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

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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.

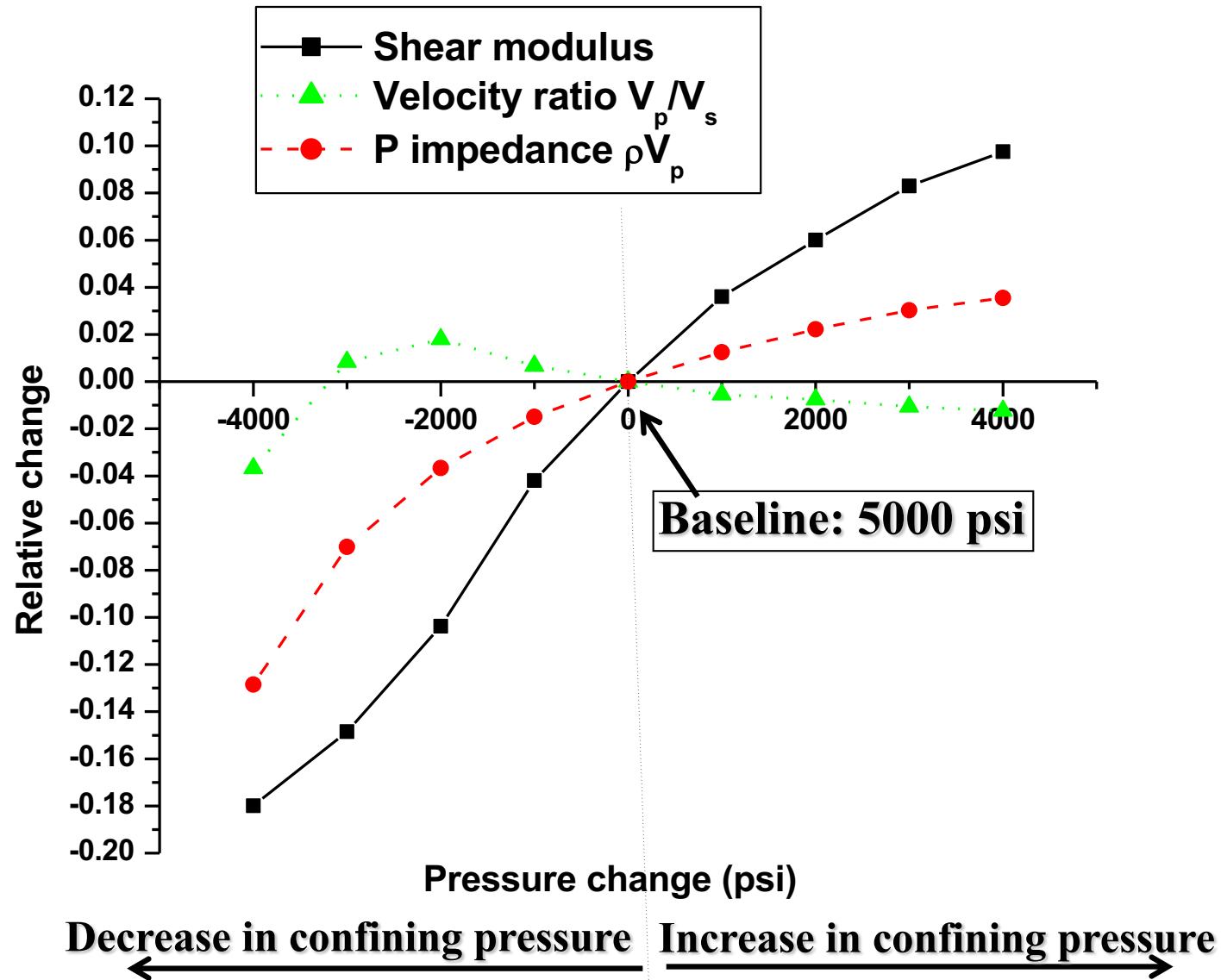- Baseline: 100% saturation
- Monitor: other different water saturations

