Earthquake Education Outreach to K–12 Students in the Inland Empire

Sally McGill

California State University, San Bernardino

Workshop for Science Educators, 2008 SCEC Annual Meeting

K-12 Outreach

- 2002-05 funding from NSF's Opportunities for Enhancing Diversity in the Geosciences
- 2007 funding from SCEC

Outreach events conducted with 2007 SCEC funding

May 18, 2007	Wells Middle School (VirLynn Burton)	82 students
May 25, 2007	Badger Springs Middle School	55 students
June 1, 2007	Wells Middle School (Gregg Mitchell)	111 students
June 1, 2007	Cope Middle School	34 students
Nov. 16, 2007	Lytle Creek Elementary	25 students
Mar. 12, 2008	Moore Middle school	70 students

Over 350 students reached

K-12 Outreach

- Typically 60 or 90 students
  - Group 1: hands-on activities in the classroom
  - Group 2: hike to San Andreas fault
  - (Group 3: campus tour)
  - Groups rotate after ~ 1.5 hours
- Mostly 6th grade classes
- Some high school classes

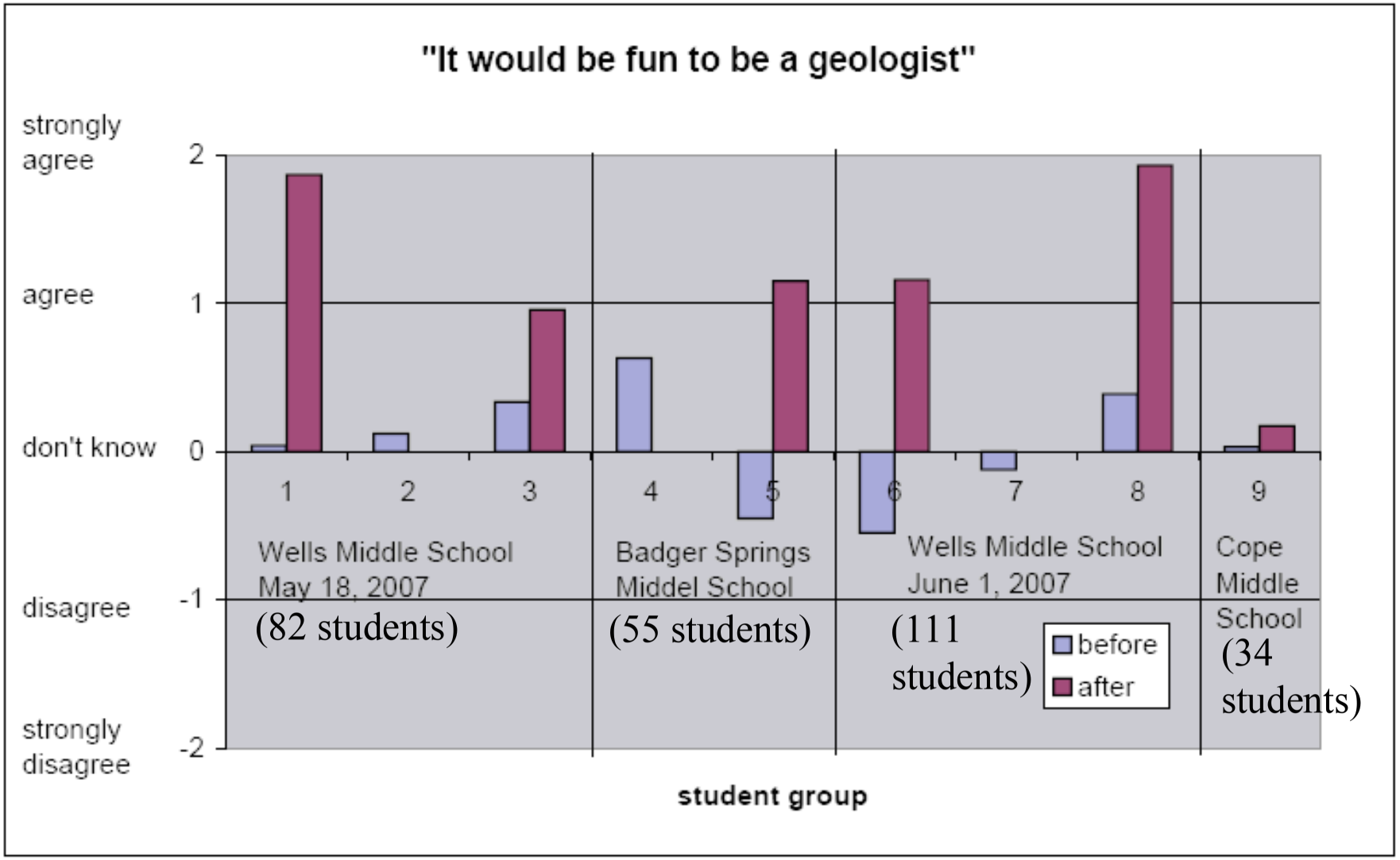
Hike to San Andreas fault

In the classroom

- What would you like to do for a career?

