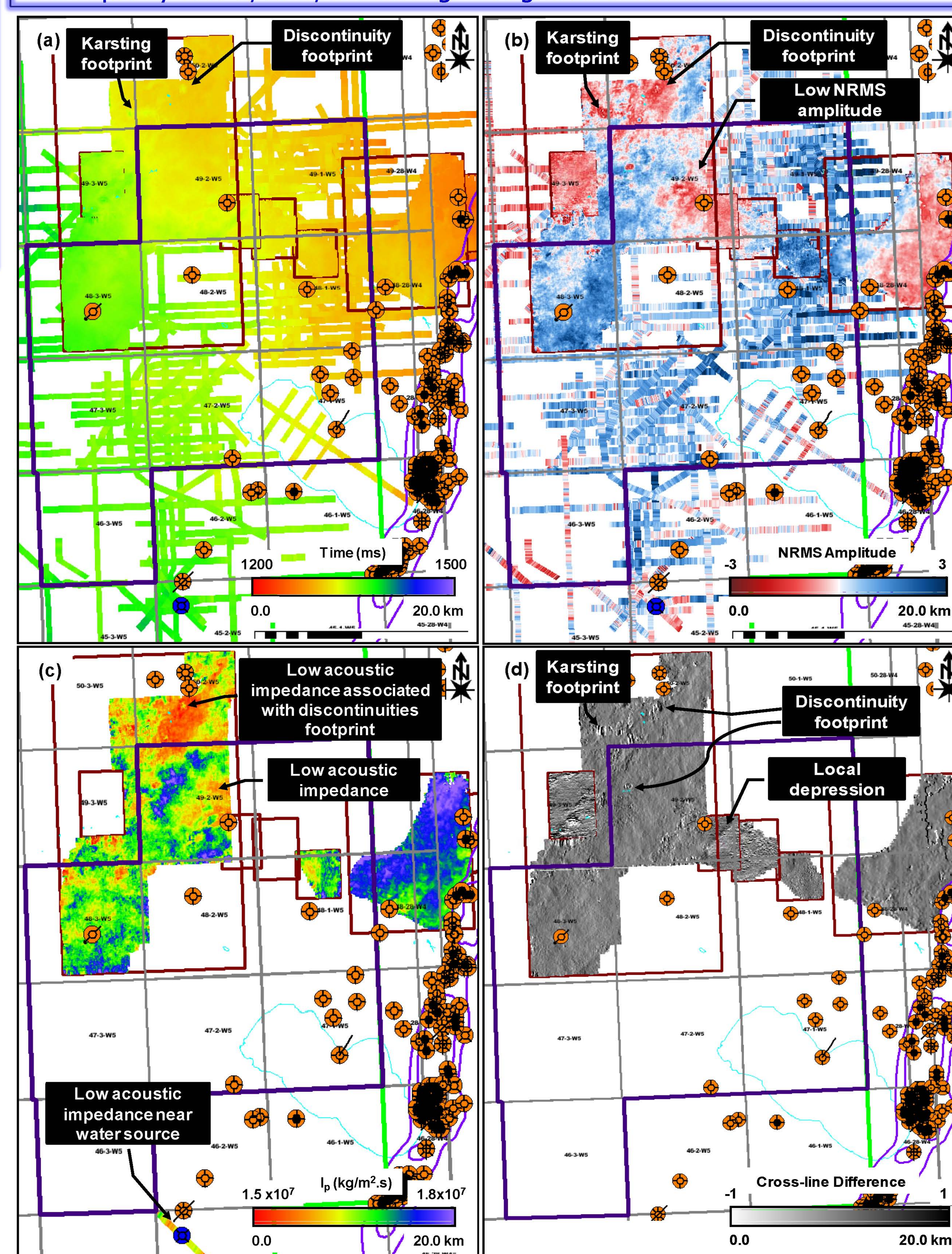

FIG. 2. Mosaic display of various seismic attributes with some of the major features identified: (a) time structure, (b) NRMS amplitude, (c) acoustic impedance and (d) coherency maps. Note that footprints do not necessary reflect physical discontinuities within the Nisku Formation.

REFERENCES

Eisinger, C. and Jensen, J., 2009, Data Integration, Petrophysics, and Geomodeling for Wabamun Area CO_2 Sequestration Project, University of Calgary, Institute for Sustainable Energy, Environment and Economy (ISEEE): Energy and Environmental Systems Group.

IV. Rock Physics and Fluid Replacement Modelling:

• The FRM results (FIG. 5) predict subtle time shift and amplitude change that is possibly within the lower threshold of seismic detectability.