Core data tests

- **Compare effects of pressure and fluid changes on the elastic properties.**

- **Compare first order and second order approximations.**

Effects of <u>pressure</u> changes on the elastic properties
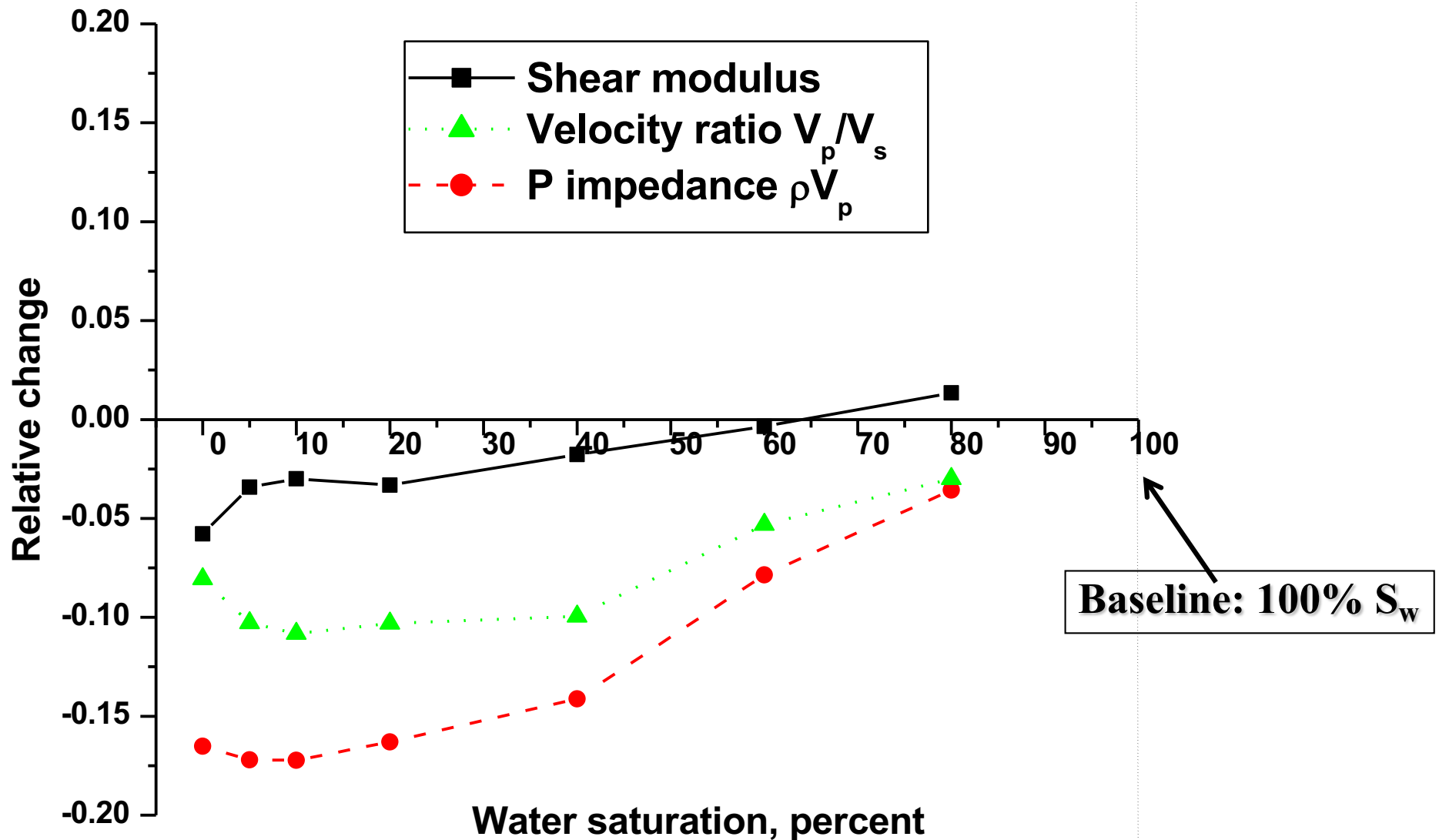
Fluid fixed (100% water saturation)

