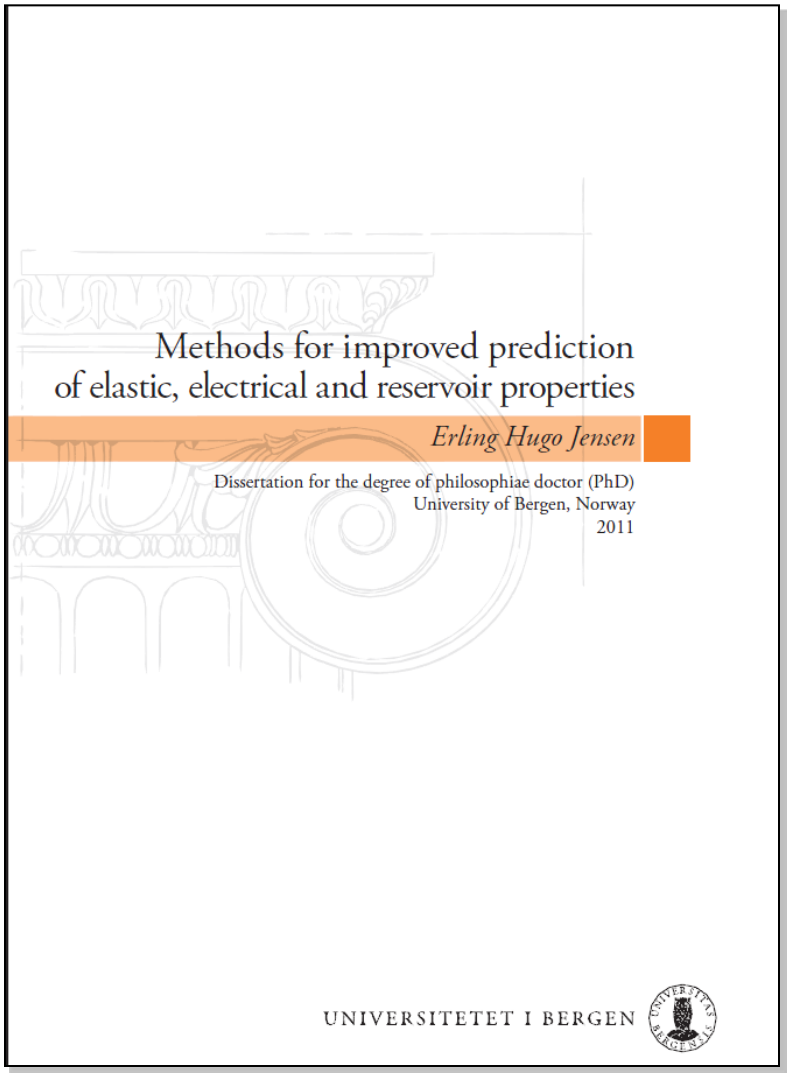
My PhD Memoirs

PhD “kick off” seminar at UiB,
December 6, 2011
by Erling Hugo Jensen

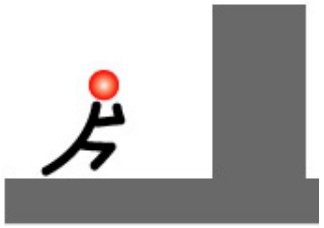
UNIVERSITY OF BERGEN

- Dr. Erling Hugo Jensen
- Doctor in petroleum geophysics at Department of Earth Science
- Successful defence October 24, 2011.
- Receive official diploma January 27, 2012.



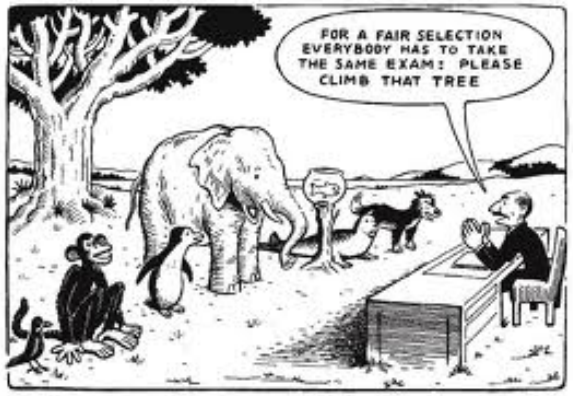
Outline

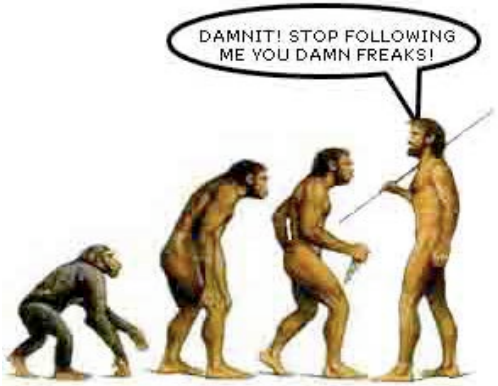
Warm up



Milestones

Challenges

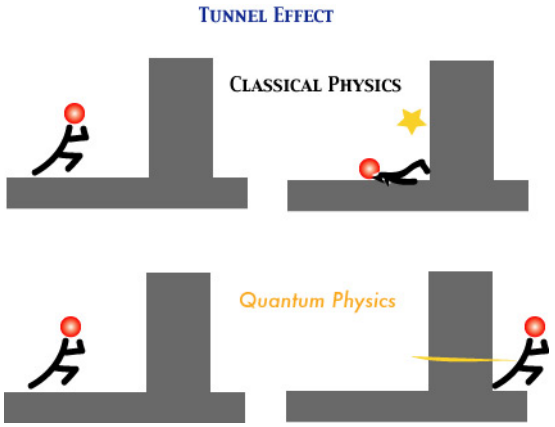




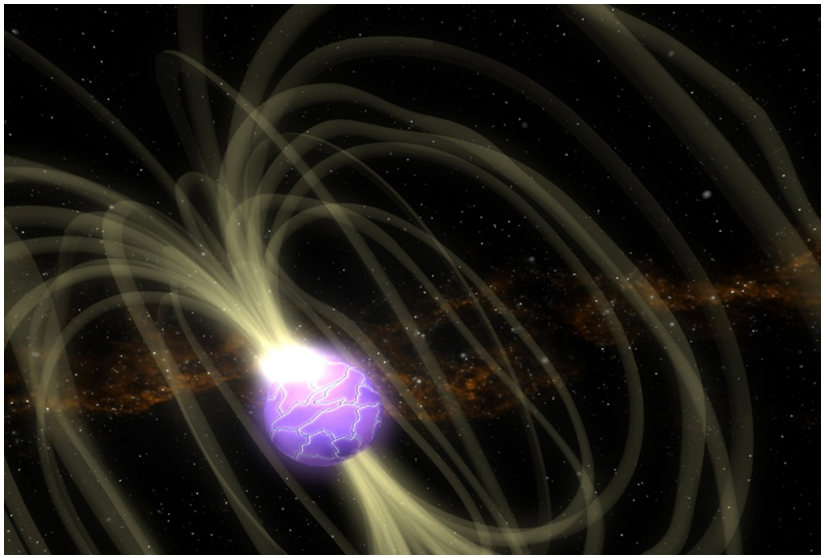
What comes next?

