Discrimination between pressure and fluid saturation using direct non-linear inversion method: *an application to time-lapse seismic data*

Haiyan Zhang, Arthur B. Weglein, Robert Keys, Douglas Foster and Simon Shaw

M-OSRP Annual Meeting
University of Houston
May 10 –12, 2006

Statement of the problem

- **Distinguishing pressure changes from reservoir fluid changes is difficult with conventional seismic time-lapse attributes.**
- **Pressure changes or fluid changes?**
  - **shear modulus *sensitive to* pressure changes**
  - **Vp/Vs *sensitive to* fluid changes**
- **A direct non-linear inversion method may be useful for accomplishing this goal.**

Introduction of the method

Inverse scattering series	Time-lapse seismic monitoring
Reference medium L_0	Initial reservoir condition
Actual medium L	Current reservoir condition
Earth property changes in space $V=L_0-L$	Reservoir property changes in time
Reference wave field G_0	Baseline survey
Actual wave field G	Monitor survey
Scattered wave field $D=G-G_0$	Monitor-Baseline

Outline

- Comparing the first and second order algorithms in estimating shear modulus and Vp/Vs contrasts.
  - Core data tests (A. R. Gregory, 1976)
  - Heidrun well log data tests
- Conclusions and Plan
- Acknowledgements

Core data tests

Fixing the fluid as 100% water saturation, while the pressure changes from 1000 to 9000psi.

- **–Baseline: pressure = 5000psi**
- **–Monitor: other different pressures**

Fixing the pressure at 5000psi, while the fluid changes from 0 to 100 percent.

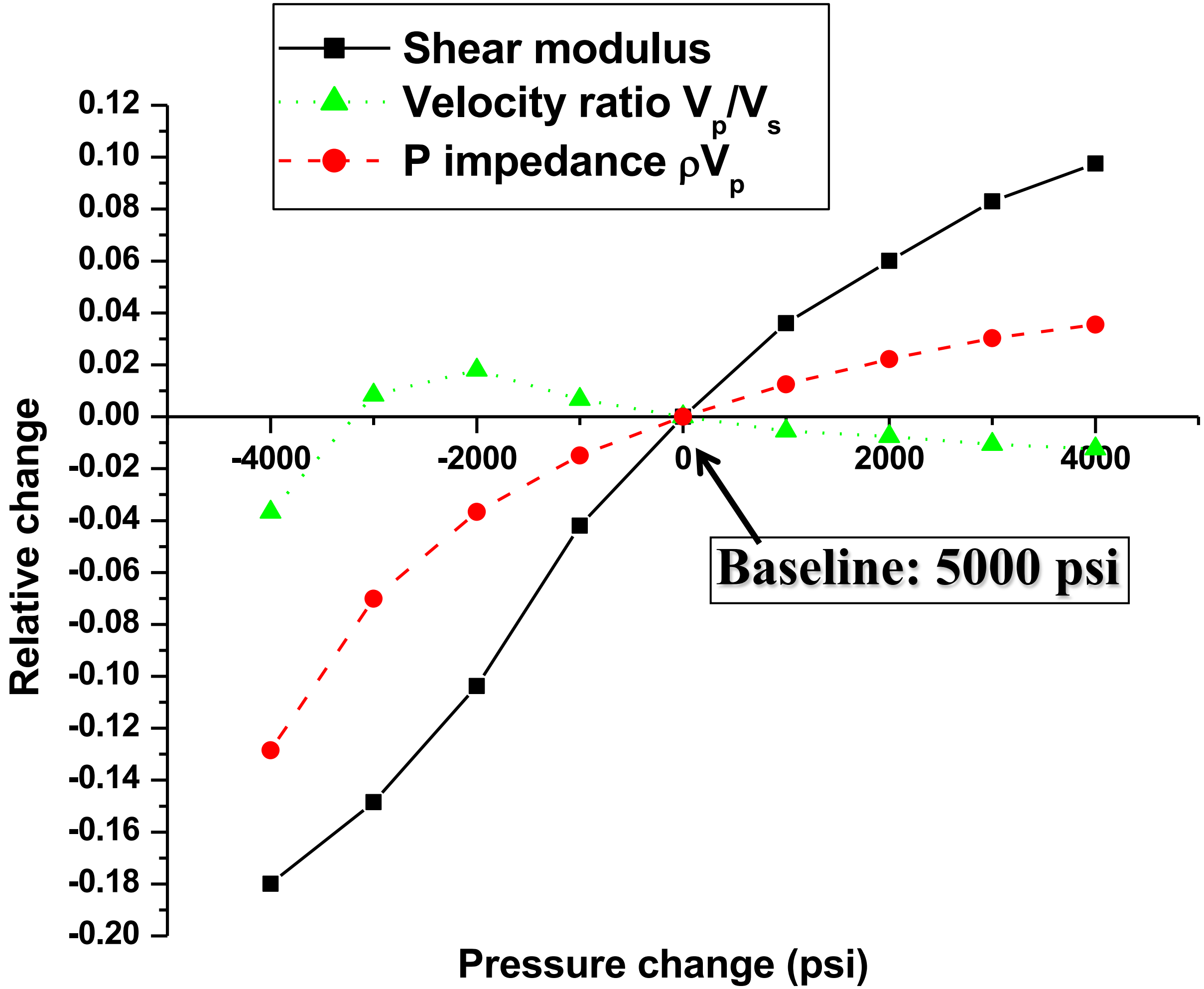
- **Baseline: 100% saturation**
- **Monitor: other different water saturations**

Core data tests

- **Compare effects of pressure and fluid changes on the elastic properties.**
- **Compare first order and second order approximations.**