A. R. Gregory 1976

Effects of fluid changes on the elastic properties

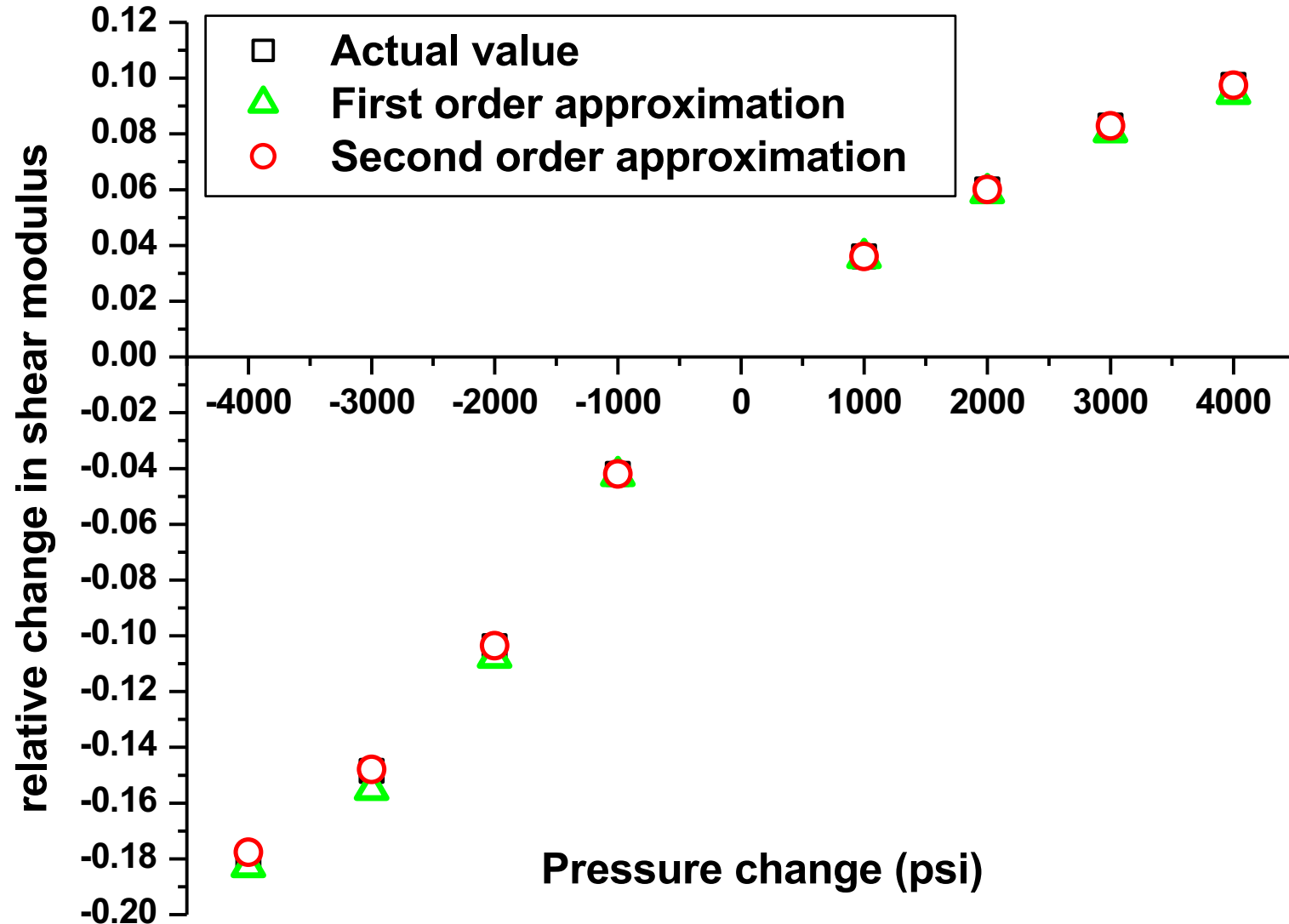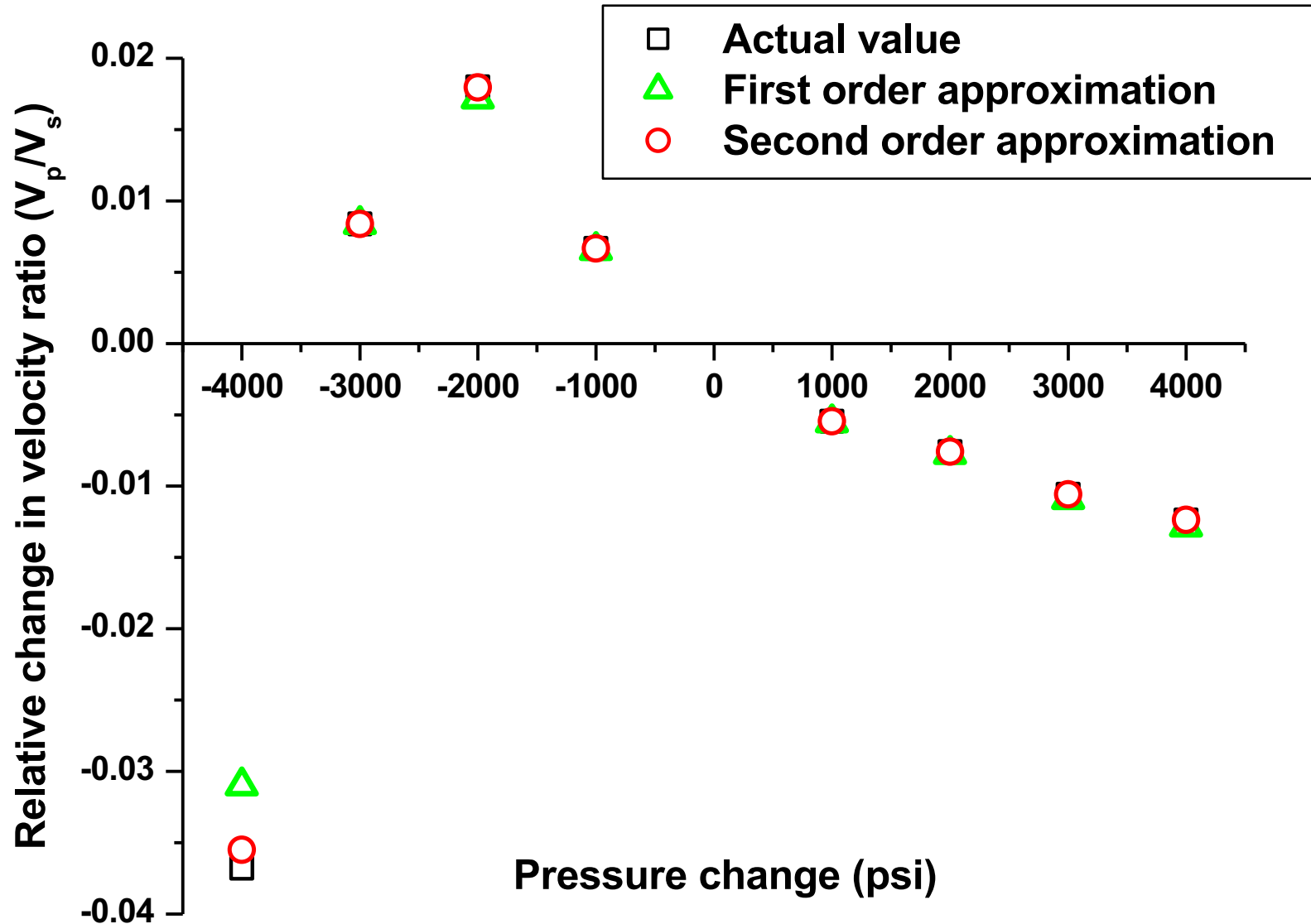**Pressure fixed (5000 psi)**   **A. R. Gregory 1976**