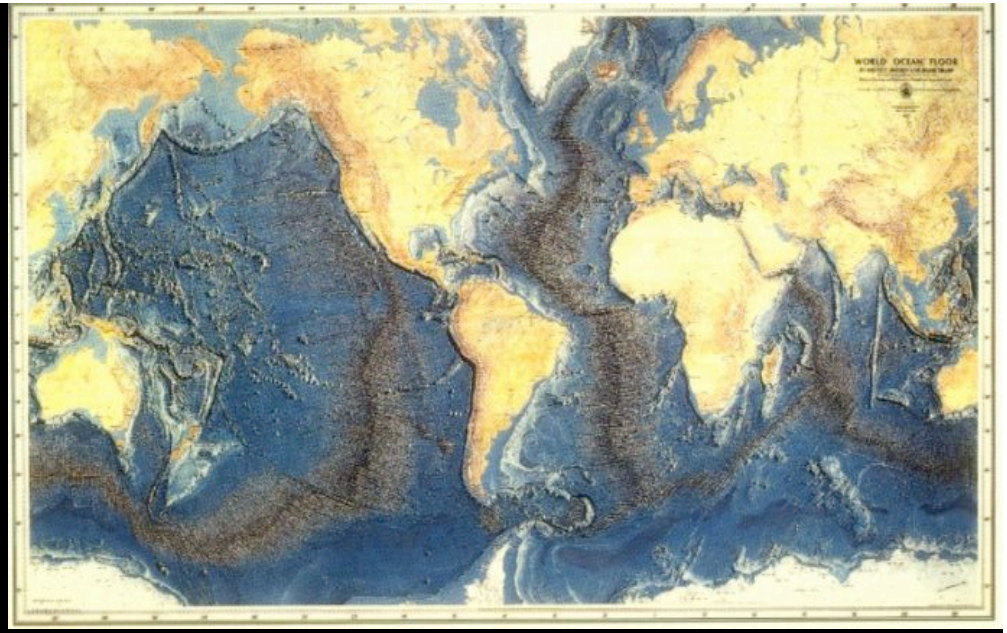
Career Choices

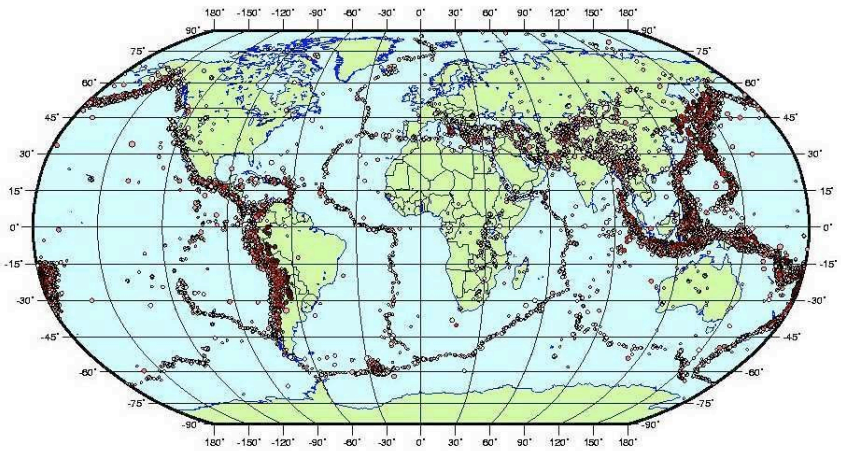
- It would be fun to be a geologist
  - strongly agree
  - agree
  - disagree
  - Strongly disagree
  - Don’t know

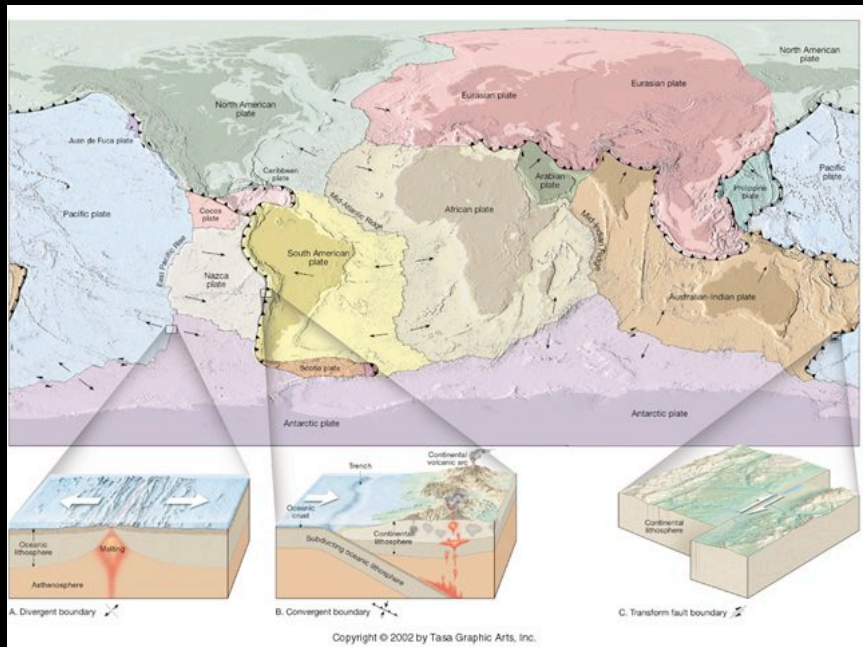

"It would be fun to be a geologist"
strongly agree
agree
don't know
disagree
strongly disagree
2
1
0
-1
-2
1
2
3
4
5
6
7
8
9
Wells Middle School May 18, 2007
(82 students)
Badger Springs Middel School
(55 students)
Wells Middle School June 1, 2007
(111 students)
Cope Middle School
(34 students)
before
after
student group