Effects of pressure changes on the elastic properties

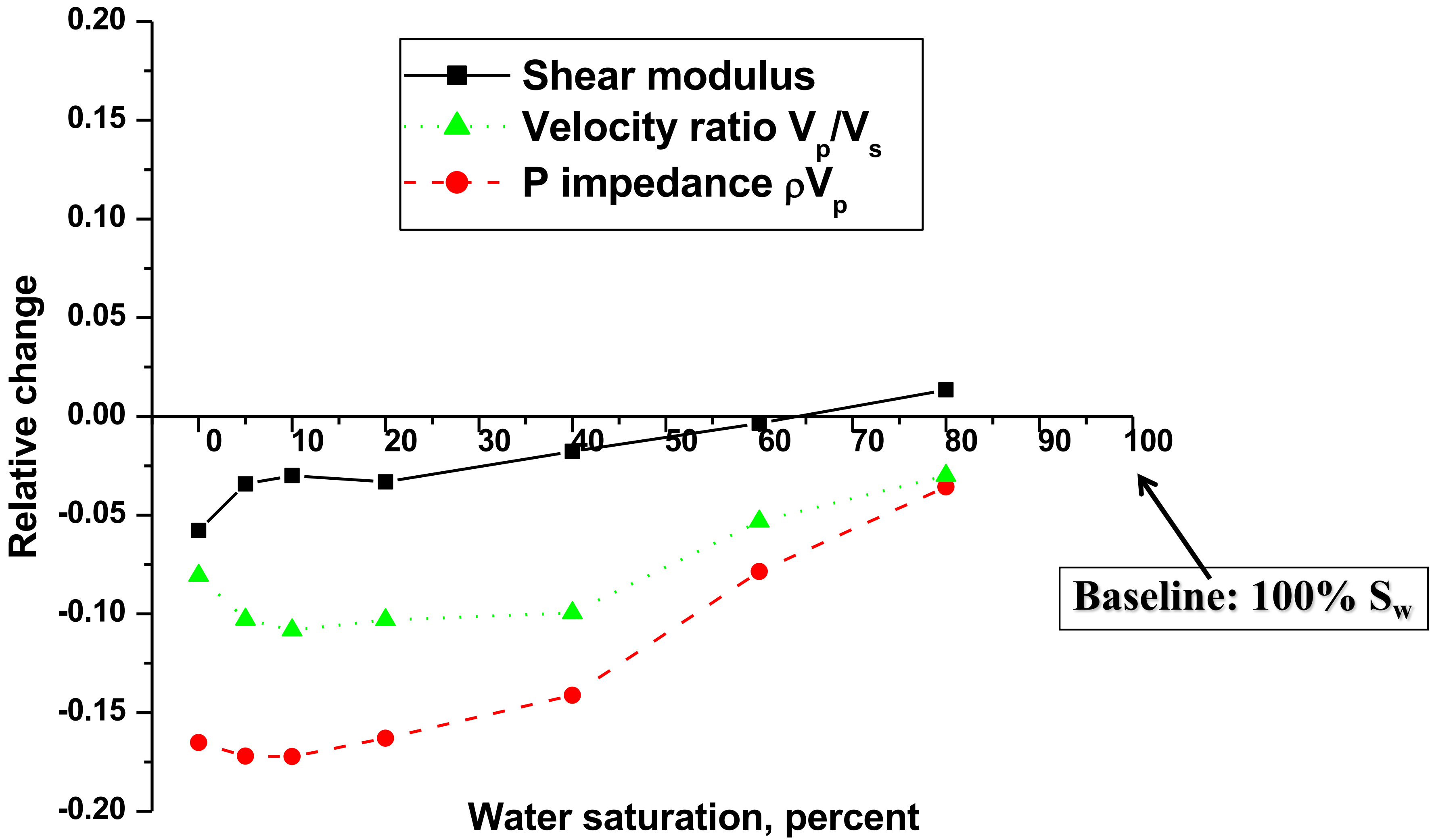
Fluid fixed (100% water saturation) **A. R. Gregory 1976**



