

GP183/223 Interpretation of Reflection Seismograms

Class meets 10:00-11:30 GeoCorner 205

Is this a problem for anyone?

At back of classroom, please pick up:

- handout for this lecture = class logistics; in class exercise
- first homework assignment = 1 set instructions,
 - + 1 set 8.5*11 seismic sections,
 - + 1 set 11*17 seismic sections

If you have brought your check (payable to Department of Geophysics) or cash for the class workbook and other handouts (\$40) please bring it to me now

GP223 Interpretation of Reflection Seismograms

*seismic interpretation
for geophysicists, geologists & petroleum engineers*

Tuesday-Thursday 10:00-11:30 Mitchell 350/372

Simon Klemperer sklemp@stanford.edu Mitchell 353
Stephan Graham sagraham@stanford.edu GeoCorner 222

Jon Rotzien jrotzien@stanford.edu Geocorner 208

Topics (see Coursework / Klemperer home page)

Simon Klemperer: Mapping

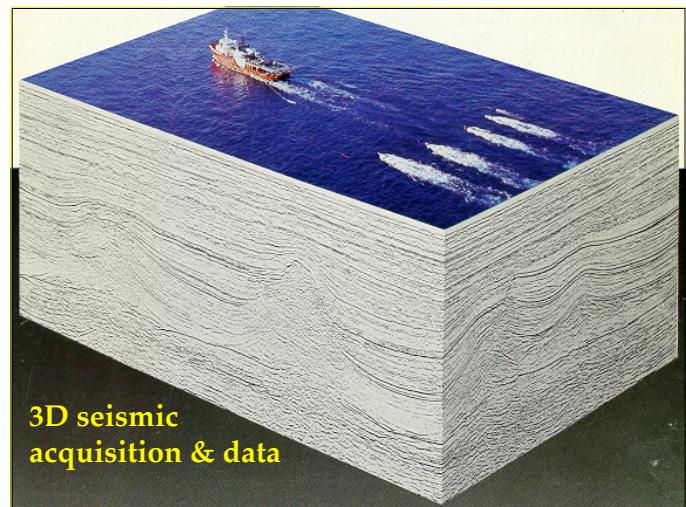
Introduction to mapping; How to map seismic data
Contouring and visualization; 3D interpretation
Resolution; Geometric and velocity effects

Simon Klemperer: Structural interpretation

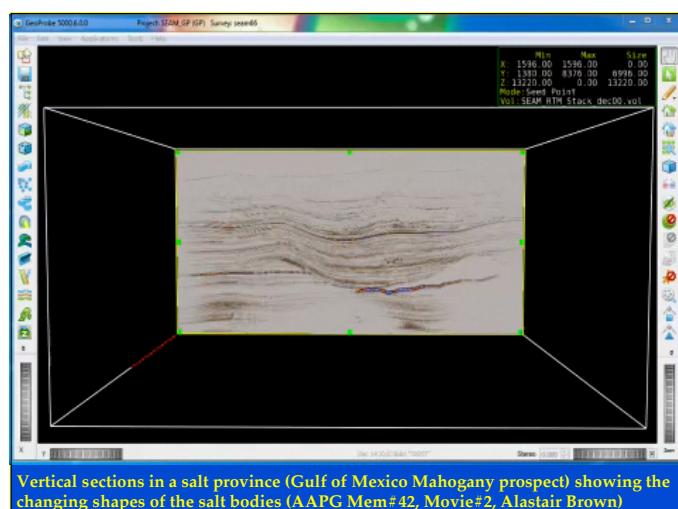
extensional structures; salt structures
compressional structures; inversion structures
wrench structures

Steve Graham: Stratigraphic interpretation

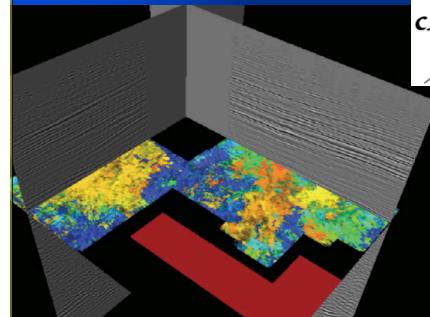
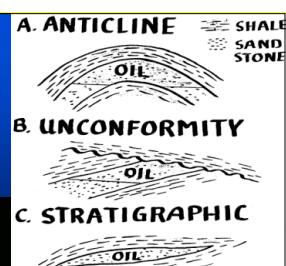
principles; seismic facies
siliciclastics; carbonates
basin analysis



3D seismic
acquisition & data



We will interpret
macroscopic stratigraphic
and structural features ...
source, seal and trap ...



