ESS 202 - Earthquakes

Profs. John Vidale & Ken Creager
TA Josh Jones

Press, 18-21

Today's agenda

- Who, where, and when?
- Who are these people lecturing us?
- Class manners and wait list policy
- Teasers to show this course has the potential to be interesting
- Questions?
- Please fill out the questionnaire
  - It counts toward as first quiz

Expected class manners

- We'll start and end on time
- Ask if something is not clear
  - A silent audience makes us nervous
- Drop by our offices
  - Whenever, or arrange by email
- Respect your classmates
  - Don't chat or make a racket during lecture
  - If you must leave early, try to sit near the door
- Feedback is welcome

Enrollment and the wait list

- Now, there are 62 students
  - 23, 20, 19
- Capacity is 70
  - Classroom has limited capacity

Where and when?

- Lectures: M, W, F 1:30 pm – 2:20 pm Johnson Hall 175
- 3 Sections: T, Th, F, Room 011/117
  - 3 hours each, show up for assigned section
  - Hand in during section or up to a week later
  - Starts this week with tour of Pacific Northwest Seismic Network
  - There is an exercise to do from the tour
  - Can't miss more than 2 labs & pass

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Class web page

- Summary of class rules
- http://courses.washington.edu/ess202/
- All lectures will be on the web
  - Full-color PowerPoint and pdf files
  - (But some Quicktime invisible on PCs)
- We'll have them up before the lecture, but w/o last-minute changes.

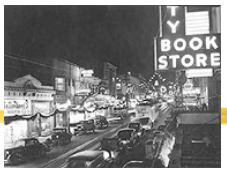
Course grading

Quizzes (20%):
10 quizzes: the course questionnaire handed out the first day counts for the 1st quiz and all students who hand it in get full credit.
Lab (30%): one per week + short paper
There will be **weekly labs**,
and a **short paper** due about mid-term will be based on work done over two lab periods.
Final Paper and Presentation(25%):
done in groups and presented at the final Lab.
Final Exam(25%)

To be clear

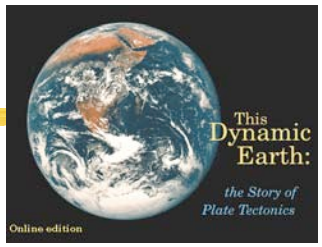
- Come to lecture for a good grade
  - If you can't make lecture
    - Email me ahead of time
      - for alternate assignment in case of a quiz
- Come to lab if you want to pass
  - Tell Josh *ahead of time* if you can't come

Book

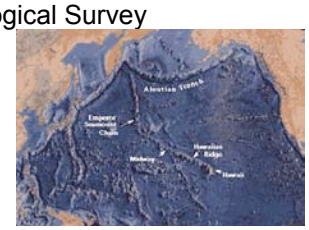


- Living with earthquakes in the Pacific Northwest
  - ~$30, in stock at bookstore, necessary
  - By Robert Yeats, 2nd Edition, 2004.
  - Partly written when Bob visited UW
    - Amazon review - A book that will hopefully wake people up who live here in the NW and make them realize that we are at just as much risk for earthquakes as California. I was a 1 year old and my parents recall their terror of ensuring my safety as well as their own during the 1965 quake that hit WA state measuring over a 7.
    - We should all take heed of the words written and secure ourselves by having a 3 day supply of food and water, knowing what the emergency response of our childrens' schools are. Because the quake that hit this summer [1999] is just a prelude to the massive one that will hit.

CD-ROM



- This Dynamic Earth
  - "The Story of Plate Tectonics"
  - Produced by the US Geological Survey
  - Cost already covered
- We'll make copies
- It will be used in lab
- Resource for lab projects



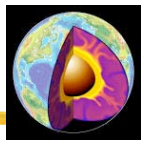
Where to find me

- Instructor: John Vidale
  - Prof, Dept. of Earth and Space Sciences
  - Director, Pacific Northwest Seismic Network
  - Washington State Seismologist
- (206) 543-6790
- 208A ATG
- seismoguy@mac.com
- Office hours by appointment, or drop in.

John's background

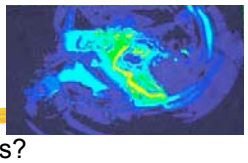
- High school in New Mexico
- Undergraduate student at Yale
  - Majored in physics, geology, and economics
- Graduate student at Caltech
  - Seismology
- Research scientist at UC Santa Cruz
- Geophysicist with the US Geological Survey
- Went to UCLA in 1995
- Came to UW 2006

John's practical skills



- Deep Earth structure
- The earthquake process
- Hazards of big earthquakes
- Simulations

John's research



- Do earthquakes correlate with tides?
- Is the inner core spinning?
- Do fault zones heal after an earthquake?
- Why do dozens of small quakes sometimes occur the same day?
- Why does Washington tremble 2 weeks a year?
- What's going on at the core-mantle boundary, half way down to the center of the Earth?
- What just happened around here?