Decrease in confining pressure ← **Increase in confining pressure** →

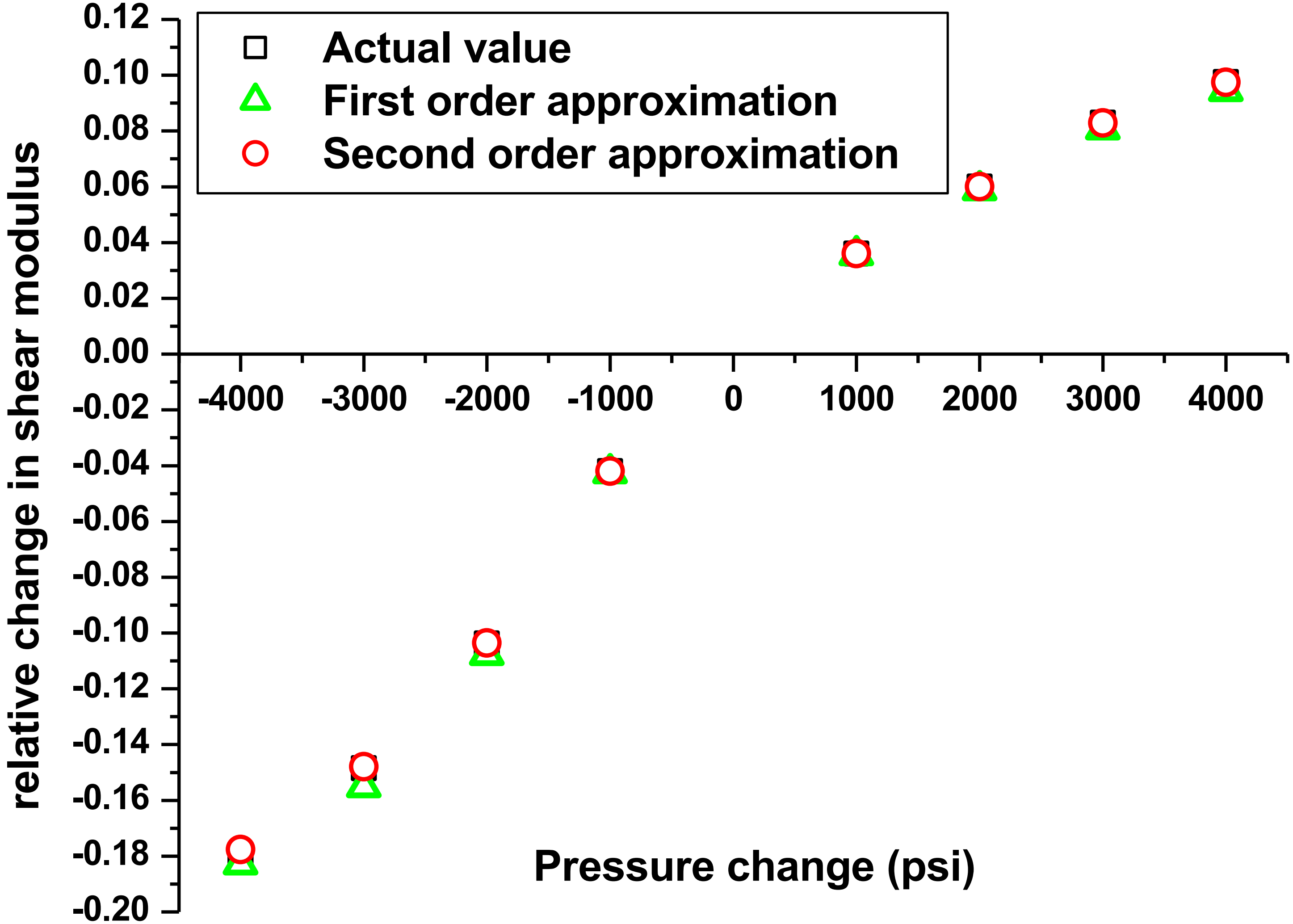
Effects of fluid changes on the elastic properties

Pressure fixed (5000 psi) **A. R. Gregory 1976**



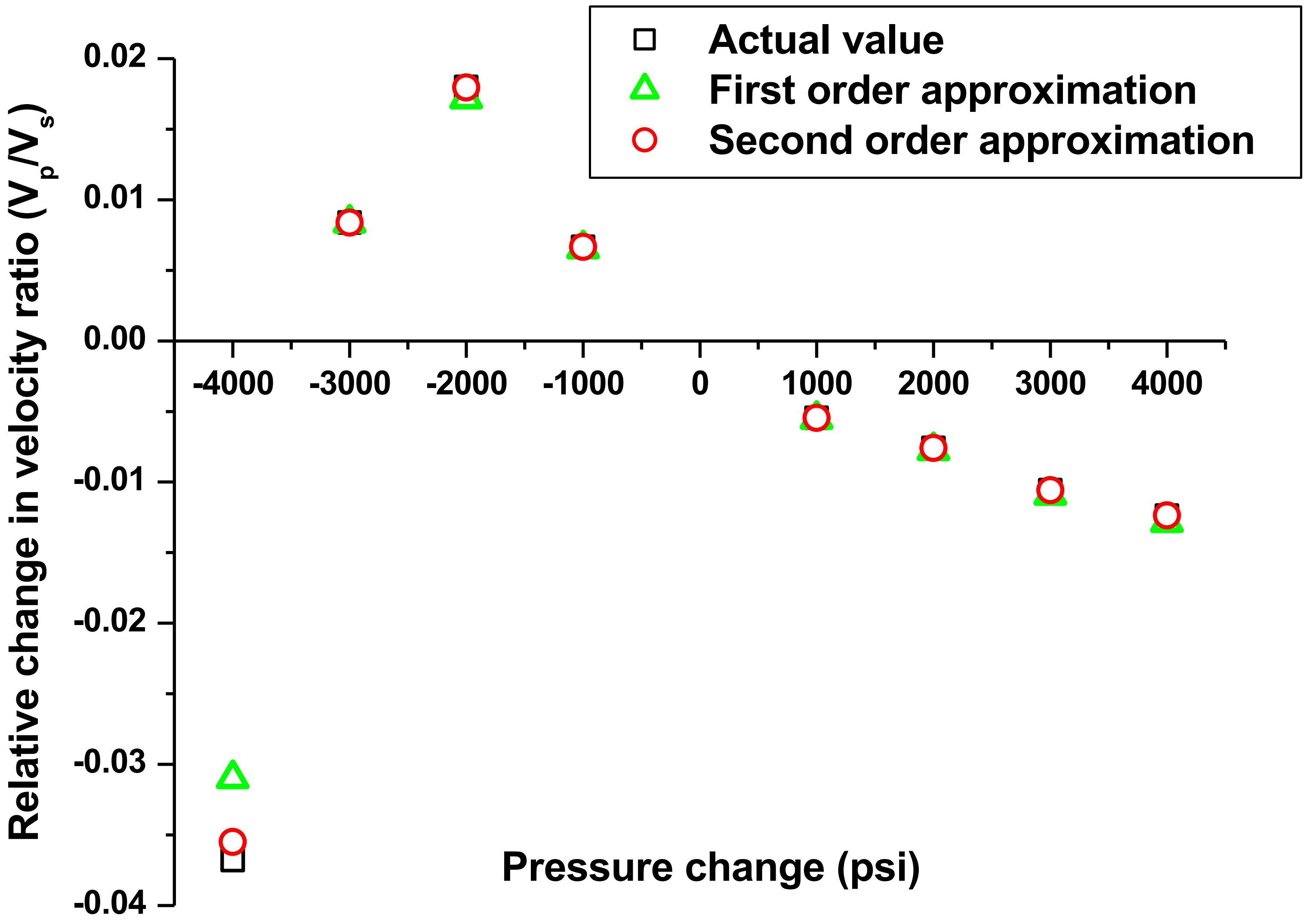
Comparison of 1st and 2nd order approximation for pressure changes