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

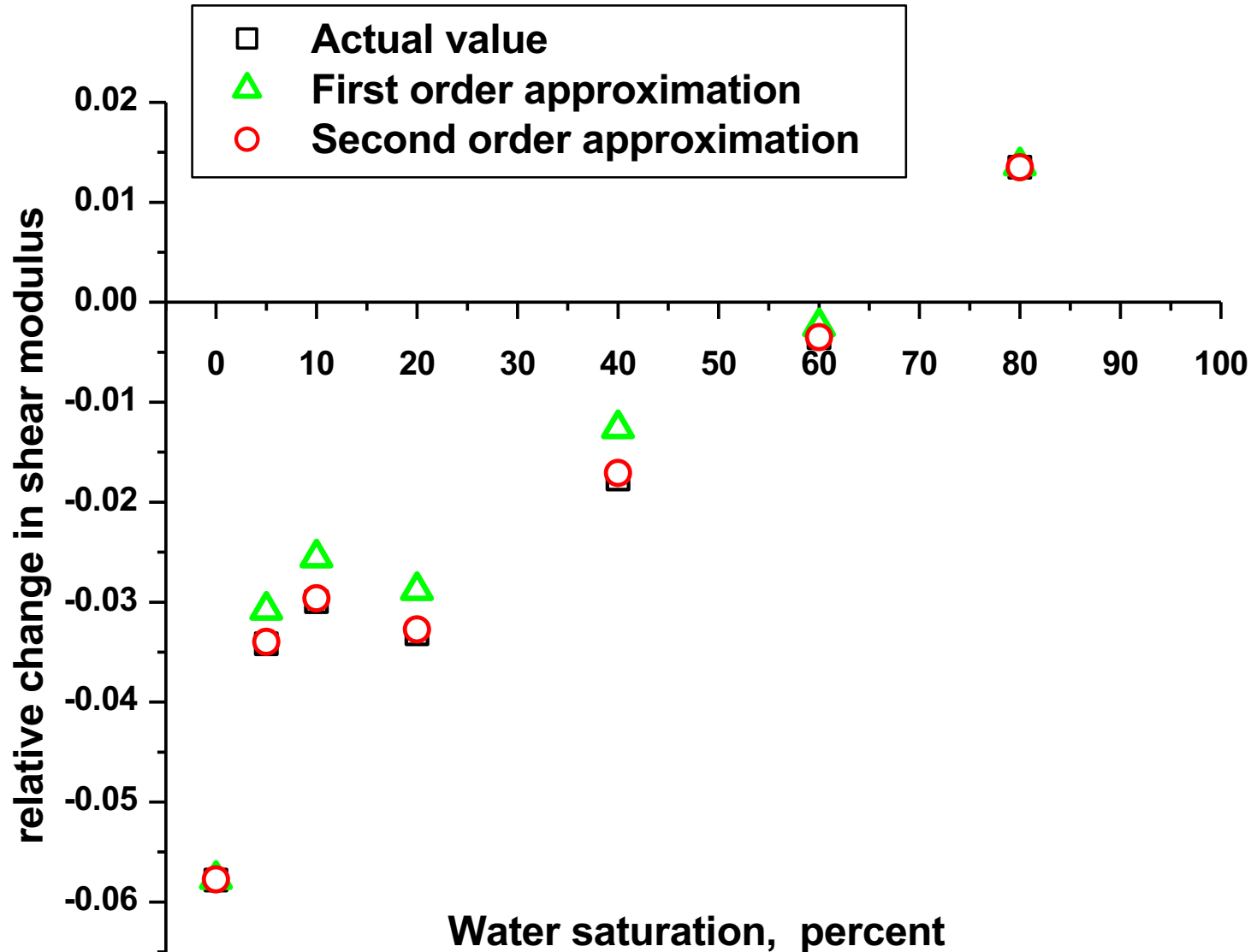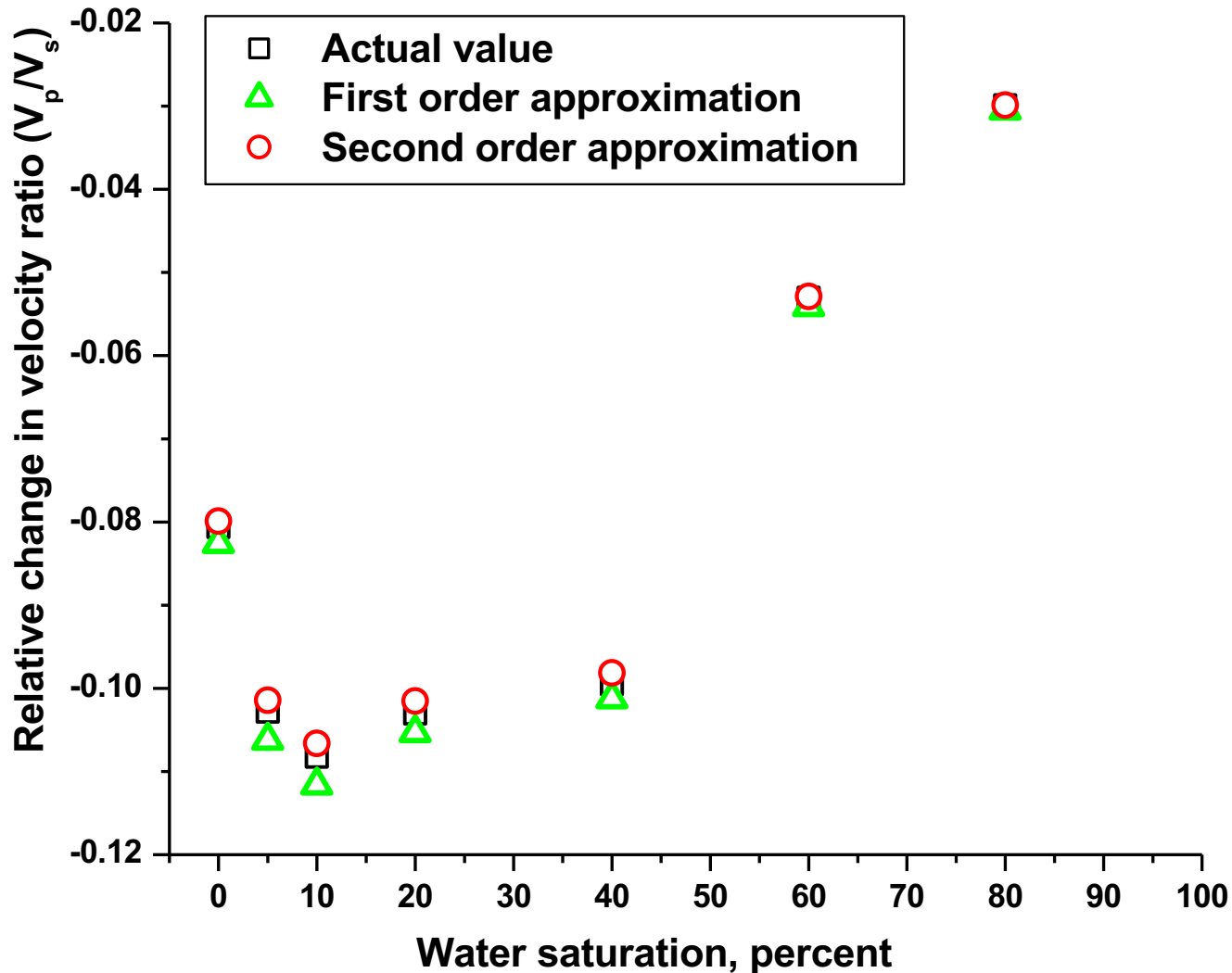**Pressure fixed (5000 psi)**   **A. R. Gregory 1976**