Science

- Observation
- Hypothesis
- Experiment
- Conclusion

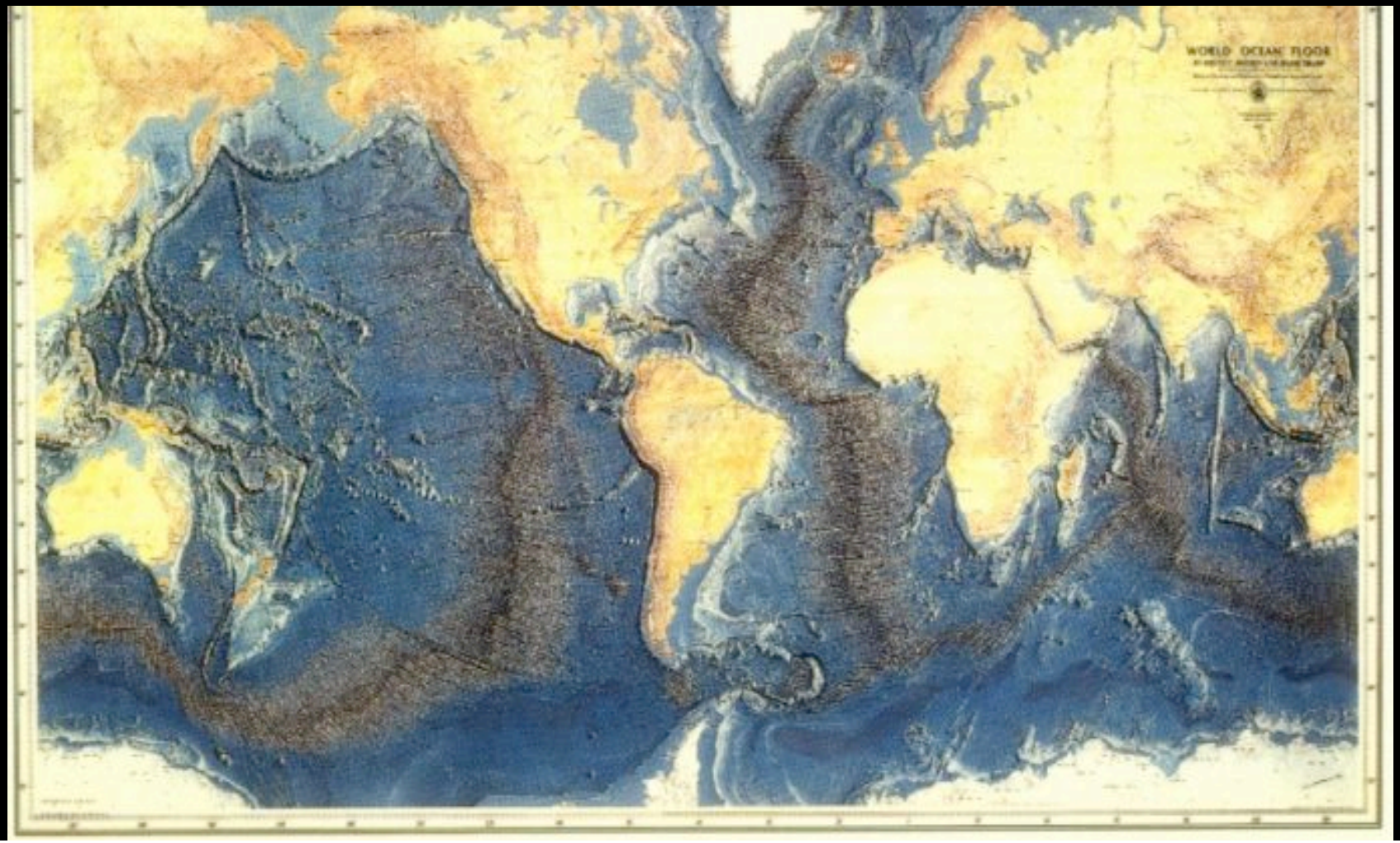






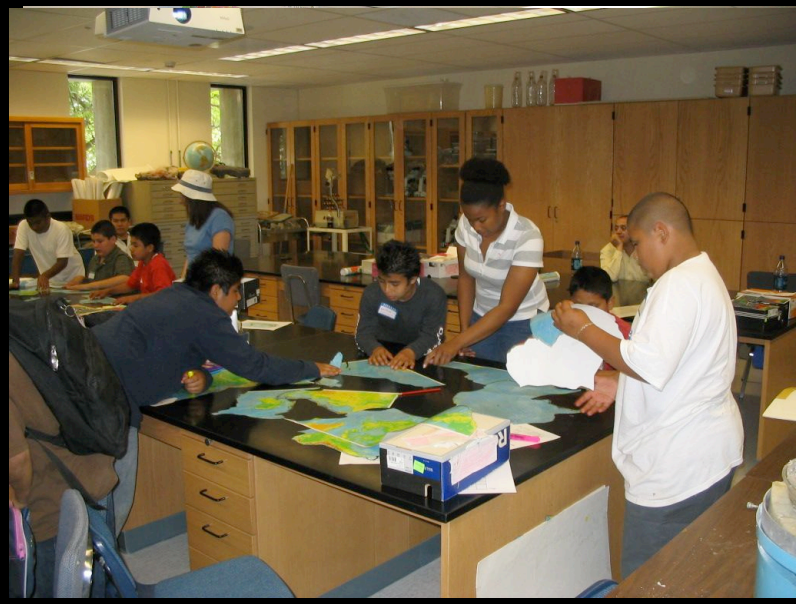
SMALL GROUP DISCUSSION:

What observations can you make about the Earth from a globe or a map?



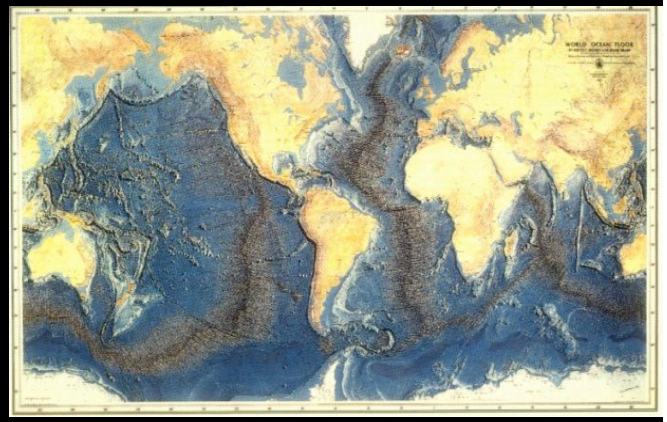
SMALL GROUP ACTIVITIES:

- Introduce activity to the whole class
- One undergraduate student works with each group of 5-6 K-12 students
- Undergrads help K-12 students to understand the activity