Fluid fixed (100% water saturation) **A. R. Gregory 1976**



Comparison of 1st and 2nd order approximation for pressure changes

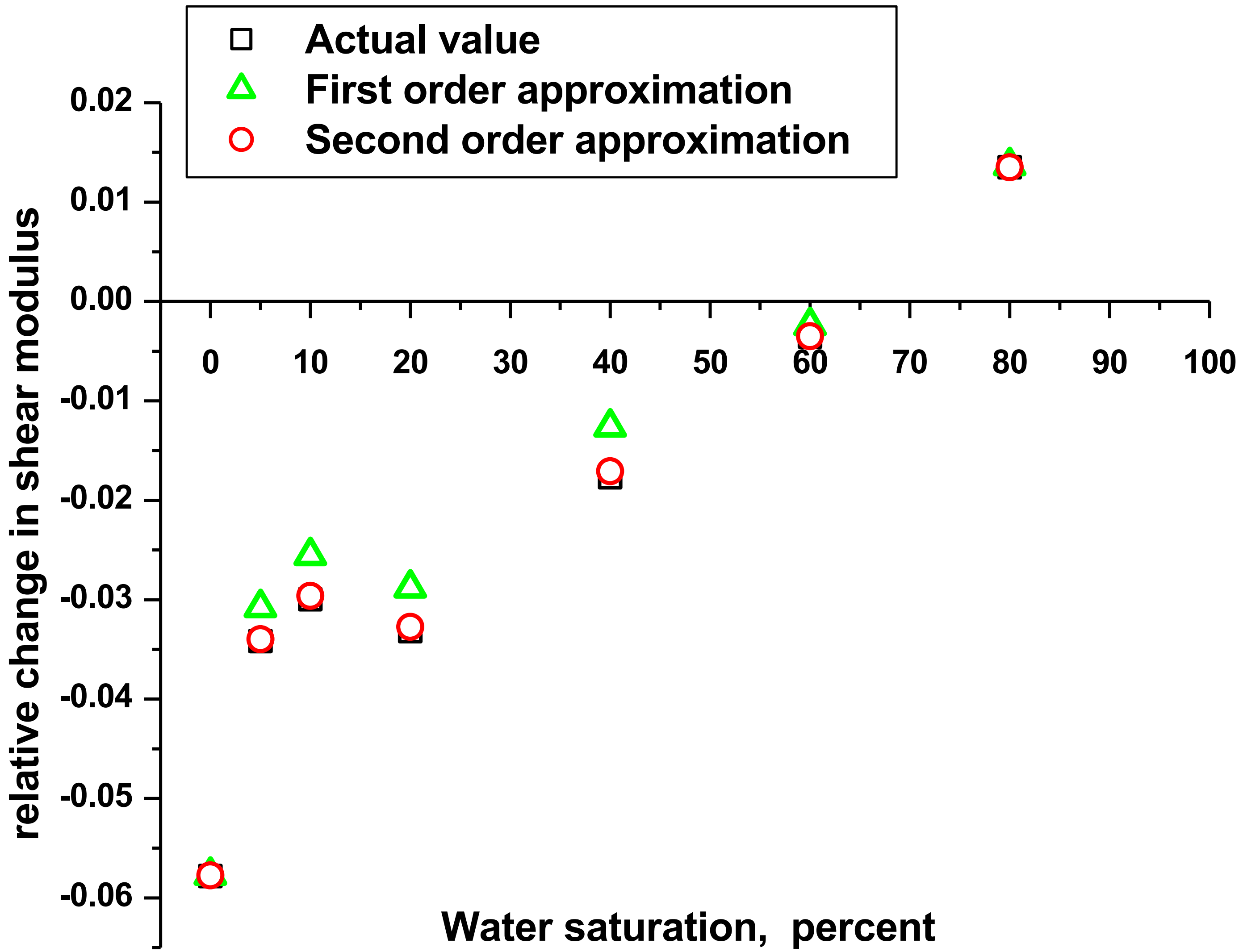
Fluid fixed (100% water saturation) **A. R. Gregory 1976**



Comparison of 1st and 2nd order approximation for fluid changes

Pressure fixed (5000 psi)