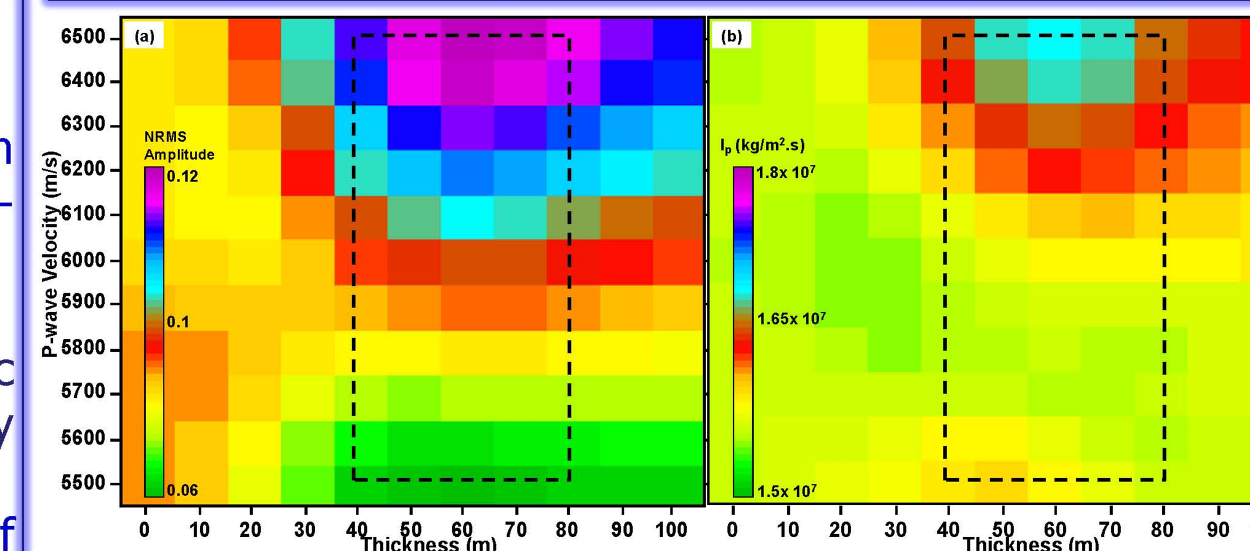

FIG. 3. Nisku event (a) NRMS amplitude and (b) acoustic impedance as function of P-wave velocity and formation thickness. The seismic response is more influenced by variation in P-wave velocity (lithology) rather than thickness. Dashed rectangle outlines likely aquifer velocity and thickness.