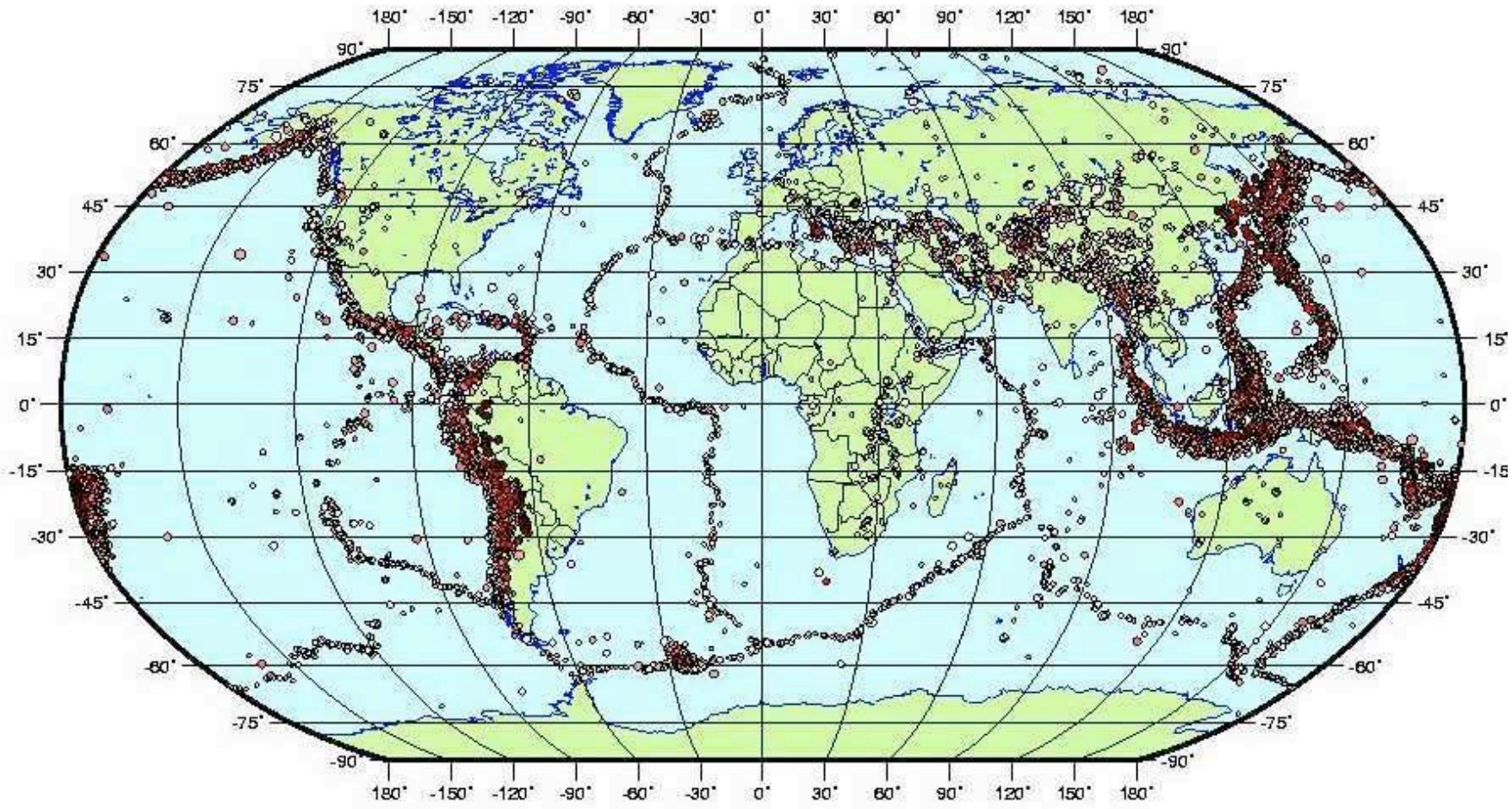


Hypothesis: Continental Drift

- Can continents really move?
- How?
- Would that cause earthquakes?
- What can we learn about the earth from earthquakes?
- Let's look at where earthquakes occur to see if we can find any patterns.
    - SeisVolE demo
    - http://pods.binghamton.edu/~ajones/



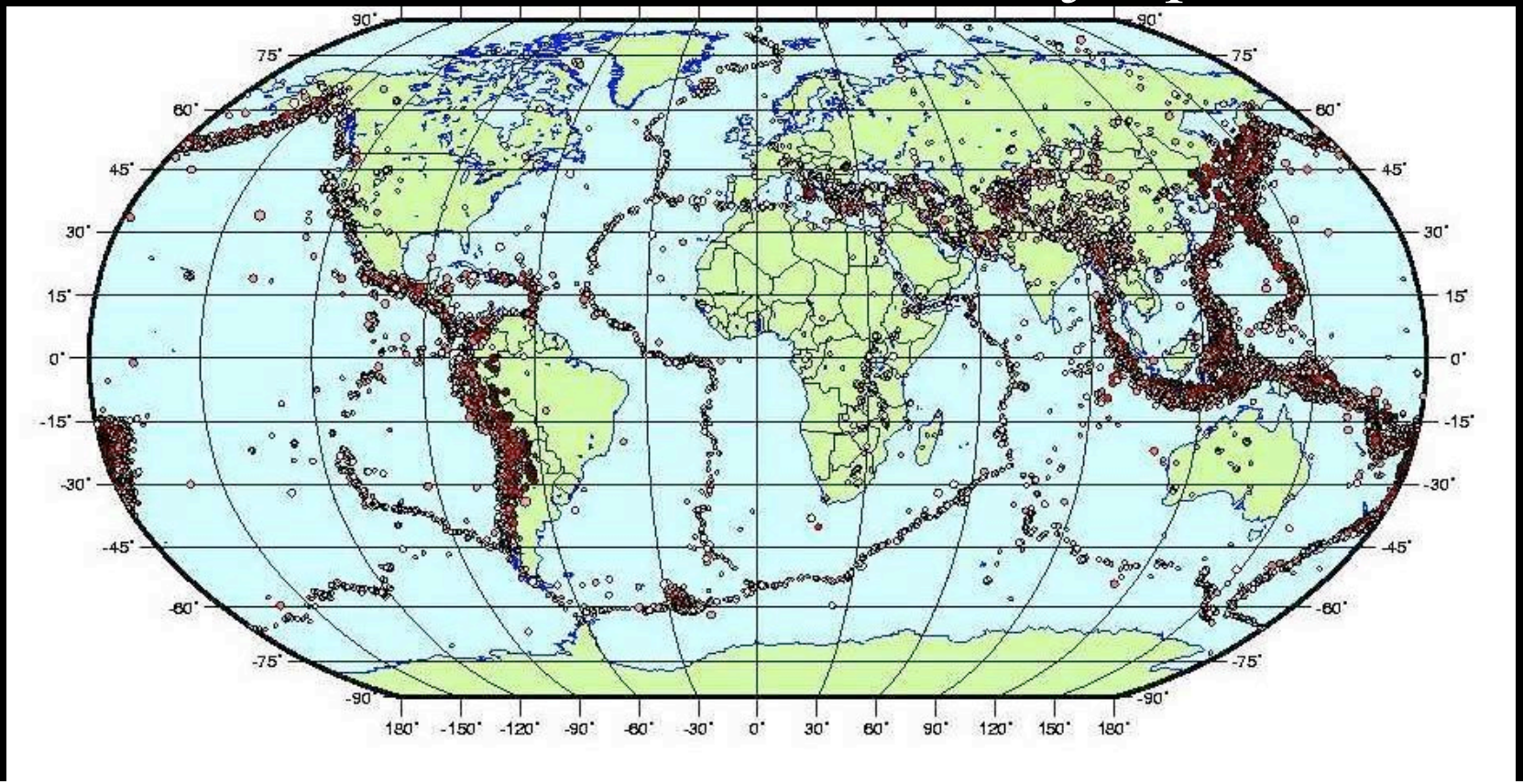
What patterns do you see?
What hypothesis can you come up with to explain these patterns?