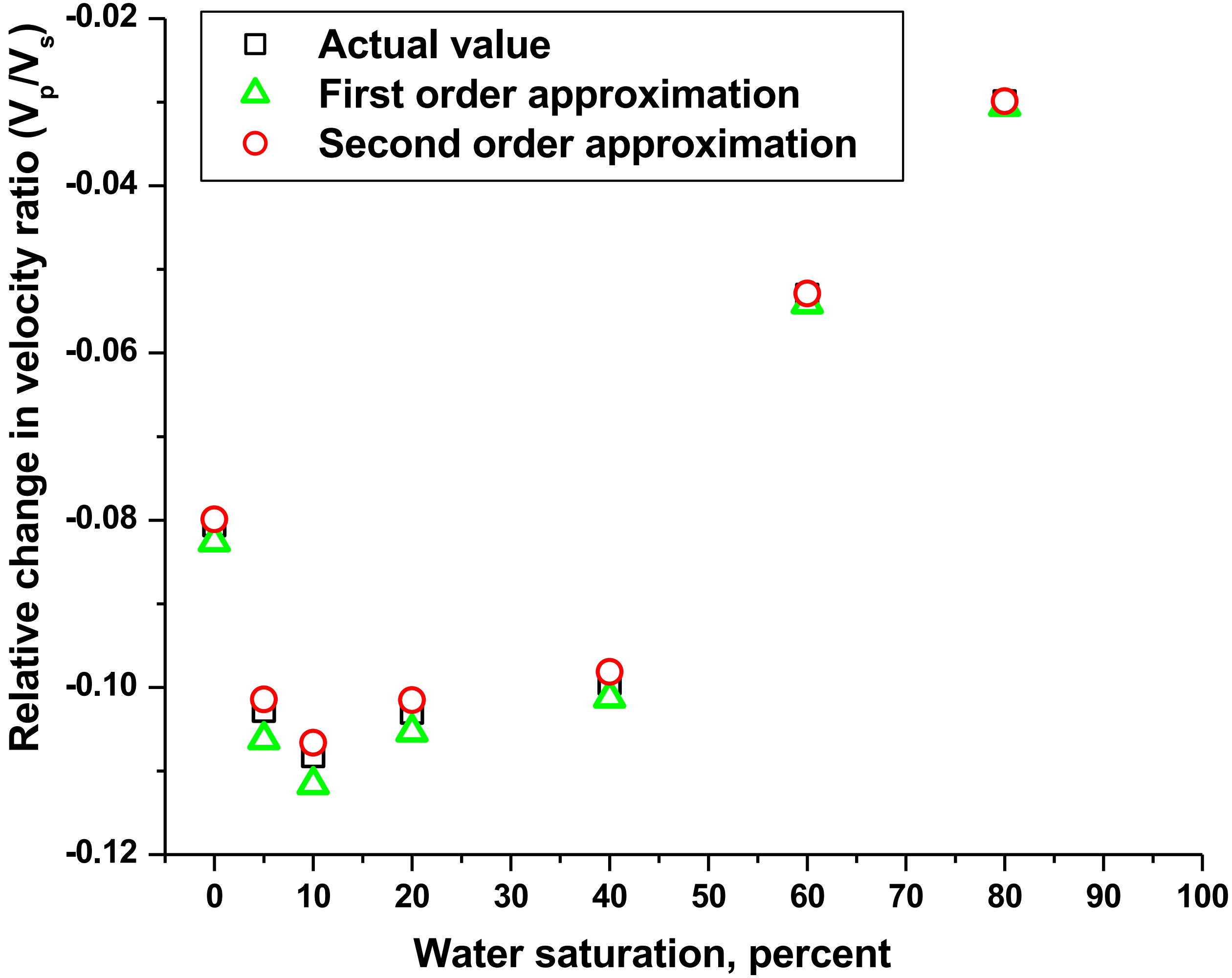
A. R. Gregory 1976



Comparison of 1st and 2nd order approximation for fluid changes

Pressure fixed (5000 psi)