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Comparison of 1st and 2nd order approximation for <u>fluid</u> changes

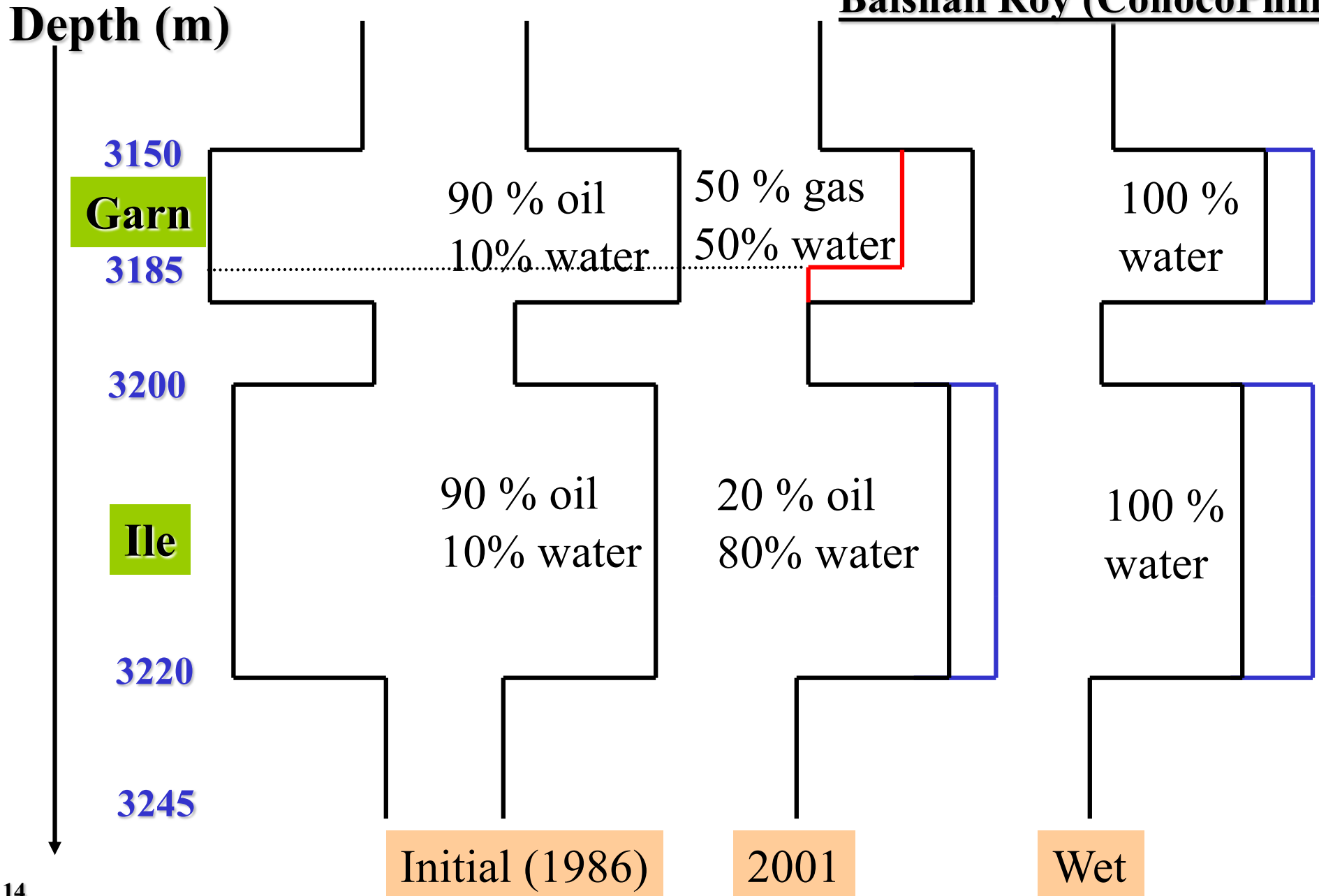**Pressure fixed (5000 psi)**   **A. R. Gregory 1976**