Ken Creager

Grew up in Seattle

Undergrad: Pomona College

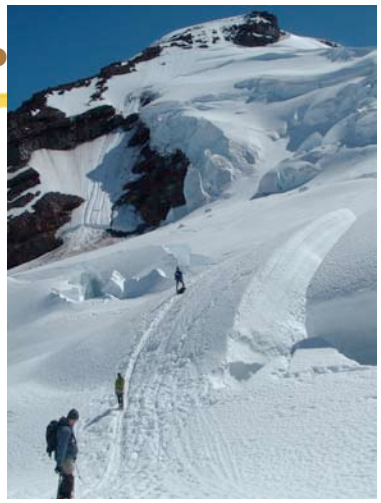
Graduate School: Scripps Institution of Oceanography

Post Doc MIT

Back to Seattle/UW

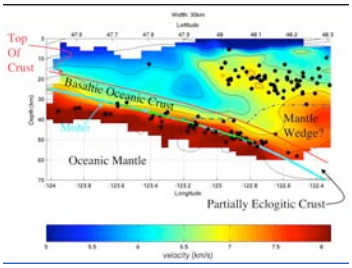
What I like to do

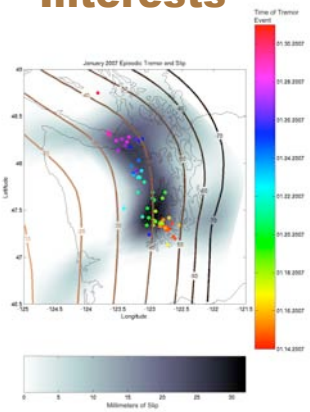
- Travel
- Hike
- Ski
- Squash



Research Interests

- Episodic Tremor and Slip
- Subduction Process
- Inner Core Anisotropy





Definitions (in Bolt's book)

- Seismology
  - The study of earthquakes and wave propagation through the Earth
- Seismicity
  - The occurrence of earthquakes in space and time
- Seismologist
  - One who studies seismograms to learn about earthquakes or the Earth

Why are quakes interesting?

- **Expensive**
  - Taxes, insurance, they break your fragile stuff
  - Deadly, particularly in third world
- Bad one could cause a **recession**
- Of **historical importance**
  - e.g., End of Minoan civilization in 1700 BC
- A **basic scientific problem**
  - How do they work?
  - Can they be predicted?

We'll explore global natural disasters

- Earthquake-induced problems
- Tsunamis (sea waves)
- Volcanoes
- Landslides
- Maybe tornadoes and hurricanes

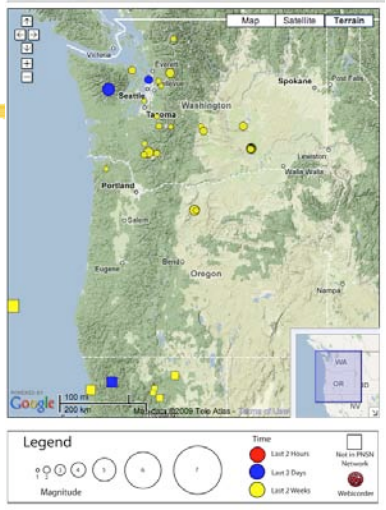
We'll watch current quakes

- An M3.6 about midnight last night
- Lots of magnitude 1's and 2's each week
- Quakes tend to happen along faults
- You can see this display on the web
  - http://www.pnsn.org/recenteqs/latest.htm