... not detailed
attributes
corresponding to e.g.
sand/shale ratios or
fluid saturation
(for that, please take
Gary Mavko's "Rock
Physics" GP 262)

**Geophysics 183/223 Reflection seismology Interpretation
Spring quarter 2011-12 Tu-Th 10.00-11.30 Geocorner 205**

The schedule (see handout) is tentative, but represents target topics for the quarter. Nine homeworks are handed out on Tuesdays, are due Tuesdays one week later, and will be returned to you one week after that.

Each week, Jon (or a guest TA) will hold office hours to address individual issues, at a time to be arranged (??), and will offer a group problem-solving session to cover the current homework. Don't expect additional help from the TA unless you've made the effort to attend the group session!

Week 1 Lecture

Tue 4/3	lecture 1 <i>lab#1</i>	Introduction to GP223; What is seismic interpretation? <i>Basic seismic interpretation; deep-crustal data (1/2/3/4 units)</i>
Thur 4/5	lecture 1	How to map seismic data: Data validation, picking & tieing
Tue 4/10	lecture 2 <i>lab#2</i>	How to map seismic data: Contouring and visualization <i>3-D visualization and contouring (3/4 units) lab#1 due</i>
Thur 4/12	lecture 3	3D interpretation
Tue 4/17	lecture 4 <i>lab#3</i>	Resolution and Phase <i>Mapping & migration (synthetics) in 3D (2/3/4 units)</i> <i>lab#2 due; #1 handed back and discussed etc, etc.</i>

Homeworks (see handout)

HW 1 Basic seismic interpretation; deep-crustal data

HW 2 3-D visualization and contouring

HW 3 Mapping and migration (synthetics) in 3D

HW 4 Real data: tracing reflectors, posting times

HW 5 Mapping extensional structures

HW 6 Mapping salt structures with a 3D data volume

HW 7 Workstation exercise (Kingdom Suite)

HW 8 Seismic stratigraphy I: facies mapping

**HW 9 Seismic stratigraphy II: regional basin evolution
(using Kingdom Suite)**

1-4 units, instructor-mandated S/NC

- S/NC: do the work you need to learn the principles and methods; but don't waste time trying for an A+ (3 or 4 units of GP 223 with instructor-mandated S/NC satisfies Geophysics departmental PhD requirements for 200-level classes)
- 4 units: the true work-load for this class, all 9 homeworks due on schedule (7 homeworks for undergrads. in Geophys 183).
- 3 or 2 units: really only intended for those grad students whose other required classes prevent them from enrolling for 4 units while staying within the 10-unit maximum load.
- 1 unit: for those who want to pretend they've learned about interpretation while never actually planning to do it themselves.

1-4 units, instructor-mandated S/NC

To be (somewhat) equitable, we will forgive two labs. for each unit below the recommended 4 units. Thus:

3 units GP223 (4 units GP183) – do 7 labs (#1, 2, 3, 4, 6, 7, 8)

2 units GP223 (3 units GP183) – do 5 labs (#1, 3, 6, 7, 8)

1 unit GP223 (2 units GP183) – do 3 labs (#1, 6, 7)

Everyone is encouraged to look over all the labs. and understand how they would do them, if they had to. Skills needed for later labs build upon skills learned in earlier labs.

Grading policy:

All labs. to be completed to grade C or better, on the official schedule (labs. are due Tuesday), to achieve a Satisfactory grade in the class

GSAC anonymous course evaluations: student comments:

- Must for future explorationists.
- Easily the most time-consuming class that I have taken at Stanford, but you will learn more than you ever thought possible.
- Well worth the time and energy. There is a fair amount of grunt work in the homeworks but if you go for S/NC grading you can do the homeworks quickly and get all the understanding while doing a shoddy job on the presentation.
- Steve Graham's half of this class was much more understandable and interesting to geology majors.
- If you aren't thrilled by sedimentology, forget Steve Graham's part of this course.

GP223: a proud tradition of hard work:

What happened during Spring Break?