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**
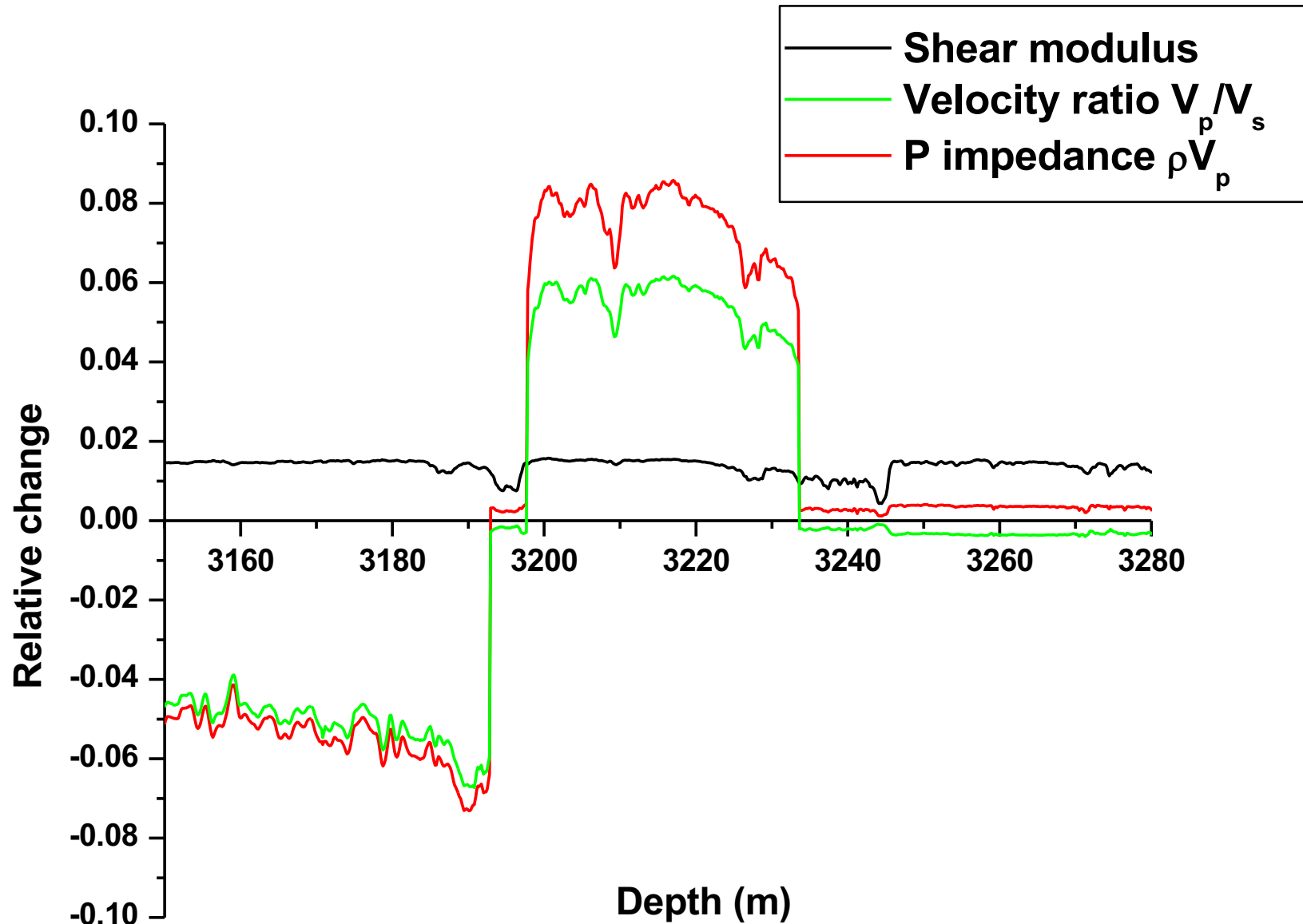
Synthetic Modeling -- A-52

Baishali Roy (ConocoPhillips)

Depth (m)