Background

- Theoretical physics (particle physics and quantum mechanics)



- Master in astrophysics at NTNU in 2000.



Artistics illustration of the magnetar SGR 0501 +4516 (Reddy 2009).

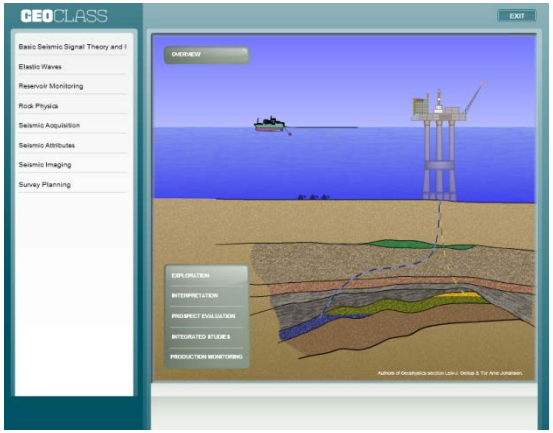
- One year workload in both mathematics and computer science

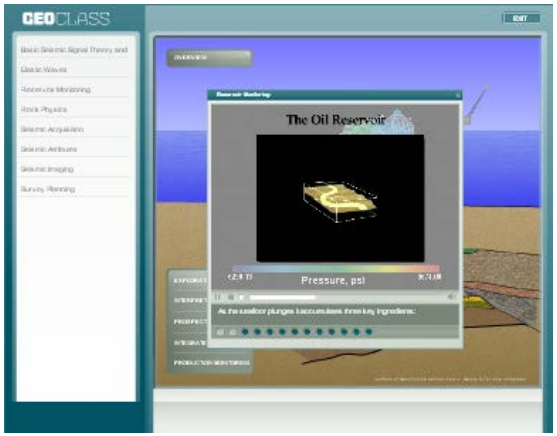
My metamorphosis

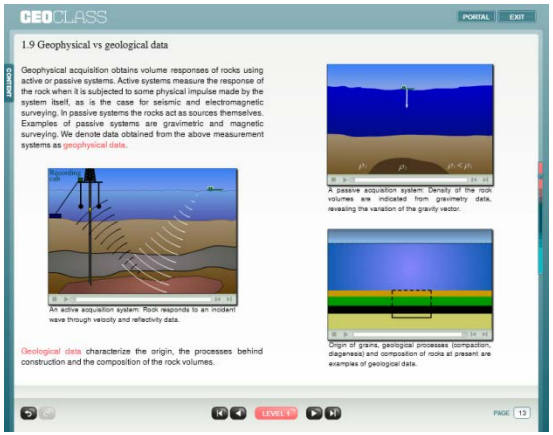
- The aftermath of my master
  - no more exams
  - a PhD is not for me

- Development of GeoCLASS; e-learning system with content from petroleum geophysics (2001)

- Introduced to the field, and the “idea” of a PhD was born



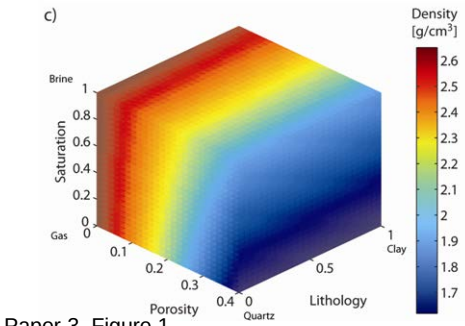




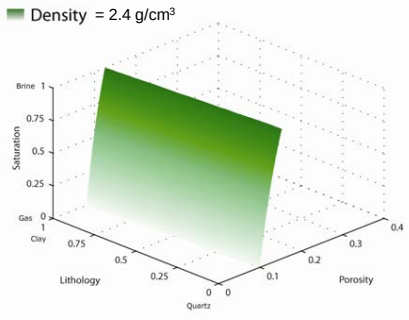
My PhD "contract"

- 4 year PhD,
  starting summer 2007
- Teaching obligations replaced with work on GeoCLASS

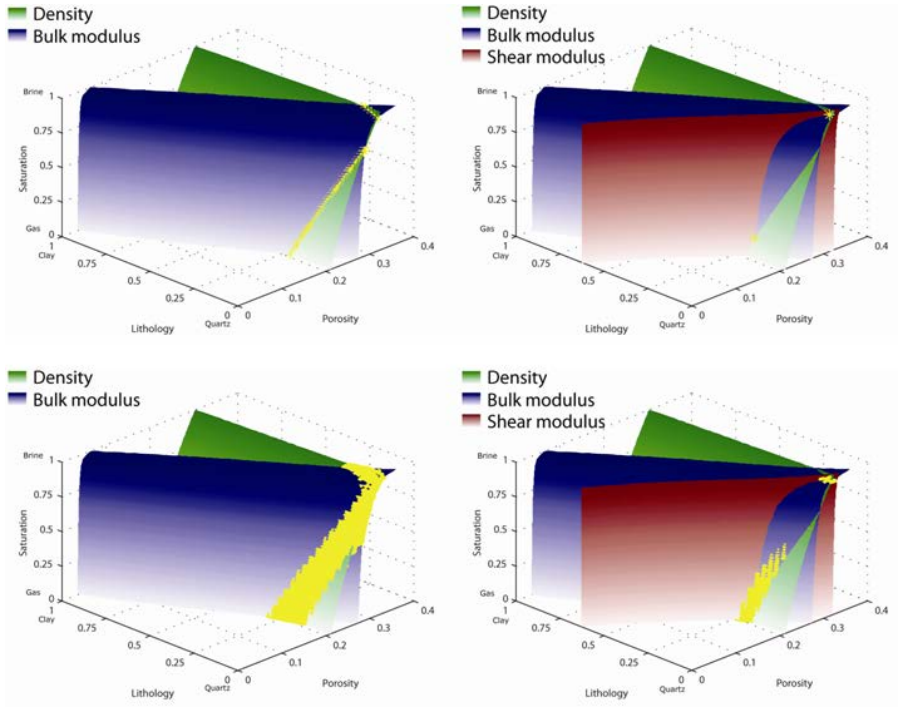
A geometric approach to inverse modelling