Did SAP really change the way geologists will be looked upon in New Zealand from now on? And did those students who took **Simon Klemperer**'s class last quarter really commit mass suicide there?

Is it true that **Dave Pollard**'s only Spring Break occupation was to catch up with those episodes of Xena, the Warrior Princess, he missed last quarter feeding his starving students?

Is it further true that **Patrick Redmond** performed a mind altering belly-dance on top of the ore deposit group's latest finding in Nevada? Or was it Marco Einaudi himself?

FridayBeer has all the answers to your questions.

FridayBeer, Geocorner @ 5pm

Top Ten Things Not Overheard at Friday Beer

1. I'll drive.
2. This would be more fun with the PEs.
3. Hey, how about a little Phil Collins?
4. I really didn't know about tomorrow's field trip leaves at 7AM.
5. This week's science assignment was fun and quick.
6. Where's Mary?
7. I had a really productive week.
8. I really like Joe's new deodorant.
9. Danny sure keeps his cool on the basketball court.
10. I think we were right by the women's bathroom with 3 stalls and wait 10 minutes for the men's to open up.

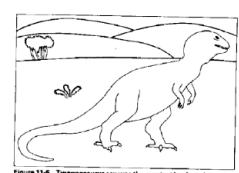


Figure 11-4 Tyrannosaurus rex was the greatest land carnivore that ever lived. Until Jim Sweeney evolved.

GES/Geophysics Friday Beer
February 21, 1997, 5PM
Geocorner Mall

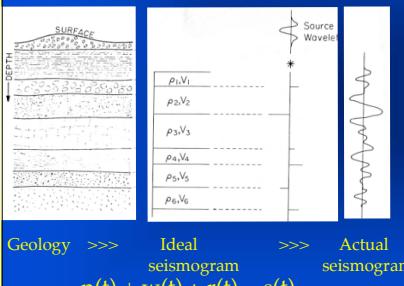
Are you in the right class?

Check out this in-class exercise: **What do you think this is?**
If you know how to do this correctly,
you should be TAing this class, not taking it!

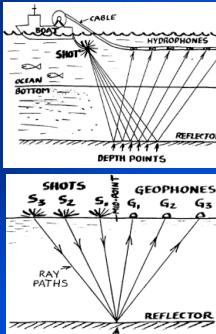


What if you missed GP222 Reflection seismology? Please do some background reading (see syllabus)

Convolution model of reflection seismograms:



Acquisition geometry (source gathers) vs. Processing geometry (CMP gathers)



Geology >>> Ideal seismogram >>> Actual seismogram

$$n(t) + w(t) * r(t) = s(t)$$

GP223 Interpretation of seismic reflection profiles

is the second in a three-quarter sequence of classes

Structural and stratigraphic interpretation of reflection profiles. Lectures and hands-on seismic interpretation, including workstation experience.

GP222 Reflection seismology

is the first in the three-class sequence, offered regularly on an alternate-year basis (next offered Fall 2013):
Methodology of seismic reflection profiling and processing

GP224 Seismic-reflection data processing

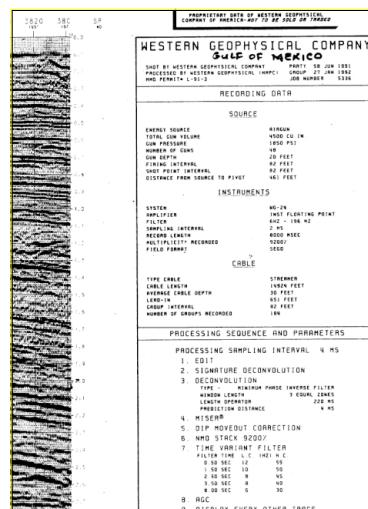
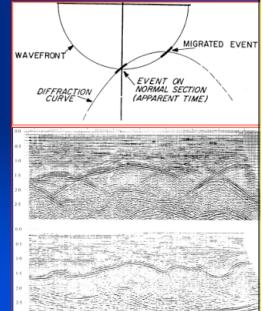
is offered whenever there is sufficient demand:

Hands-on experience; students individually process a reflection profile from field data to migrated stack, using commercial software.