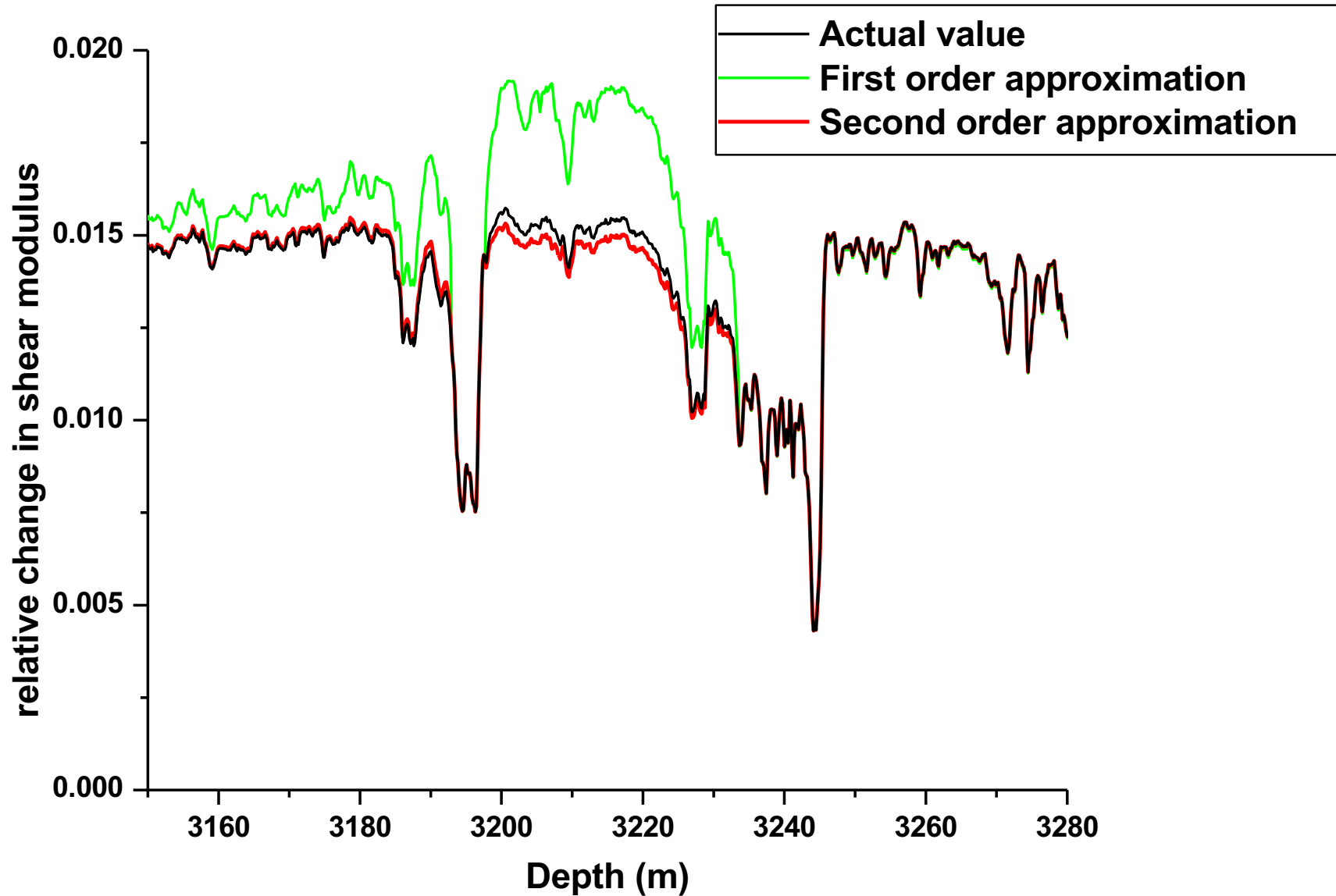| Depth		Initial (1986)	2001	Wet
3150				
Garn		90 % oil	50 % gas	100 %
3185		10% water	50% water	water
3200				
Ile		90 % oil	20 % oil	100 %
		10% water	80% water	water
3220				
3245				

Initial (1986)   2001   Wet

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Heidrun well log data tests

- Compare effects of pressure and fluid changes on the elastic properties.

- Compare first order and second order approximations.