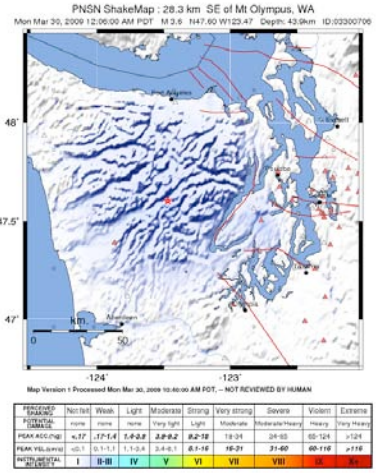
Kate Hutton and Lucy Jones at Caltech

WA-OR quakes last two weeks

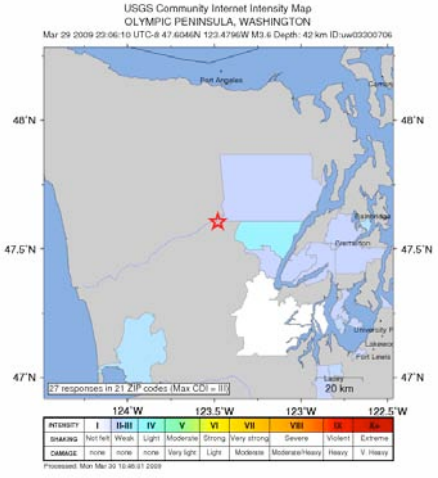
Bill Steele of the PNSN



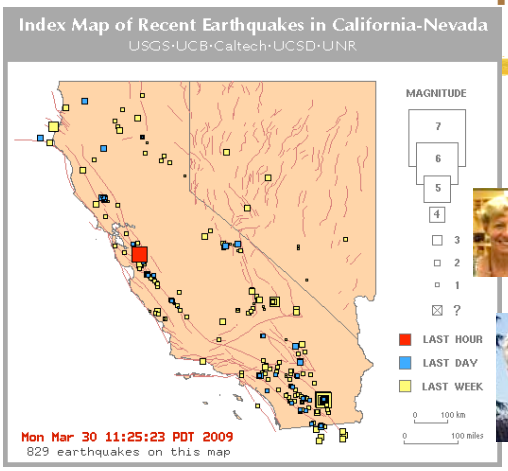
Instrumental shaking



27 hits



This week's California quakes



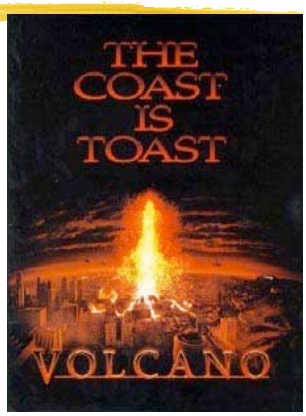
Tom Broche
USGS

Barbara Romanowicz
UC Berkeley

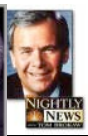
Rob Clayton
Caltech

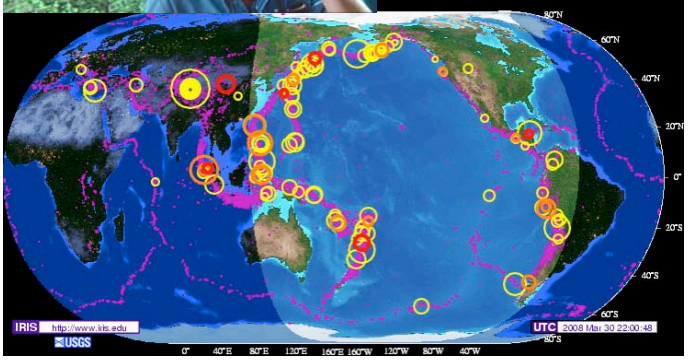
We'll watch world seismicity

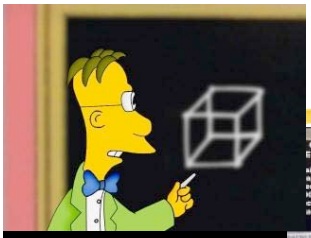
- You'll see many world maps in this course
- Lots of magnitude 3's, 4's and 5's each week
- You can see this display on the web
  - http://www.iris.edu/seismon



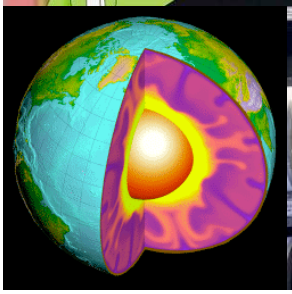
World-wide







We'll learn some science



Course outline - first half

- Why do earthquakes happen?
  - Plate tectonics
- Physical description of earthquakes
- How earthquakes are measured
- How quakes show us inside of the Earth
- How many quakes are there, foreshocks
- Can quakes be predicted
- Volcanoes, tsunamis, nuclear blasts

Course outline - 2nd half

- Earthquake hazards
  - Fault zone is a bad place to live
  - Soft soils are a bad place to live
  - Hazards in the neighborhood
  - How quakes damage buildings
  - How to build for earthquakes
  - What to do before, during, and after an earthquake

Scientific Method

- Careful observations
- Hypothesis building
- Tests of the competing hypotheses
- Refine or abandon and rebuild
  - Principle of simplicity
  - Analogies, generalization