More stuff you would benefit from knowing:

Understand the processing sequence on side-labels:

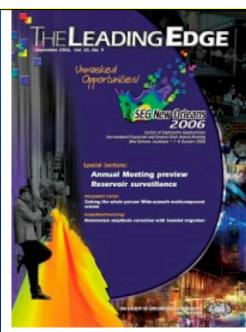
Migration: placing reflections in their correct spatial location:
 $\sin \alpha = \tan \beta$



recommended general reading:

The Leading Edge, monthly magazine from the SEG, *free* with your *free* membership at <http://students.seg.org/>

"TLE introduces new geophysical theory, instrumentation, and established practices to scientists in a wide range of geoscience disciplines presented in a semitechnical manner that minimizes mathematical theory and emphasizes practical applications."



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recommended general reading:

AAPG Explorer, monthly magazine from the AAPG, *free* with your *free* membership at <http://www.aapg.org/member/student/>

"The premiere news publication for AAPG and the petroleum industry."



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Four valuable books on 3-day reserve in Branner (and on explorationists' bookshelves around the world):

- *Tucker & Yorston* is a quick, easy and valuable read: please read it cover-to-cover.
- *Tearpock & Bischke* is the place to go if you ever want help contouring or making a 3D map that is geologically and physically correct, or want to start balancing sections.
- *Brown* has zillions of examples of workstation interpretations, and behind the industry flim-flam there is a lot of useful information.
- *Emery & Myers* is the current standard textbook on stratigraphic interpretation.

Other resources:

Background geophysics; seismic methodology:

- *Dobrin, M.B., & Savit, C.H.* 1988. Introduction to geophysical prospecting. McGraw-Hill, 4th ed., pp. 867.
- *Telford, W.M., et al.* 1989. Applied geophysics. Cambridge University Press, 2nd ed., pp. 770.

Atlases of seismic data

- *Abbott, W.O., & Branson, D.L.* 1979. Atlas of seismic stratigraphy. Shell Oil Company, Houston.
- *Bally, A.W., ed.* 1983. Seismic expression of structural styles. AAPG Studies in Geology 15. Vols 1-3.
- *Weimer, P., & Davis, T.L.* 1996. Applications of 3-D seismic data to exploration and production. AAPG Studies in Geology, No. 42. pp. 270.
- *Klemperer, S.L., & Hobbs, R.W.* 1992. The BIRPS Atlas of deep seismic reflection profiles around the British Isles. Cambridge University Press, pp. 128.

GP223 Reflection interpretation

Any questions?

What is the most important skill needed by a seismic interpreter?

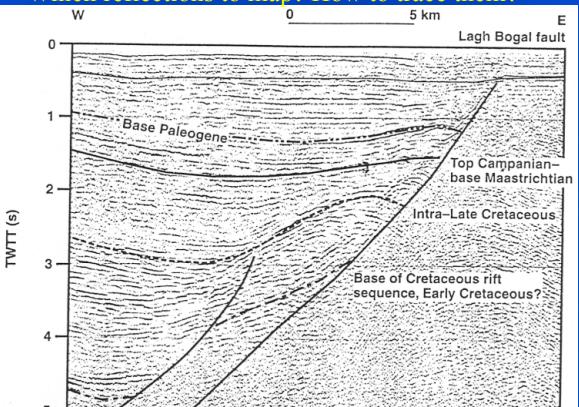
The Leading Edge, June 1998

The ability to do 3D seismic interpretation on an interactive workstation.

This requires the knowledge and integration of five basic elements:

- 1/ geophysical theory;
- 2/ petroleum geology and engineering;
- 3/ the mechanics of seismic interpretation;
- 4/ the computer operating system;
- 5/ the 3D interpretation software

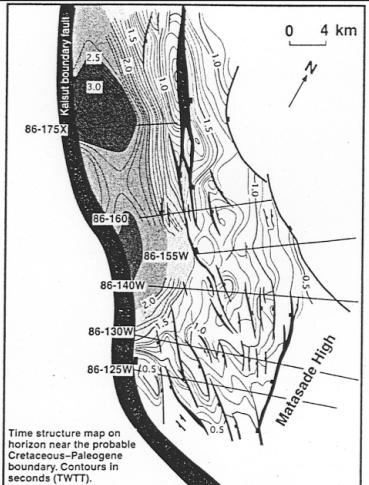
Interpretation at the ~ 10 – 1000 meter scale
Structure, stratigraphy and geo-history
Which reflections to map? How to trace them?