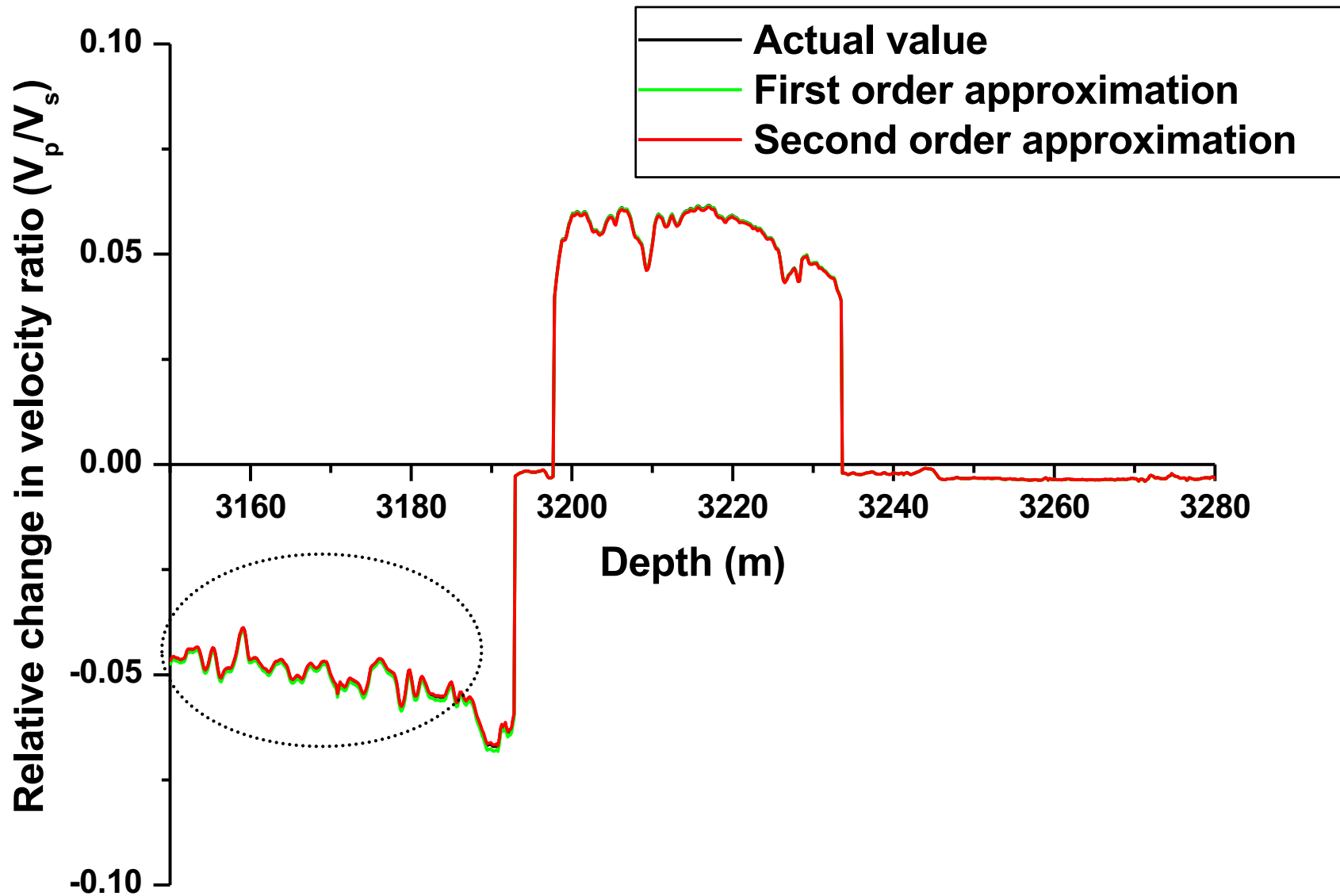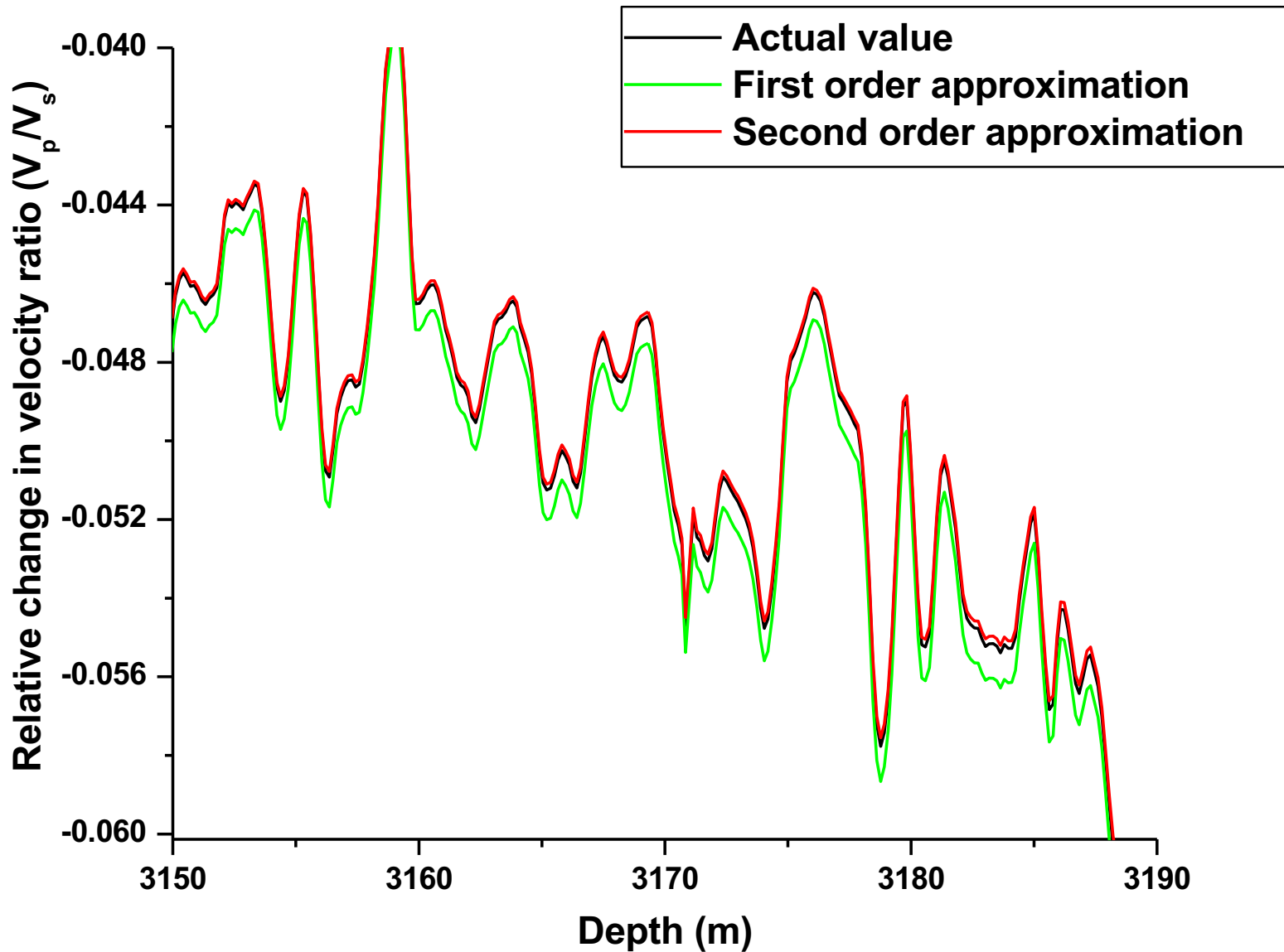# Heidrun well log data tests

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

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