Plate tectonics

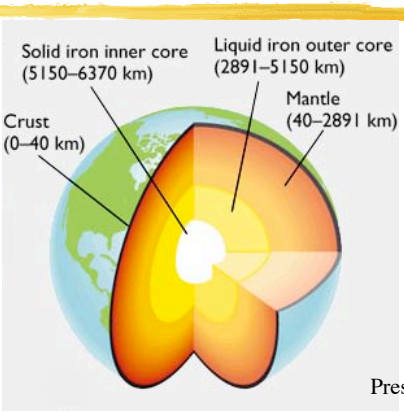
- Driving force for earthquakes

- I'll show
  - Basic Earth structure
  - How the Earth is convecting
  - Rigid plates moving at the surface
  - Boundaries between the plates

More details

- 3 types of plate boundaries
- How are plates moving today
- How have they have moved recently
- Why we believe plate tectonics
- How types of faults relate to types of plate boundaries

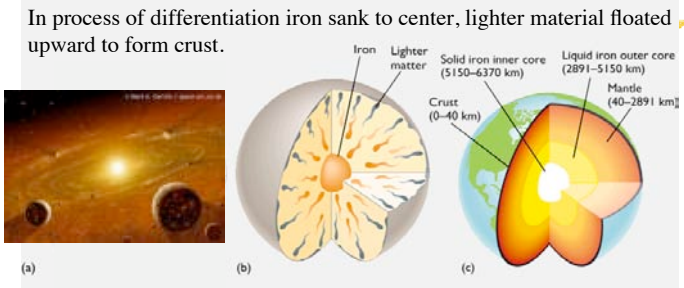
Core, mantle, and crust



Press, 1-6c

Formation of the Earth

In process of differentiation iron sank to center, lighter material floated upward to form crust.

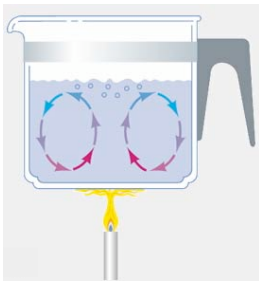


Convection

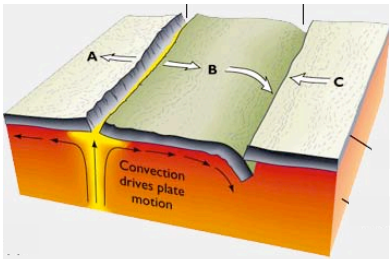
- Heat a liquid from below, cool it on top
  - Cooler material is more dense
  - Hotter material is less dense
- So the cool stuff on top sinks, and the warms stuff on the bottom rises
- The liquid continually overturns, like in a pot on a stove
- Convection is tending to make everything have a more similar temperature