Paper 3, Figure 1



Thesis, Figure 3.3

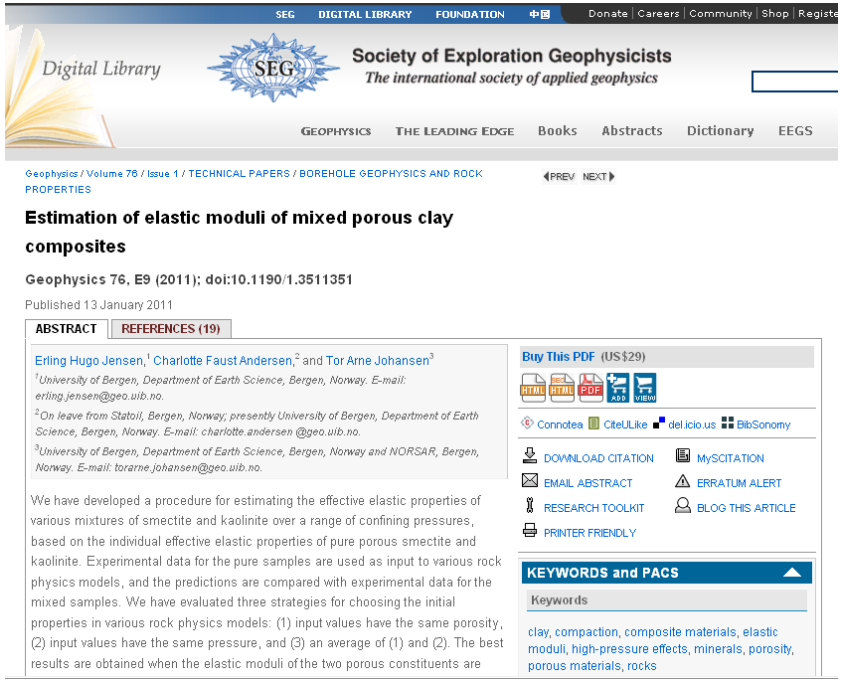


Thesis, Figure 3.7

Jensen 2011.

A couple of empirical advices

- Attend PhD defences and trial lectures
- Have at least one paper published during your PhD
- Use the resources which are available to you
- Prepare yourself to hit the wall at least once during your PhD



Milestones

- Getting the position as PhD
- Stanford University
- First paper
- First conference
- Wedding
- 6 months report
- Submitting my thesis
- Trial lecture
- Defence
- Celebrate

Milestones

- Getting the position as PhD
- Stanford University
- First paper
- First conference
- Wedding
- 6 months report
- Submitting my thesis
- Trial lecture
- Defence
- Celebrate

UNIVERSITETET I BERGEN
Det matematisk-naturvitenskapelige fakultet

Erling Hugo Jensen
Krohnhaugen 4
5059 Bergen

Deres ref.	Vår ref.	Dato
	07/6613/MN ELF	02.07.2007

STIPENDIAT I RESERVOARGEOFYSIKK– TILBUD OM MIDLERTIDIG TILSETTING

Universitetet i Bergen har gleden av å tilby deg stilling som stipendiat i reservoargeofysikk ved Institutt for geovitenskap i tilknytning til prosjektet *"Quantifying the effects of sediment deposition, compaction and pore fluid on rock properties and seismic signatures"* for 4-årsperioden 1. juli 2007-30. juni 2011.

Stillingen er innlemmet i Statens Pensjonskasse.

Vedr. søknad om opptak til PhD-studiet

Viser til søknad datert 26.02.08.
Forskerutdanningsutvalget behandlet søknaden din, og besluttet i møte 28.02.08 å ta deg opp til fakultetets forskerutdanningsprogram.

Foreløpig tittel: "Estimation of reservoir quality from geophysical parameters".
Veiledningskomité: prof. Tor Arne Johansen, GEO og prof. Leiv-J. Gelius, Geo, UiO (biveileder).

Planen for det individuelle studiet er godkjent og omfatter følgende:

Del 1:

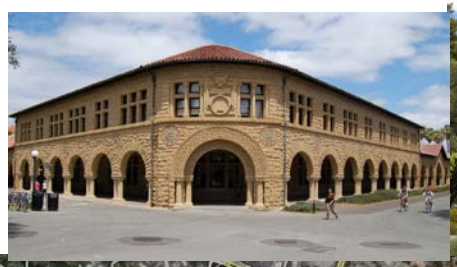
MNF490	Vitenskapsteori og etikk	3/essay	07/vår
GEOF294	Reservoargeofysikk	10/muntlig	08/høst
GEOF395	Avansert anvendt seismisk analyse	10/muntlig	09/vår
Spesialpensum	Spesialpensum i elektromagnetisme (EM)	5/muntlig	08/vår

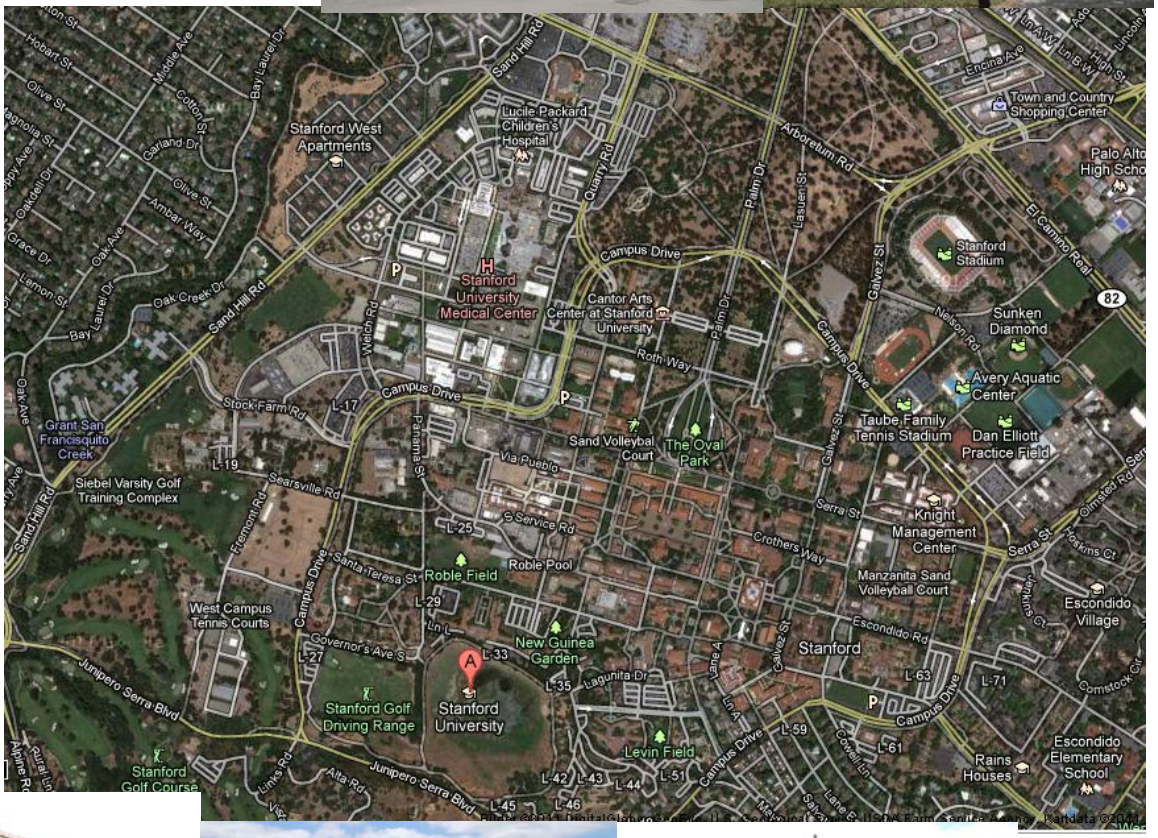
Del 2:

Int. konferanse	2	2008/2009
Seminar, selvvalgt emne	1	Vår 2011

Milestones

- Getting the position as PhD
- Stanford University
- First paper
- First conference
- Wedding
- 6 months report
- Submitting my thesis
- Trial lecture
- Defence
- Celebrate





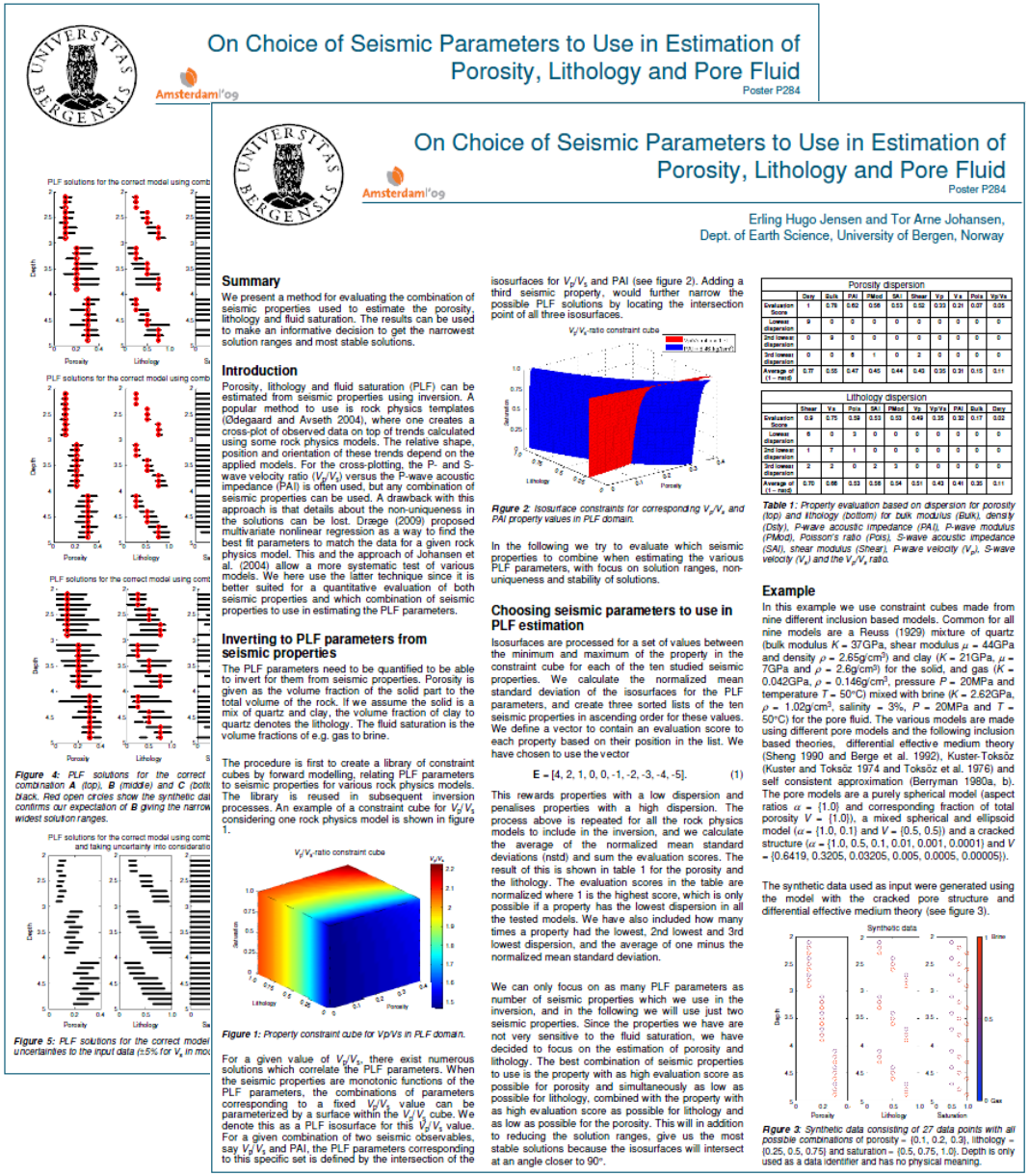
Milestones

- Getting the position as PhD
- Stanford University
- First paper
- First conference
- Wedding
- 6 months report
- Submitting my thesis
- Trial lecture
- Defence
- Celebrate

- Submitted to Geophysics December 2009
- Received moderate review Jan 30, 2010
- Revised manuscript submitted March 25, 2010
- Received minor revision June 22, 2010
- Revised manuscript submitted July 23, 2010
- Accepted for publication after (another) minor revision Aug 10, 2010
- Accepted for publication (for real) Sept 14, 2010
- Proof reading
- Online and in print Jan 2011

Milestones

- Getting the position as PhD
- Stanford University
- First paper
- First conference
- Wedding
- 6 months report
- Submitting my thesis
- Trial lecture
- Defence
- Celebrate



On Choice of Seismic Parameters to Use in Estimation of Porosity, Lithology and Pore Fluid

Poster P284

Amsterdam'09

Erling Hugo Jensen and Tor Arne Johansen,
Dept. of Earth Science, University of Bergen, Norway

Summary

We present a method for evaluating the combination of seismic properties used to estimate the porosity, lithology and fluid saturation. The results can be used to make an informative decision to get the narrowest solution ranges and most stable solutions.

Introduction

Porosity, lithology and fluid saturation (PLF) can be estimated from seismic properties using inversion. A popular method to use is rock physics templates (Ødegaard and Avseth 2004), where one creates a cross-plot of observed data on top of trends calculated using some rock physics models. The relative shape, position and orientation of these trends depend on the applied models. For the cross-plotting, the P- and S-wave velocity ratio (V_p/V_s) versus the P-wave acoustic impedance (PAI) is often used, but any combination of seismic properties can be used. A drawback with this approach is that details about the non-uniqueness in the solutions can be lost. Dræge (2009) proposed multivariate nonlinear regression as a way to find the best fit parameters to match the data for a given rock physics model. This and the approach of Johansen et al. (2004) allow a more systematic test of various models. We here use the latter technique since it is better suited for a quantitative evaluation of both seismic properties and which combination of seismic properties to use in estimating the PLF parameters.