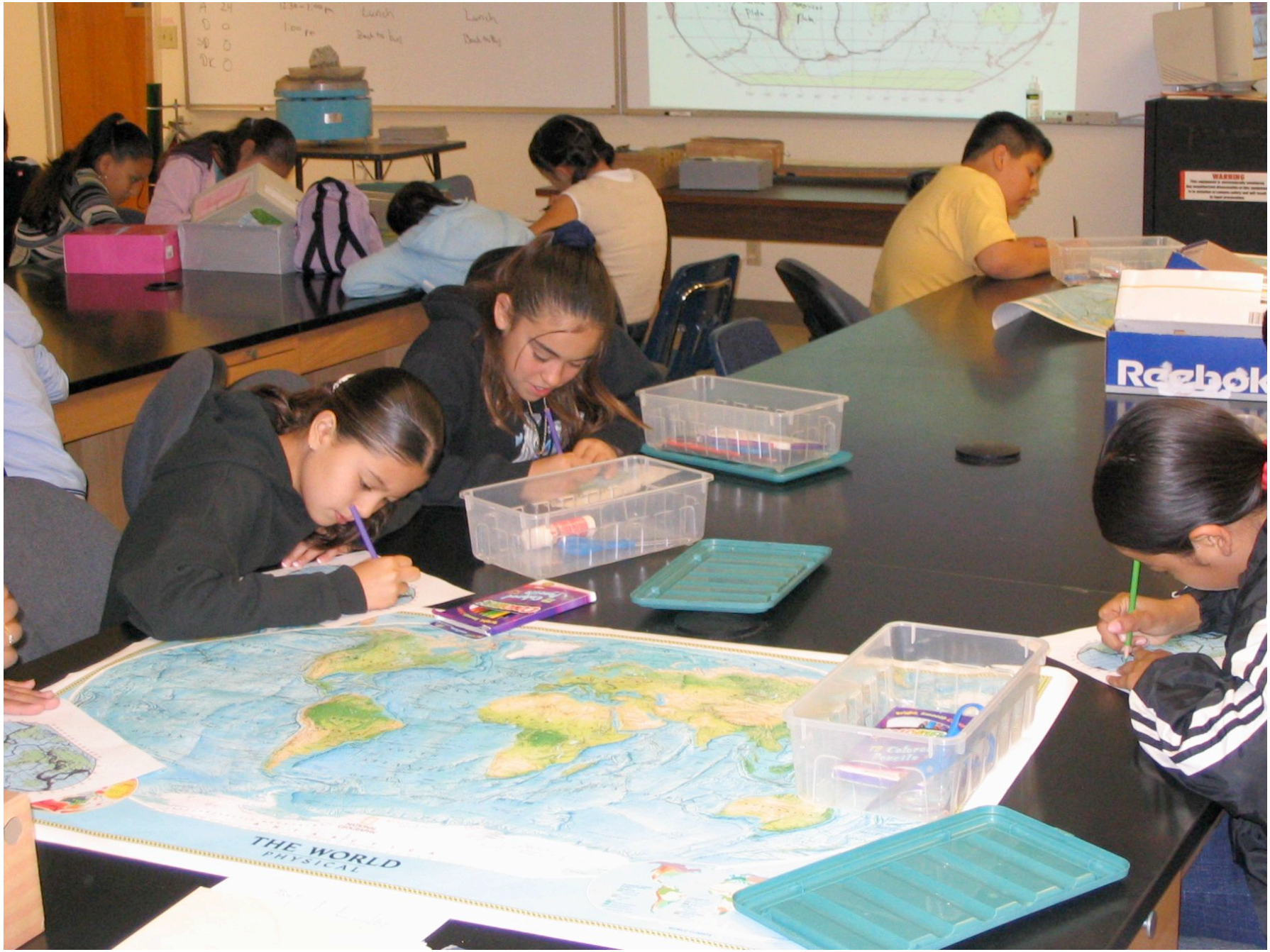


SMALL GROUP ACTIVITY

Hypothesis: Plate Tectonics

- Connect the dots (earthquake locations) to show the outlines of the tectonic plates
- Label the names of some of the major plates

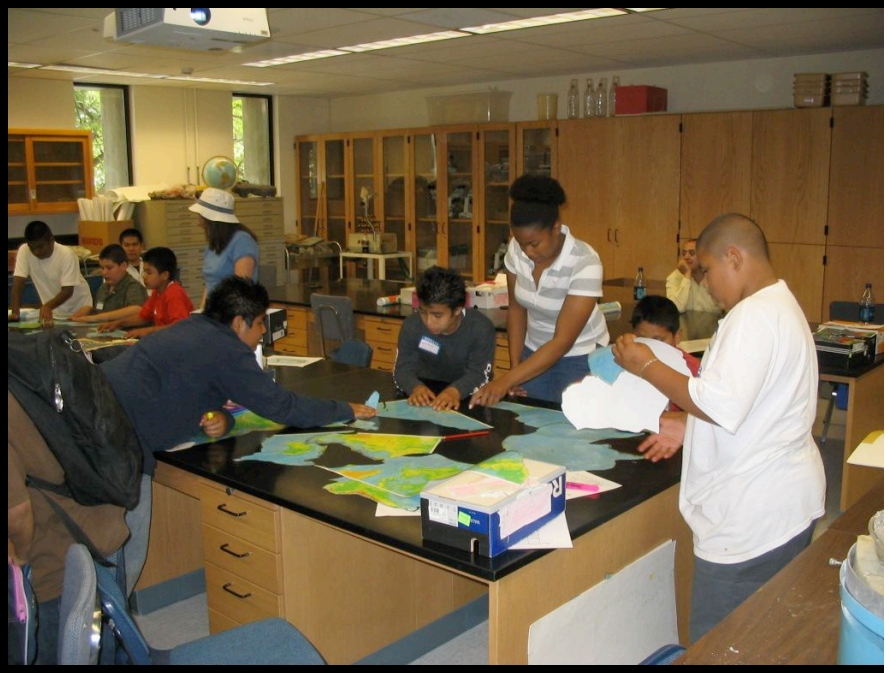



THE WORLD
PHYSICAL

SMALL GROUP ACTIVITY

Plate Tectonics Puzzle

Lesson plan: Larry Braile, Purdue University, and Shirley Braile, Happy Hollow Elementary School



Map:
Simkin, T., J. D. Unger, R. I. Tilling, P. R. Vogt and H. Spall, This Dynamic Planet, World Map of Volcanoes, Earthquakes, Impact Craters and Plate Tectonics, 1994.