Making maps of three-dimensional surfaces and structures

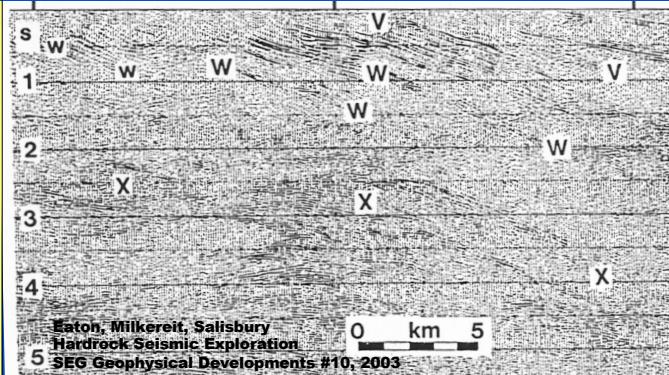
Note the scale of interest - a few kilometers

Map shows numerous faults as well as a subsurface stratigraphic horizons. Times are interpolated between and extrapolated beyond the seismic profiles.



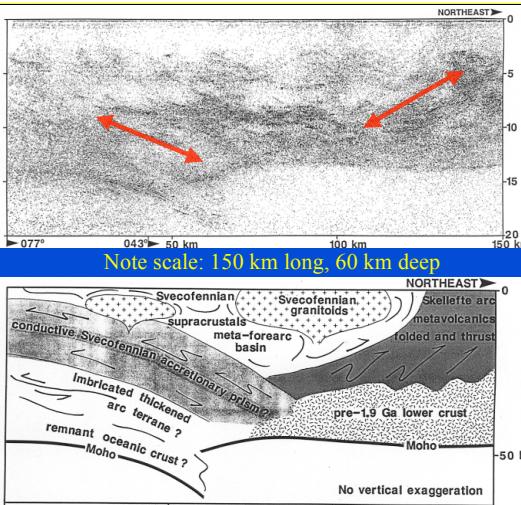
Basin exploration is mostly for hydrocarbons - but not always:
Archaean Witwatersrand Basin, host to 75% of Earth's gold
at 9g/t: strata-bound mineral deposits.
W: base of West Rand Group; X: basement complex

W: base of West Rand Group; X: basement complex



Interpreting *reflection patterns* (regional fabrics and trends) in igneous and metamorphic basement.

“Evidence for early Proterozoic plate tectonics in the Baltic Shield”, Nature 1990



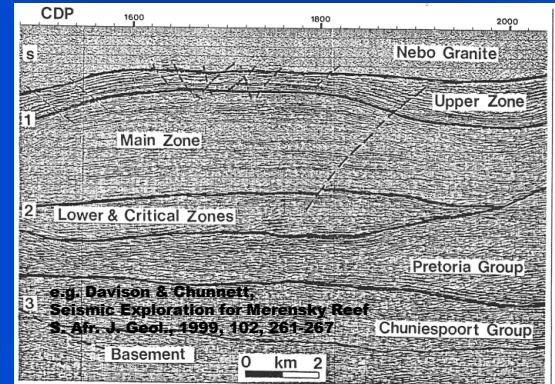
840 |
10² m long, 10¹ m penetration

Going to the other extreme:
Mapping bedrock depth for
building foundations or
hydrologic studies

Mapping subsurface voids
to locate old mines, prevent
highway collapse

Most seismic is in sedimentary basins - but not always:

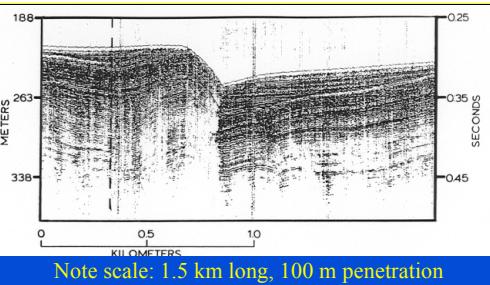
Strata-bound platinum at the base of the "Lower & Critical zones" within the Bushveld layered igneous intrusion: Merensky Reef is 0.3 m thick, 6g/t, proven to 2 km depth