Inverting to PLF parameters from seismic properties

The PLF parameters need to be quantified to be able to invert for them from seismic properties. Porosity is given as the volume fraction of the solid part to the total volume of the rock. If we assume the solid is a mix of quartz and clay, the volume fraction of clay to quartz denotes the lithology. The fluid saturation is the volume fractions of e.g. gas to brine.

The procedure is first to create a library of constraint cubes by forward modelling, relating PLF parameters to seismic properties for various rock physics models. The library is reused in subsequent inversion processes. An example of a constraint cube for V_p/V_s considering one rock physics model is shown in figure 1.

Figure 1: Property constraint cube for Vp/Vs in PLF domain.

For a given value of V_p/V_s, there exist numerous solutions which correlate the PLF parameters. When the seismic properties are monotonic functions of the PLF parameters, the combinations of parameters corresponding to a fixed V_p/V_s value can be parameterized by a surface within the V_p/V_s cube. We denote this as a PLF isosurface for this V_p/V_s value. For a given combination of two seismic observables, say V_p/V_s and PAI, the PLF parameters corresponding to this specific set is defined by the intersection of the isosurfaces for V_p/V_s and PAI (see figure 2). Adding a third seismic property, would further narrow the possible PLF solutions by locating the intersection point of all three isosurfaces.

Figure 2: Isosurface constraints for corresponding V_p/V_s and PAI property values in PLF domain.

In the following we try to evaluate which seismic properties to combine when estimating the various PLF parameters, with focus on solution ranges, non-uniqueness and stability of solutions.

Choosing seismic parameters to use in PLF estimation

Isosurfaces are processed for a set of values between the minimum and maximum of the property in the constraint cube for each of the ten studied seismic properties. We calculate the normalized mean standard deviation of the isosurfaces for the PLF parameters, and create three sorted lists of the ten seismic properties in ascending order for these values. We define a vector to contain an evaluation score to each property based on their position in the list. We have chosen to use the vector

$$\mathbf{E} = [4, 2, 1, 0, 0, -1, -2, -3, -4, -5]. \quad (1)$$

This rewards properties with a low dispersion and penalises properties with a high dispersion. The process above is repeated for all the rock physics models to include in the inversion, and we calculate the average of the normalized mean standard deviations (nstd) and sum the evaluation scores. The result of this is shown in table 1 for the porosity and the lithology. The evaluation scores in the table are normalized where 1 is the highest score, which is only possible if a property has the lowest dispersion in all the tested models. We have also included how many times a property had the lowest, 2nd lowest and 3rd lowest dispersion, and the average of one minus the normalized mean standard deviation.

We can only focus on as many PLF parameters as number of seismic properties which we use in the inversion, and in the following we will use just two seismic properties. Since the properties we have are not very sensitive to the fluid saturation, we have decided to focus on the estimation of porosity and lithology. The best combination of seismic properties to use is the property with as high evaluation score as possible for porosity and simultaneously as low as possible for lithology, combined with the property with as high evaluation score as possible for lithology and as low as possible for the porosity. This will in addition to reducing the solution ranges, give us the most stable solutions because the isosurfaces will intersect at an angle closer to 90°.

Porosity dispersion

	Dary	Bulk	PAI	PMod	SAI	Shear	Vp	Vs	Pois	Vp/Vs
Evaluation Score	1	0.78	0.62	0.58	0.53	0.52	0.33	0.21	0.07	0.05
Lowest dispersion	9	0	0	0	0	0	0	0	0	0
2nd lowest dispersion	0	9	0	0	0	0	0	0	0	0
3rd lowest dispersion	0	0	6	1	0	2	0	0	0	0
Average of (1 – nstd)	0.77	0.55	0.47	0.45	0.44	0.43	0.35	0.31	0.15	0.11

Lithology dispersion

	Shear	Vs	Pois	SAI	PMod	Vp	Vp/Vs	PAI	Bulk	Dary
Evaluation Score	0.3	0.75	0.59	0.53	0.55	0.49	0.35	0.32	0.17	0.03
Lowest dispersion	6	0	3	0	0	0	0	0	0	0
2nd lowest dispersion	1	7	1	0	0	0	0	0	0	0
3rd lowest dispersion	2	2	0	2	3	0	0	0	0	0
Average of (1 – nstd)	0.70	0.66	0.53	0.58	0.54	0.51	0.43	0.41	0.30	0.11

Table 1: Property evaluation based on dispersion for porosity (top) and lithology (bottom) for bulk modulus (Bulk), density (Dary), P-wave acoustic impedance (PAI), P-wave modulus (PMod), Poisson's ratio (Pois), S-wave acoustic impedance (SAI), shear modulus (Shear), P-wave velocity (V_p), S-wave velocity (V_s) and the V_p/V_s ratio.

Example

In this example we use constraint cubes made from nine different inclusion based models. Common for all nine models are a Reuss (1929) mixture of quartz (bulk modulus K = 37GPa, shear modulus μ = 44GPa and density ρ = 2.65g/cm³) and clay (K = 21GPa, μ = 7GPa and ρ = 2.6g/cm³) for the solid, and gas (K = 0.042GPa, ρ = 0.146g/cm³, pressure P = 20MPa and temperature T = 50°C) mixed with brine (K = 2.62GPa, ρ = 1.02g/cm³, salinity = 3%, P = 20MPa and T = 50°C) for the pore fluid. The various models are made using different pore models and the following inclusion based theories, differential effective medium theory (Sheng 1990 and Berge et al. 1992), Kuster-Toksöz (Kuster and Toksöz 1974 and Toksöz et al. 1976) and self consistent approximation (Berryman 1980a, b). The pore models are a purely spherical model (aspect ratios α = {1.0} and corresponding fraction of total porosity V = {1.0}), a mixed spherical and ellipsoid model (α = {1.0, 0.1} and V = {0.5, 0.5}) and a cracked structure (α = {1.0, 0.5, 0.1, 0.01, 0.001, 0.0001} and V = {0.6419, 0.3205, 0.03205, 0.005, 0.0005, 0.00005}).

The synthetic data used as input were generated using the model with the cracked pore structure and differential effective medium theory (see figure 3).

Figure 3: Synthetic data consisting of 27 data points with all possible combinations of porosity = {0.1, 0.2, 0.3}, lithology = {0.25, 0.5, 0.75} and saturation = {0.5, 0.75, 1.0}. Depth is only used as a data identifier and has no physical meaning.