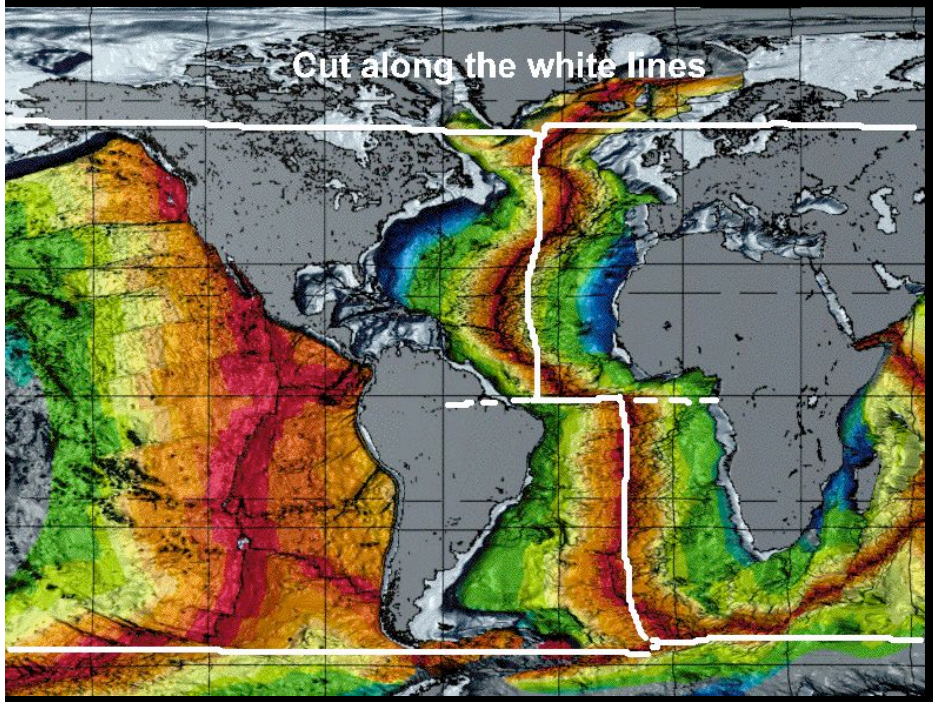
SMALL GROUP ACTIVITY

Plate Tectonics Puzzle

- Become familiar with the major plates
- Could Africa and South America have been connected in the past? How?
- What is in between Africa and South America today?
- How did it get there?

SMALL GROUP ACTIVITY

- Build a shoe-box model that demonstrates how new sea floor was created as Africa and South America drifted apart



http://www.ngdc.noaa.gov/mgg/image/AtlanticAge.jpg

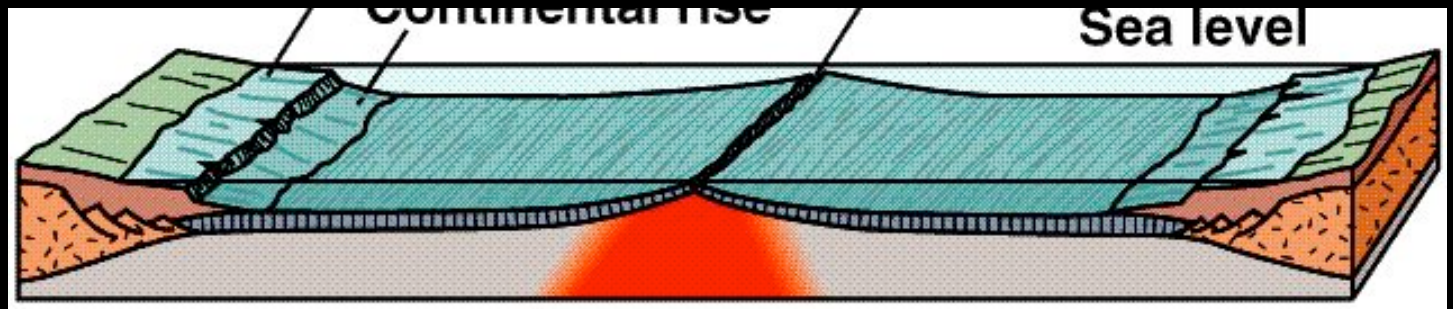
SMALL GROUP ACTIVITY

- Questions
  - –How would you explain this model to your parents or to a friend?
  - –How is new sea floor created?
  - –How could we test the hypothesis of sea-floor spreading?

Sea-floor spreading

- How could we test the hypothesis of sea-floor spreading? What does this hypothesis predict?

- Observation
- Hypothesis
- Prediction
- Experiment
- Conclusion



C Continental sediments blanket the subsiding margins to form continental shelves and rises. The ocean widens and a mid-oceanic ridge develops (Atlantic Ocean).