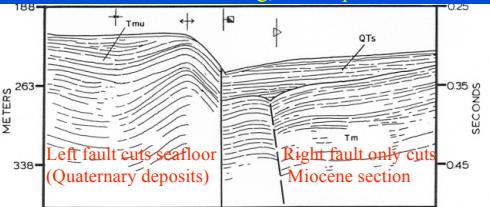
Going to the other extreme:

Seafloor expression of active faults offshore LA

Single-channel
marine records
(*not CMP*),
several 10^2 Hz,
electrical
“uniboom”
source



Note scale: 1.5 km long, 100 m penetration



Going to the other extreme:
Mapping bedrock depth for
building foundations or
hydrologic studies

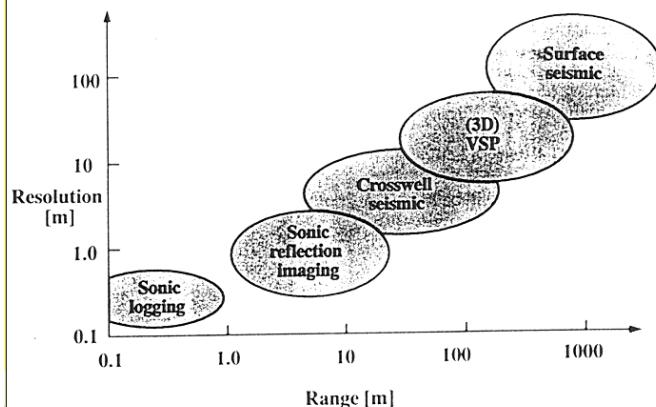
In the subsurface, short-penetration, high-resolution reflection imaging requires *downhole methods*:

VSP (vertical seismic profile, surface source, downhole receiver):

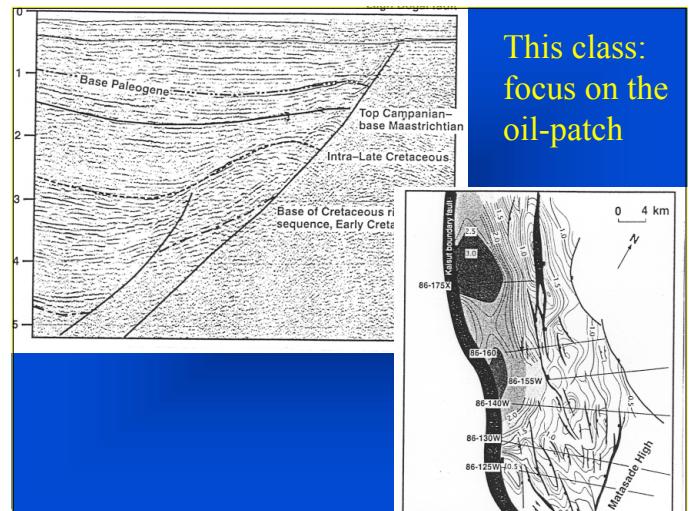
Cross-well:

Sonic log

Higher resolution *requires* higher frequency
therefore is shorter range (lower penetration)



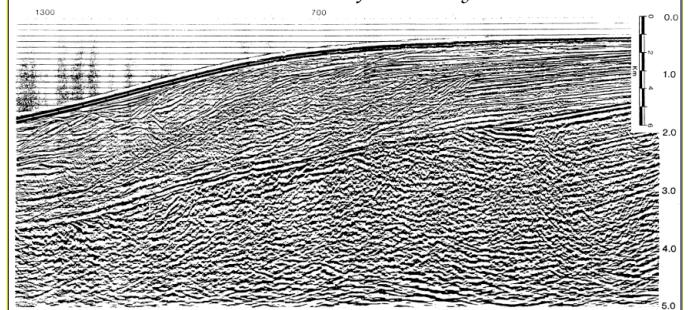
This class:
focus on the
oil-patch



GP223 Reflection interpretation

Any questions?

O: Southwest Africa continental margin
sw Homework #1 - due one week from today



- Interpreting requires difficult decisions, on the basis of incomplete data.
- Your decisions, however difficult, are *required*, as the basis on which you will drill, or acquire more data, or abandon the prospect.
- You cannot *not* make the decision - you *must* interpret the seismic data.

GP223 Reflection interpretation

Homeworks - handed out Tuesday
TA-led session - TBA
Homeworks - due back in class the following Tuesday

*Any
questions?*