Milestones

- Getting the position as PhD
- Stanford University
- First paper
- First conference
- Wedding
- 6 months report
- Submitting my thesis
- Trial lecture
- Defence
- Celebrate

Milestones

- Getting the position as PhD
- Stanford University
- First paper
- First conference
- Wedding
- 6 months report
- Submitting my thesis
- Trial lecture
- Defence
- Celebrate

Erling H Jensen
Institutt for Geovitenskap
Universitetet i Bergen

Bergen, 6. mai 2011

Forskerutdanningsutvalget
Institutt for Geovitenskap

SØKNAD OM GODKJENNING AV STUDIEPLAN (6 MND. RAPPORT)

Jeg søker herved om godkjenning av min studieplan for mitt Ph.D. studium med tanke på innlevering av oppgaven min innen arbeidskontrakten min går ut, den 30. juni 2011

Foreløpig tittel:
Strategies for predicting reservoir parameters and effective rock properties – Inverse Rock Physics Modelling

Veiledningskomité: Tor Arne Johansen (hovedveileder - UiB) og Leiv-J Gelius (biveileder - UiO).

Studieplanen min er i samsvar med sist endret studieplan (innsendt søknad 19/10/10 og mottatt beskjed om godkjenning 15/02/11)

Aktivitet	Studiepoeng	Karakter	Semester – år
Formell del			
Kurs: MNF490 – Theory of science and ethics	3	Bestått	Vår – 2007
Kurs: GEOF294 - Reservoirgeophysics	10	B	Vår - 2009
Kurs: GEOF395 – Advanced Applied Seismic Analysis	10	Bestått	Vår - 2009
Spesialpensum i controlled source electromagnetic (CSEM) methods	3	B	Vår – 2011
Formidling			
Presentasjon av forskning på internasjonal konferanse: Poster på EAGE Amsterdam 2009.	2	Bestått	Sommer - 2009
Introduksjonskurs i diverse geofysiske begreper: Avholdt i Sudan sommeren 2010.	2	Bestått	Sommer– 2010
Totalt antall studiepoeng:	30		

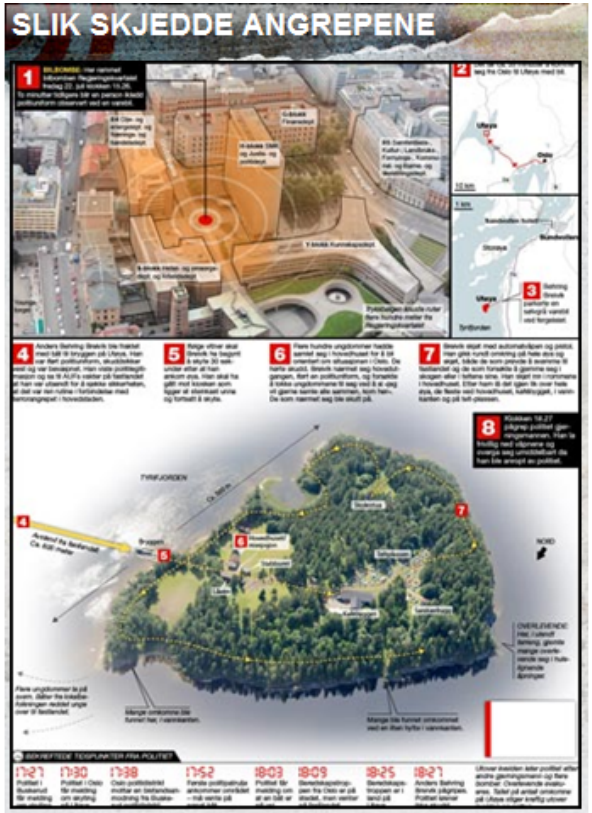
Dokumentasjon for gjennomførte aktiviteter er tidligere innlevert foruten dokumentasjon på spesialpensum. Den ble levert inn 5. mai 2011 etter at eksamen ble avholdt. I tillegg vil jeg avholde prøveforelesning i oppgitt emne etter innlevering av avhandlingen.

Mvh

Erling H Jensen

Milestones

- Getting the position as PhD
- Stanford University
- First paper
- First conference
- Wedding
- 6 months report
- **Submitting my thesis** … at about 14:00 July 22, 2011
- Trial lecture
- Defence
- Celebrate



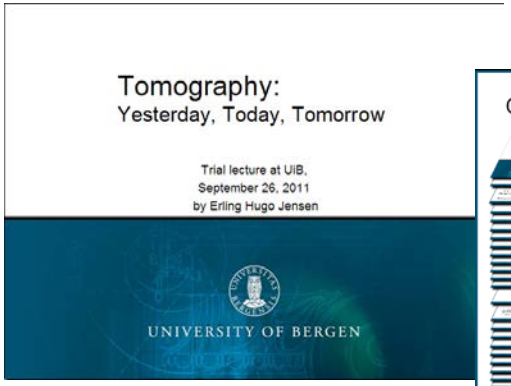
Grafikk: Klikk for å se en større oversikt og videoer

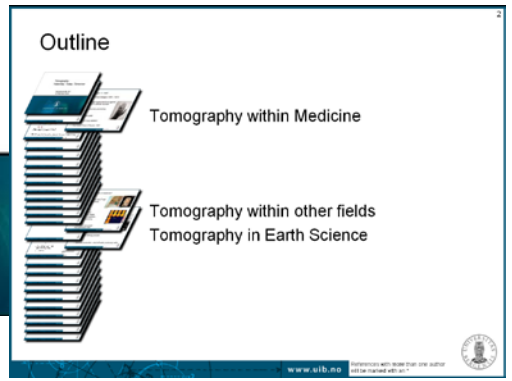
Dette skjedde 22. juli

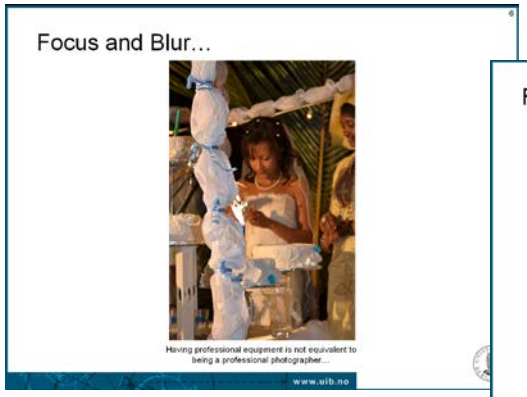
15:26: Bomben i regjeringskvartalet eksploderer.
17.26: Politiet i Buskerud får melding om skyting
17.30: Politiet i Oslo får melding om skyting på Utøya
17.38: Oslo politidistrikt mottar en bistandsanmodning fra Buskerud politidistrikt.
17.52: Første politipatrulje kommer frem til området og venter på egnet båt.
18.03: Politiet får melding om at en båt er på vei.
18.09: Beredskapstroppen fra Oslo ankommer Storøya i bil. Går over i båt for å ta seg til Utøya.
18.25: Beredskapstroppen er i land på Utøya
18.27: Anders Behring Breivik pågripes. Politiet løsner ikke skudd.