Oceanic crust

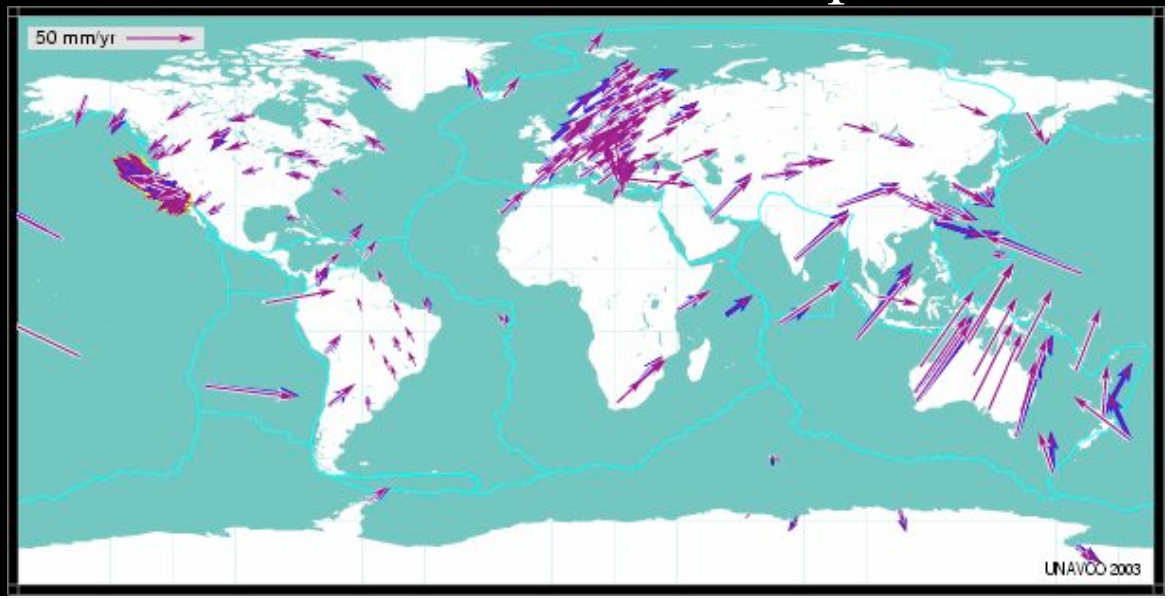
Oceanic crust

Sea-floor spreading

- How could we test the hypothesis of sea-floor spreading? What does this hypothesis predict?
  1. Africa and South America should still be moving away from each other today

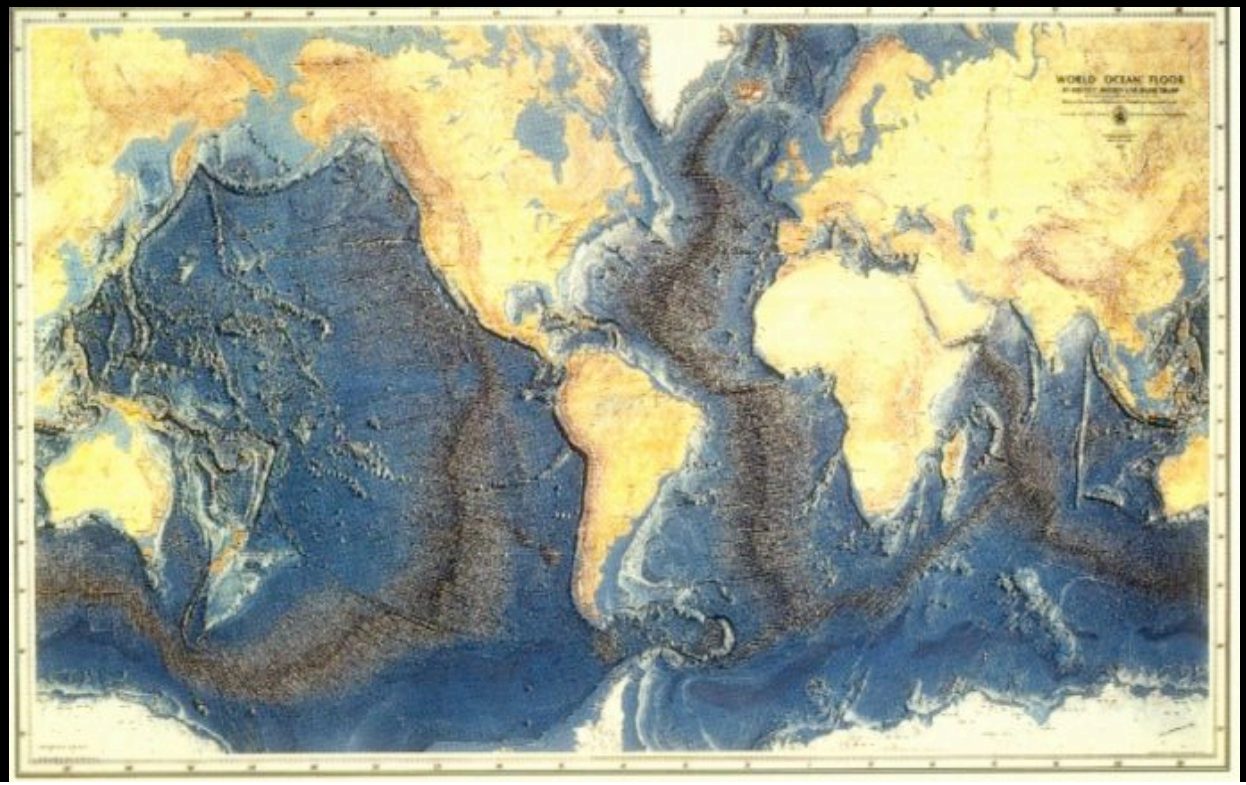
Global Positioning System

- Can measure the movement of the plates



Sea-floor spreading

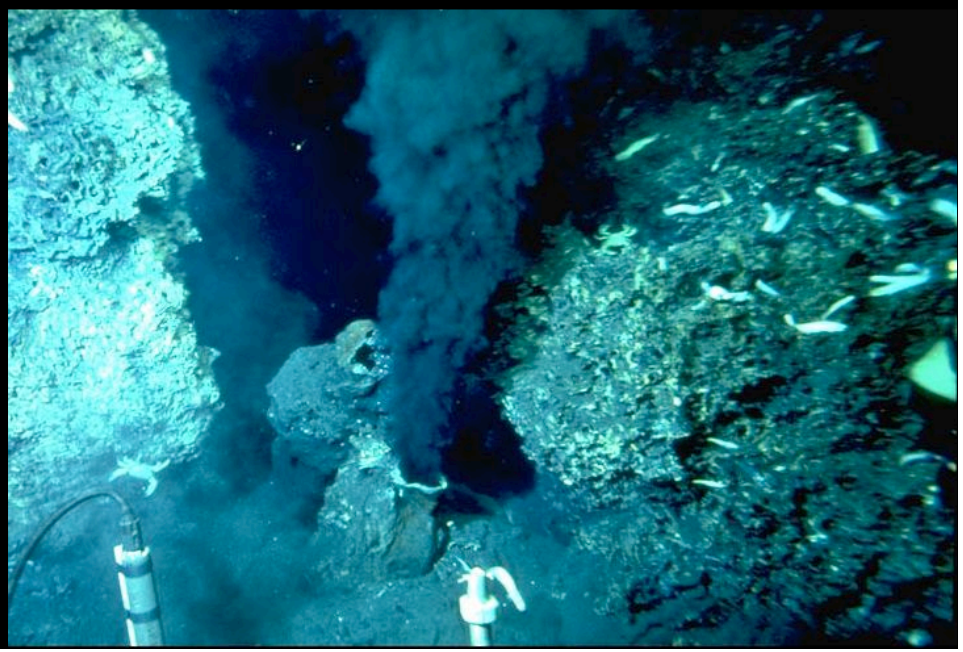
- How could we test the hypothesis of sea-floor spreading? What does this hypothesis predict?
  2. Volcanoes in the middle of the Atlantic Ocean (to create the new sea floor)