A. R. Gregory 1976

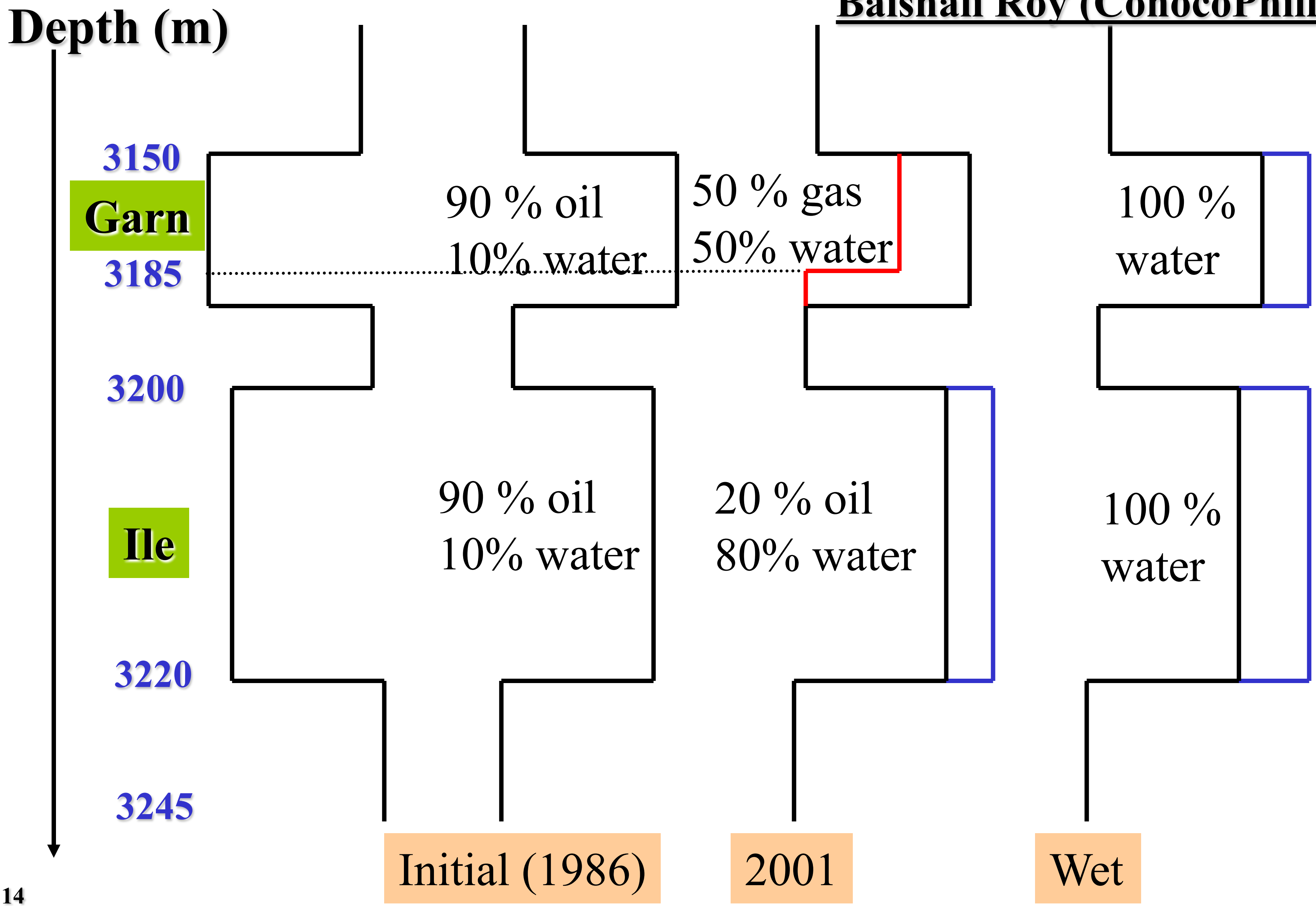


Outline

- Comparing the first and second order algorithms in estimating shear modulus and Vp/Vs contrasts.
  - Core data tests (A. R. Gregory, 1976)
  - Heidrun well log data tests
- Conclusions and Plan
- Acknowledgements

Synthetic Modeling -- A-52

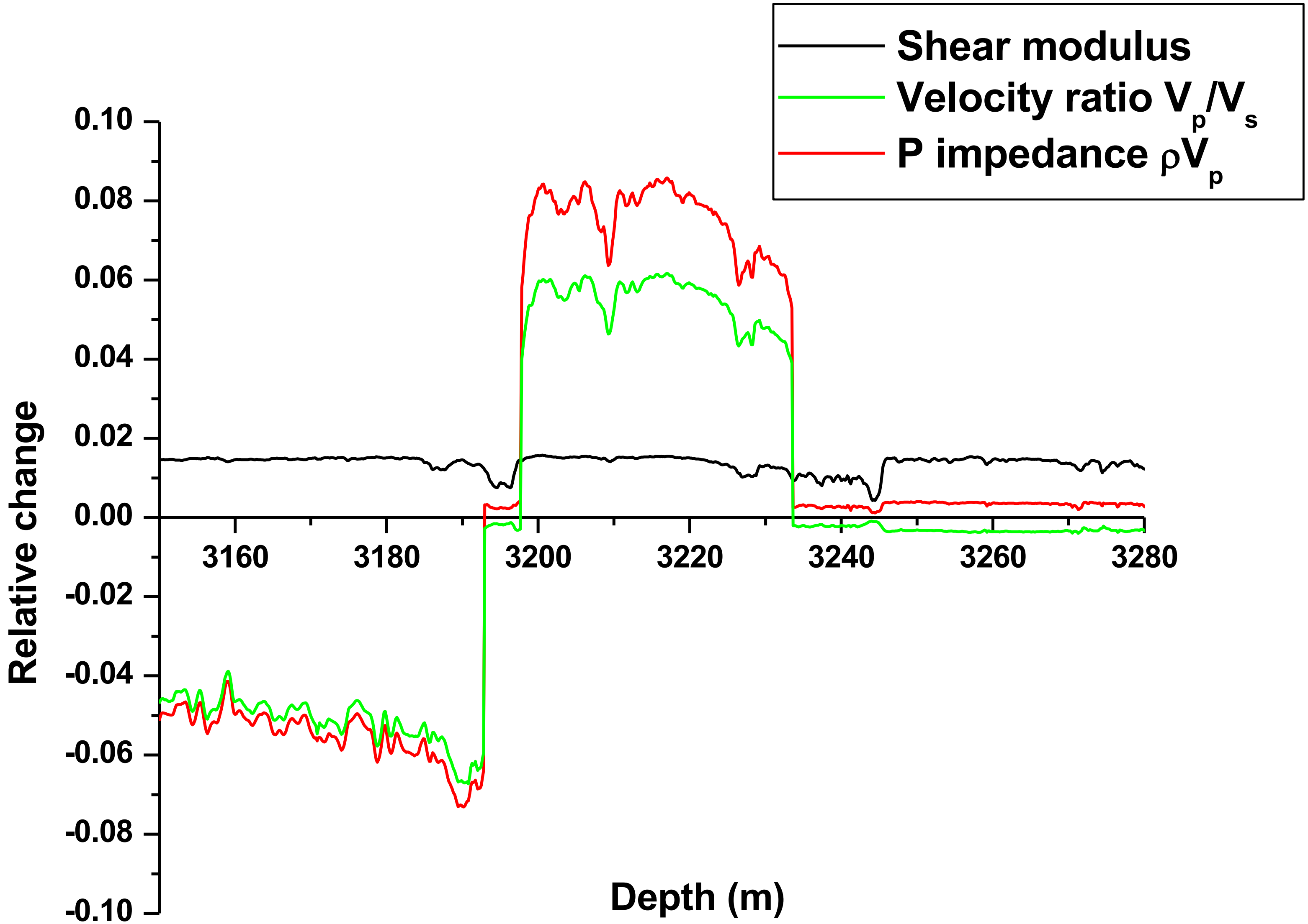
Baishali Roy (ConocoPhillips)