Convection in action

- Water on stove

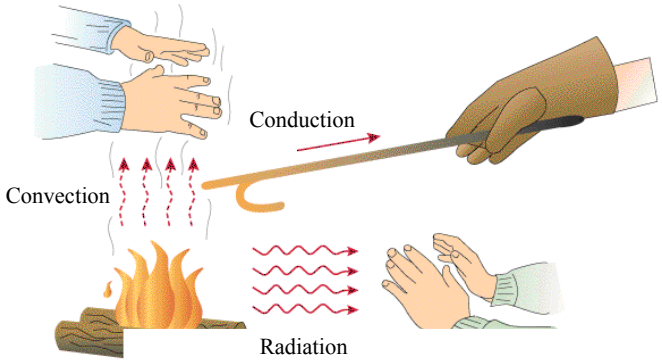


Tectonic plates on mantle



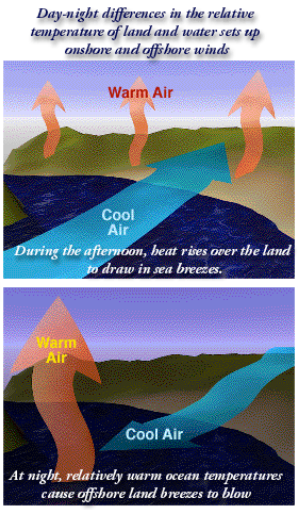
Press, 1-13a, 1-14a

Ways to transport heat



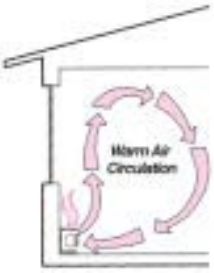
Convection we can feel

Heat from the fire

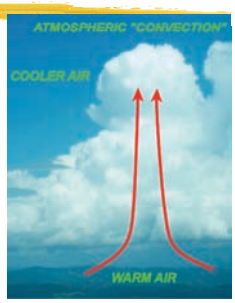


More thermal convection

Hot-air balloon

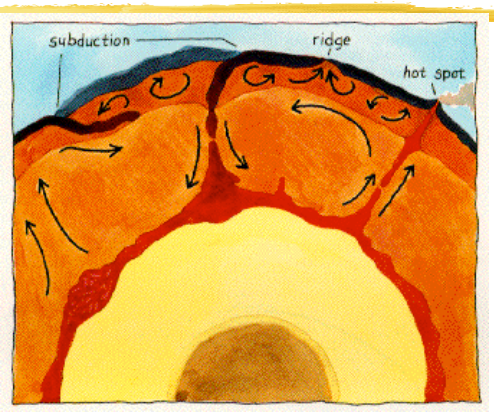


Baseboard heating

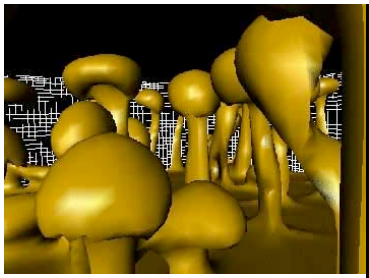


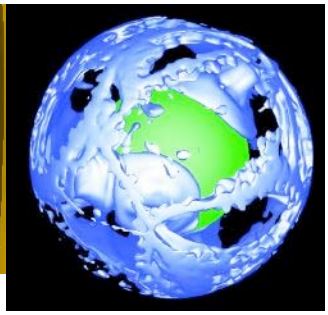
Thunderheads

from Scientific American (Mike Wysession's article, March '95)

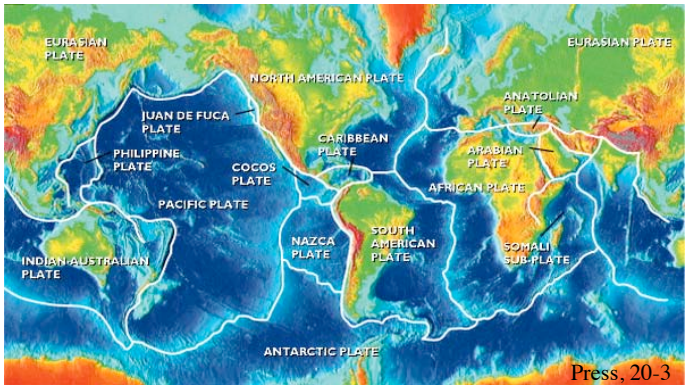


Exotic convection in the Earth's mantle





Map of the major plates



Press, 20-3

Large Numbers
A quick review of exponents

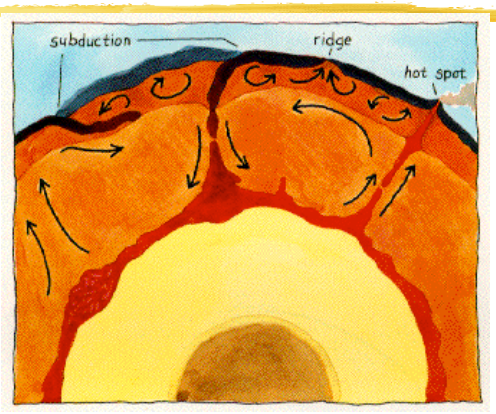
- Thousand = 1,000= 10^3
  - Number of minutes you'll listen to me talk
- Million = 1,000,000 = 10^6
  - Number of people in medium-large city
- Billion = 1,000,000,000 = 10^9
  - Number of people on Earth (5 Billion)
- Trillion = 1,000,000,000,000 = 10^{12}
  - Rough number of dollars in economy

Distance scales

There was machinist named Peter
Who wouldn't accept the new meter
So he gladly retired
And now he's inspired
To drink beer by the pint, not the liter
-Shopdog 05-2000

- Centimeter (cm) about 0.4 inches
- Meter (m) is about 3 ft.
- Kilometer (km) is 1000 m (~10^3 m, ~10^5 cm)
  - 1 km = 0.6 mile
- Continents typically several thousands of km across (~10^3 km, ~10^6 m, ~10^8 cm)
  - North America is about 5000 km across
  - Atlantic about 8000 km wide
  - Pacific about 15,000 km wide

from Scientific American
(Mike Wysession's article, March '95)



Some facts

- Tectonic plates move about 40 mm/year
- This is 40 km per million years
- The mantle is moving at similar velocities
- It takes about 100 million years for the mantle to overturn
- Outer core is liquid, and is also convecting, but much faster
  - creating the Earth's magnetic field