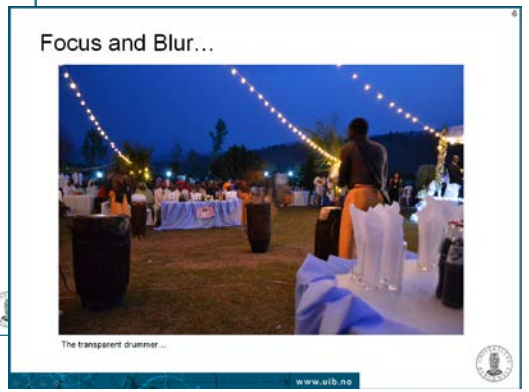
Milestones

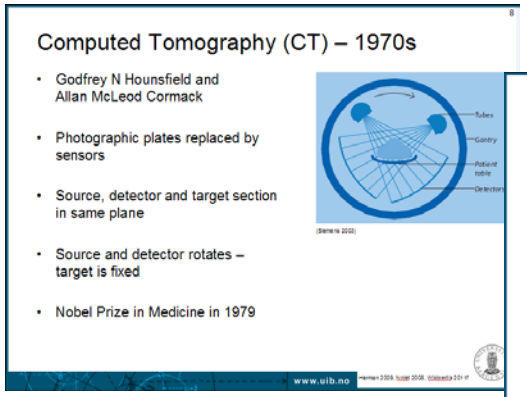
- Getting the position as PhD
- Stanford University
- First paper
- First conference
- Wedding
- 6 months report
- Submitting my thesis
- Trial lecture
- Defence
- Celebrate

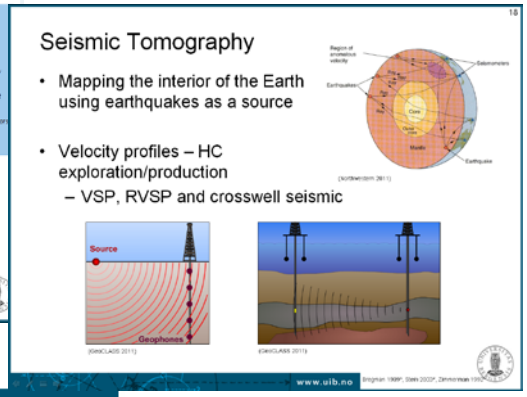






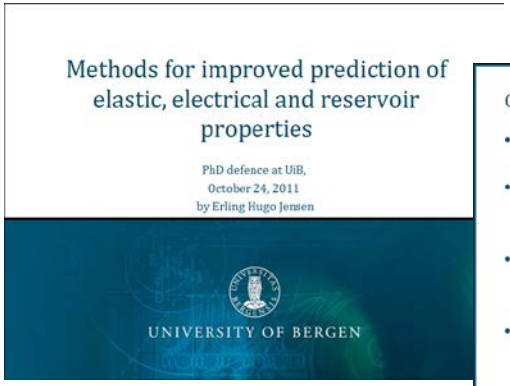


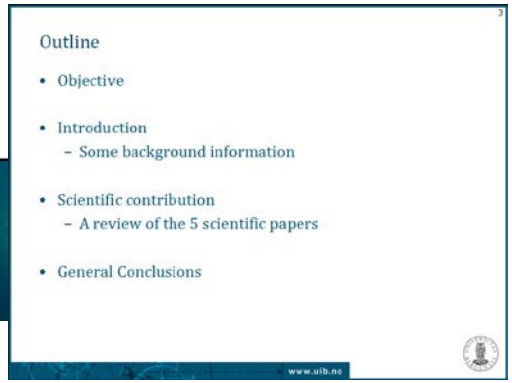


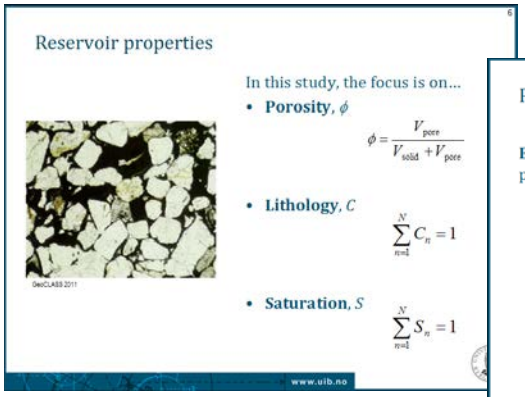


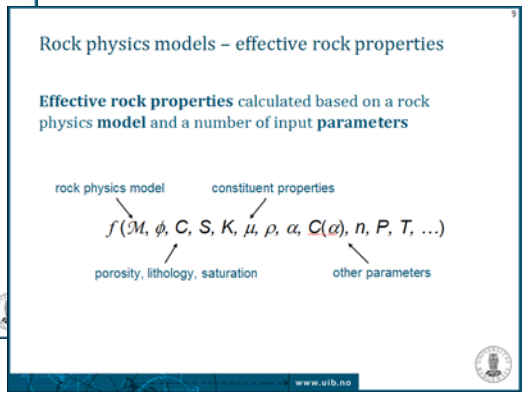
Milestones

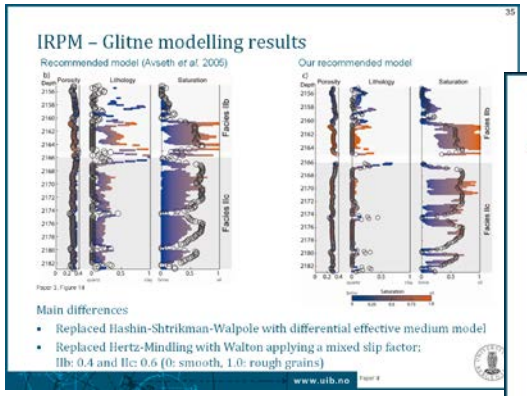
- Getting the position as PhD
- Stanford University
- First paper
- First conference
- Wedding
- 6 months report
- Submitting my thesis
- Trial lecture
- **Defence**
- Celebrate