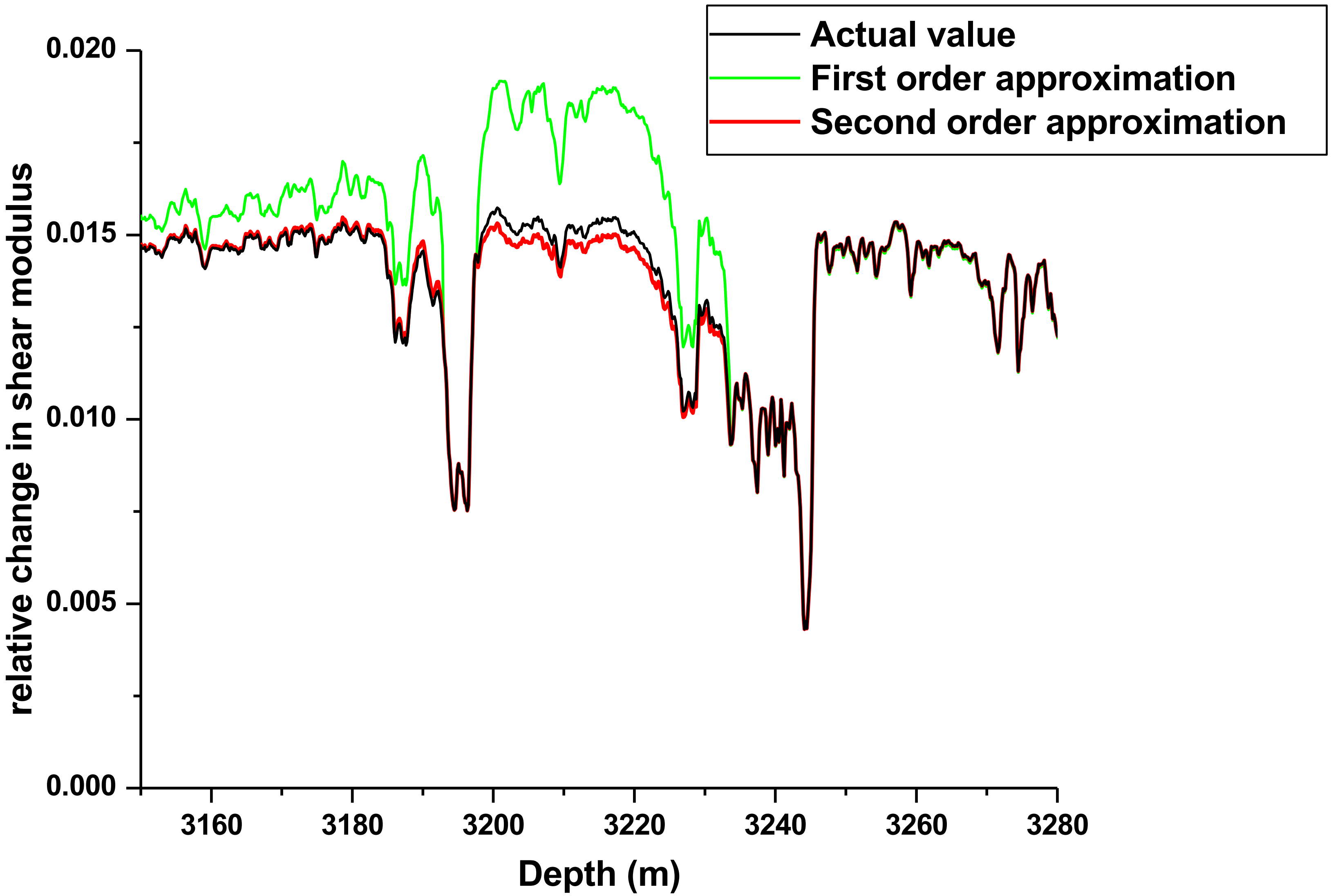
Heidrun well log data tests

- Compare effects of pressure and fluid changes on the elastic properties.
- Compare first order and second order approximations.