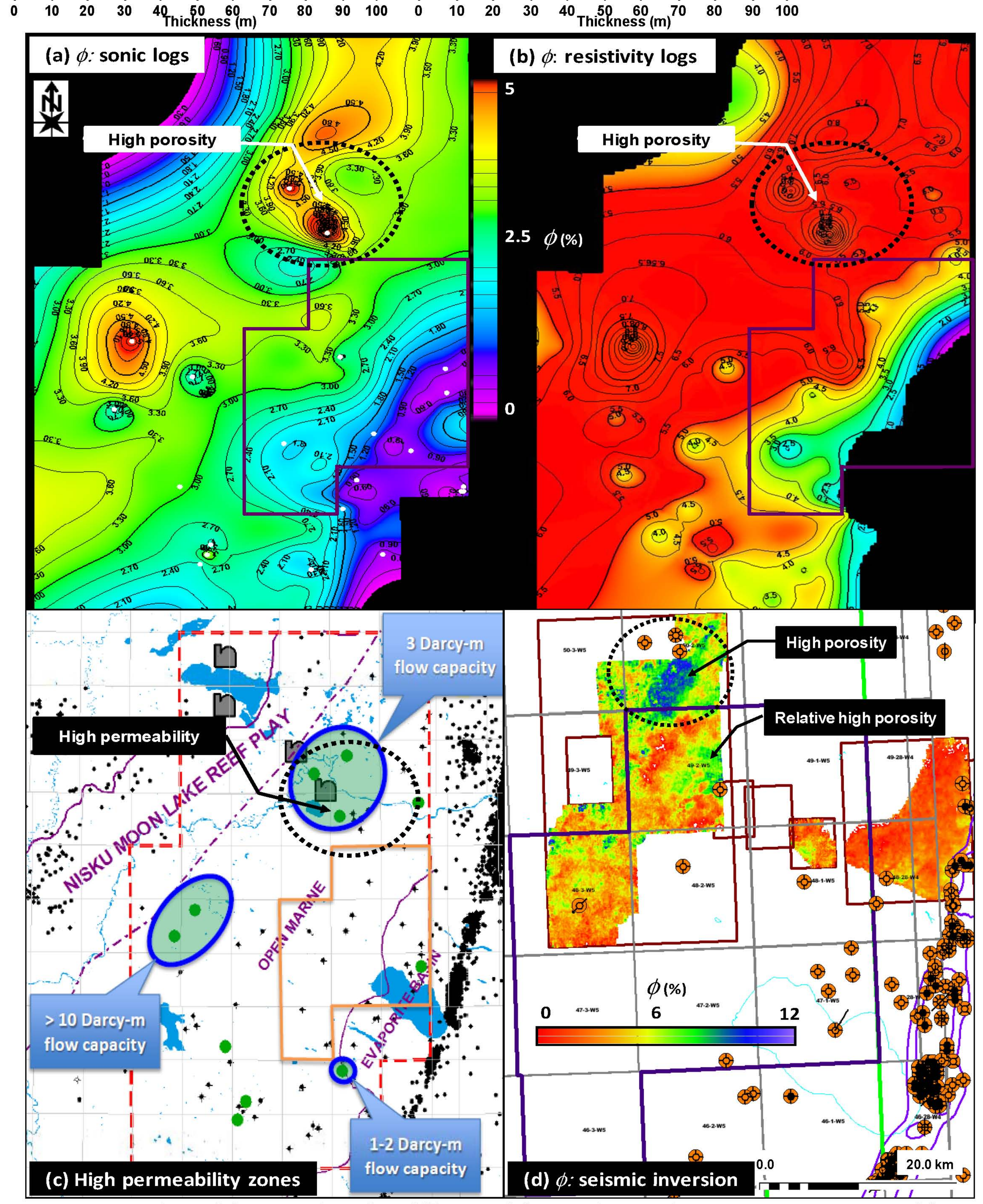

FIG. 4. Porosity map derived from wireline data [3] using (a) sonic logs and time-average equation, (b) resistivity logs and Archie's law; (c) permeability map derived from core analysis; (d) porosity map derived from seismic inversion.

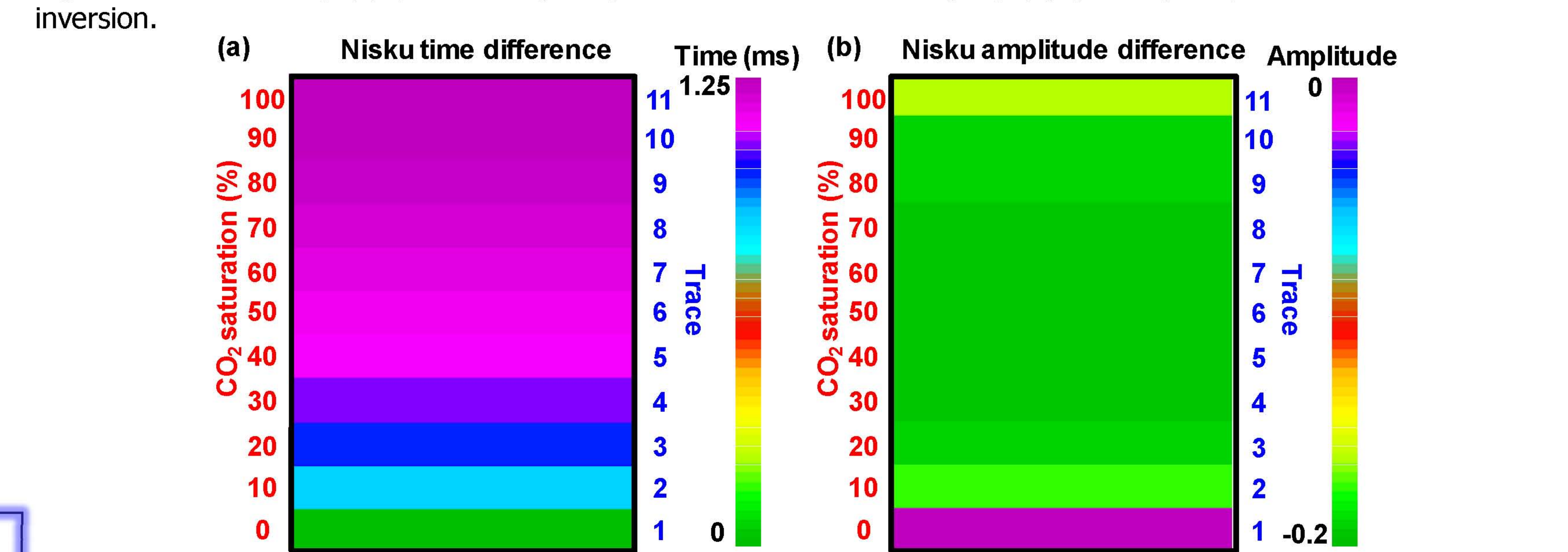

FIG. 5. FRM results showing (a) time shift and (b) amplitude change of the Nisku event between the base and monitor seismic surveys (difference = monitor - base). The highest incremental change associated with the initial increase in CO2 saturation (i.e. from 0 to 20%).