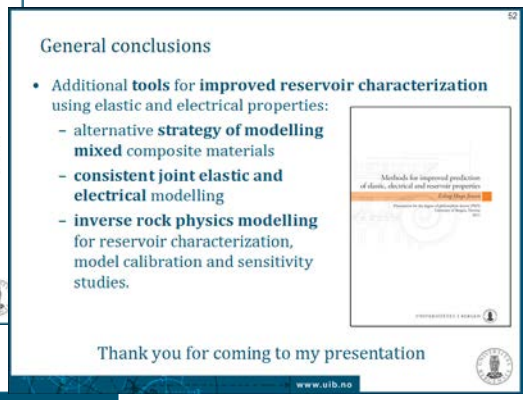












Milestones

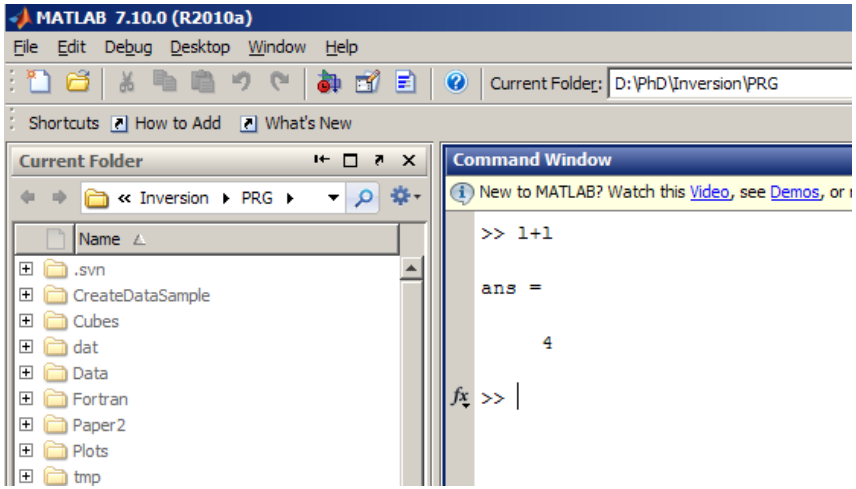
- Getting the position as PhD
- Stanford University
- First paper
- First conference
- Wedding
- 6 months report
- Submitting my thesis
- Trial lecture
- Defence
- Celebrate

Challenges

- Scientific or technical problems
- Failing a course
- Rejection of a submitted paper
- Having to redo the trial lecture
- Delays
- Murphy's law
- Prepare yourself…
- … which must not be confused with worrying

Challenges

- Scientific or technical problems
- Failing a course
- Rejection of a submitted paper
- Having to redo the trial lecture
- Delays
- Murphy's law
- Prepare yourself…
- … which must not be confused with worrying



Challenges

- Scientific or technical problems
- Failing a course
- Rejection of a submitted paper
- Having to redo the trial lecture
- Delays
- Murphy's law
- Prepare yourself…
- … which must not be confused with worrying

Challenges

- Scientific or technical problems
- Failing a course
- Rejection of a submitted paper
- Having to redo the trial lecture
- Delays
- Murphy's law
- Prepare yourself…
- … which must not be confused with worrying

Challenges

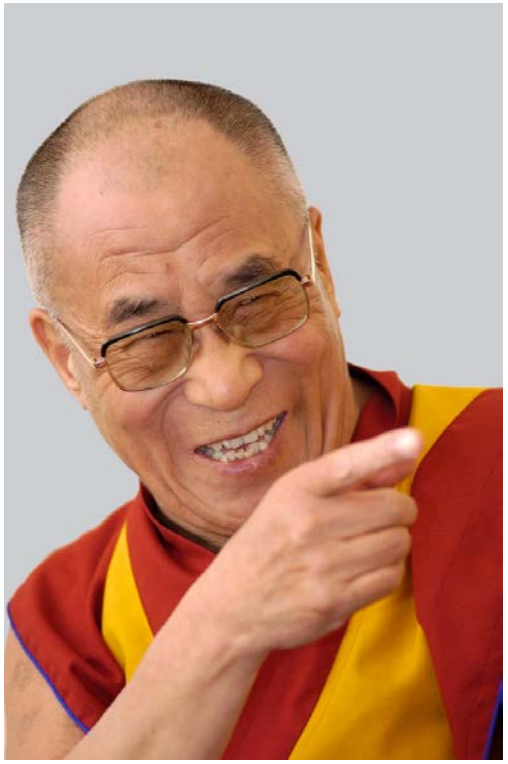
- Scientific or technical problems
- Failing a course
- Rejection of a submitted paper
- Having to redo the trial lecture
- Delays
- Murphy's law
- Prepare yourself…
- … which must not be confused with worrying

"It is an experience common to all men to find that, on any special occasion, such as the production of a magical effect for the first time in public, everything that *can* go wrong *will* go wrong. "

Nevil Maskelyne (1908),
British stage magician.

Challenges

- Scientific or technical problems
- Failing a course
- Rejection of a submitted paper
- Having to redo the trial lecture
- Delays
- Murphy's law
- Prepare **yourself…**
- … which must not be confused with worrying



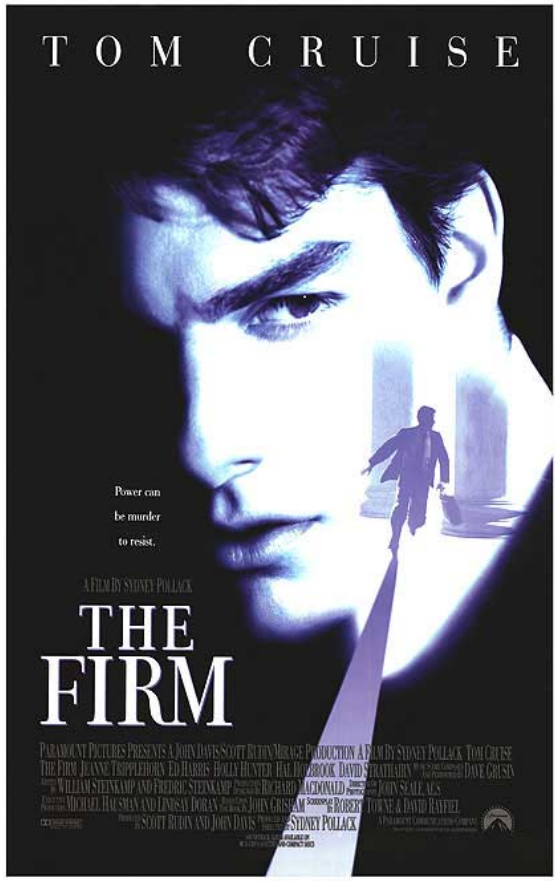
"If you have fear of some pain or suffering, you should examine whether there is anything you can do about it. If you can, there is no need to worry about it; if you cannot do anything, then there is also no need to worry."

His Holiness Dalai Lama (b. 1935),
Head of the Dge-lugs-pa order of Tibetan Buddhists.

"The longer you wait for the future, the shorter it will be"

Loesje (1983), *Dutch fictional Character*.

- Vacuum
  - I got a PhD… What do I do now?
- Hunting for a job
  - Takes time
  - Network building
- What am I doing?
  - Continuing at UiB
  - Post Doc



Thank you for your attention!