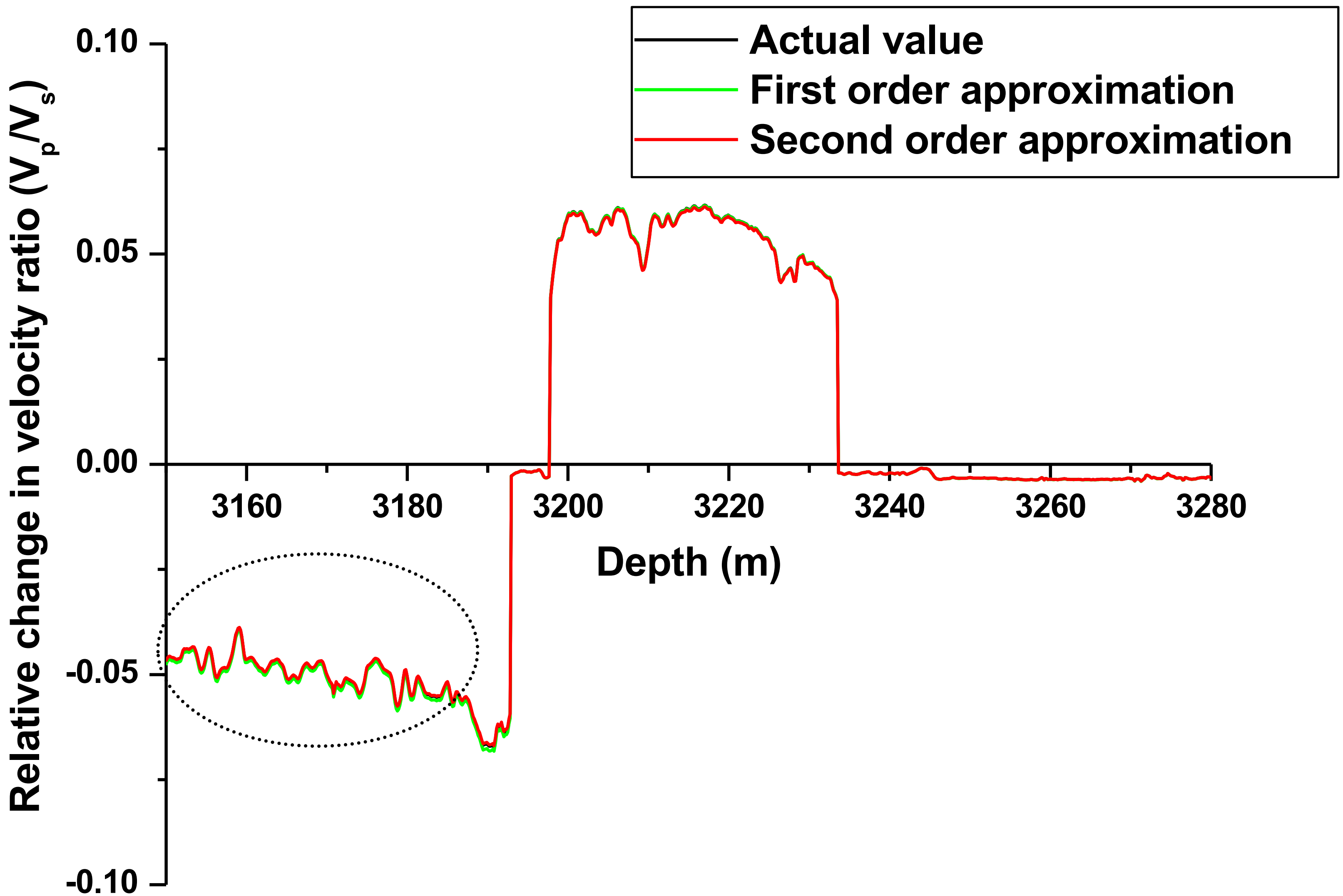
Heidrun well log data tests



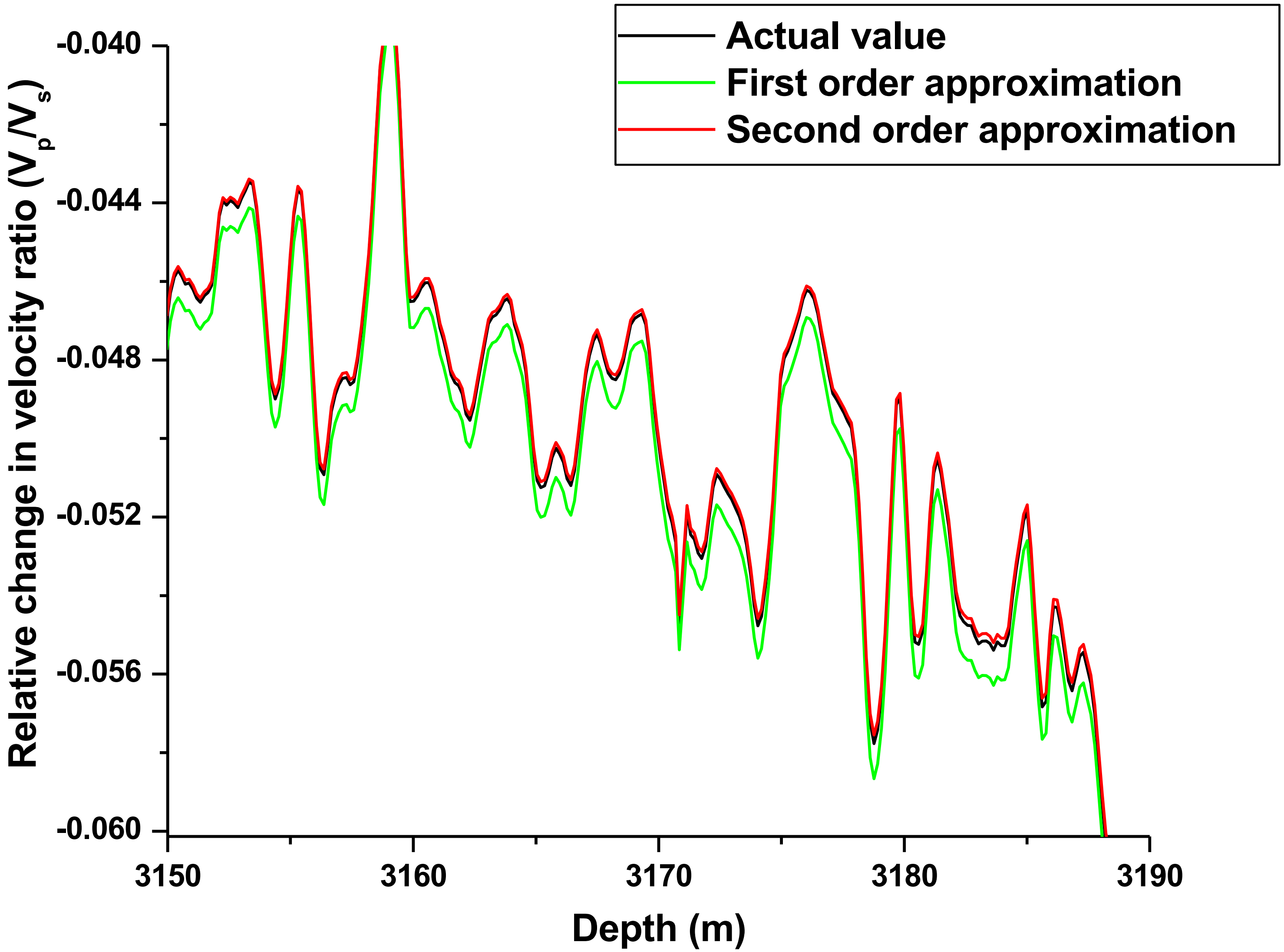
Heidrun well log data tests



Heidrun well log data tests



Heidrun well log data tests



Observations

- The second order approximation provides improvements in the earth property predictions.

- In this well log data case, the second order approximation is more helpful for predicting shear modulus compared to Vp/Vs.

Plan

- **Comparing the first and second order algorithms in estimating shear modulus and Vp/Vs contrasts.**
  - **Heidrun synthetic data**
  - **Real seismic data tests (Heidrun)**

Acknowledgements

- Baishali Roy (ConocoPhillips)
- Thanks to ConocoPhillips for providing the opportunity.

- The M-OSRP sponsors are thanked for supporting this research.