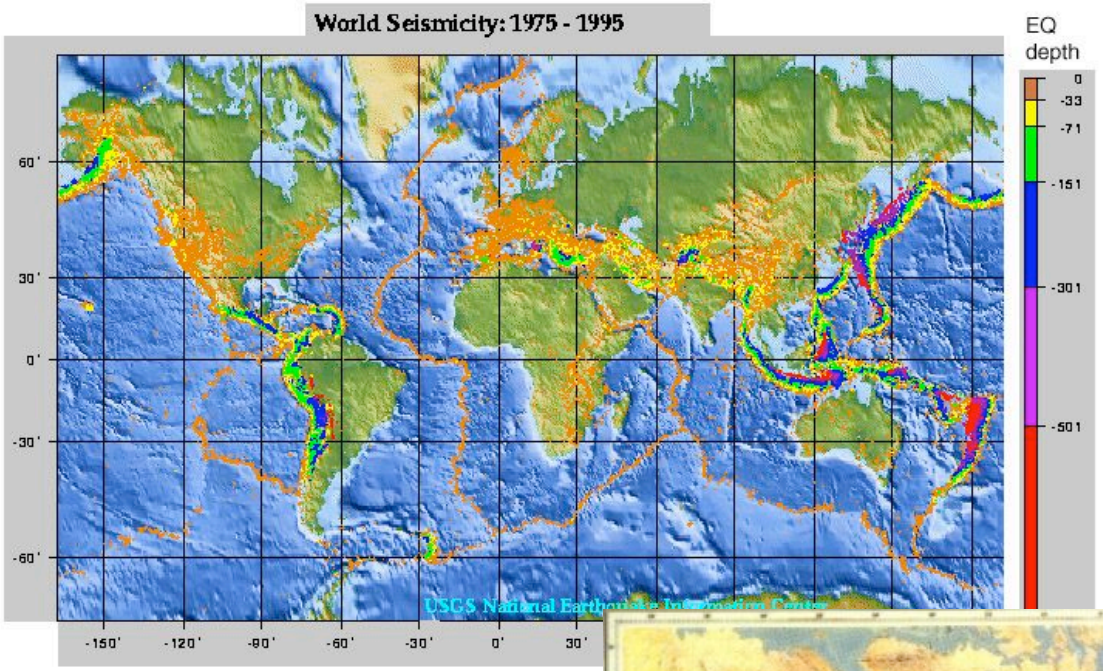


Fractures along a mid-ocean ridge

Pillow basalt along mid-ocean ridges– when basaltic lava erupts underwater, it forms pillows

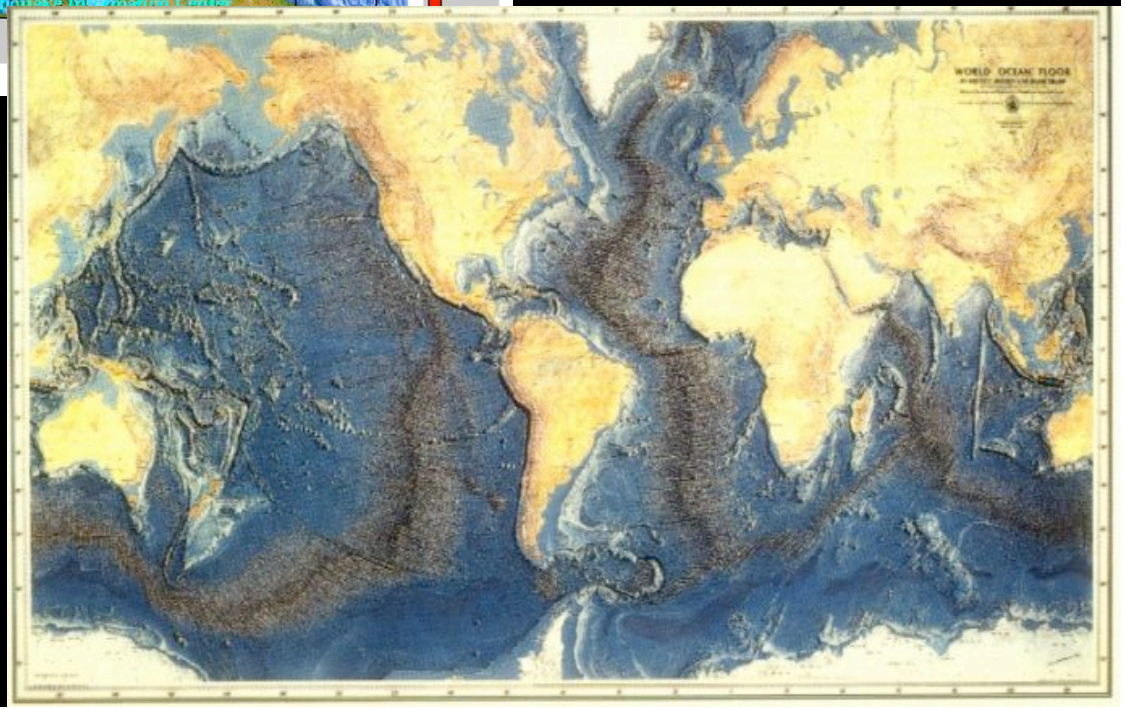
Hot springs along mid-ocean ridges, known as "black smokers"



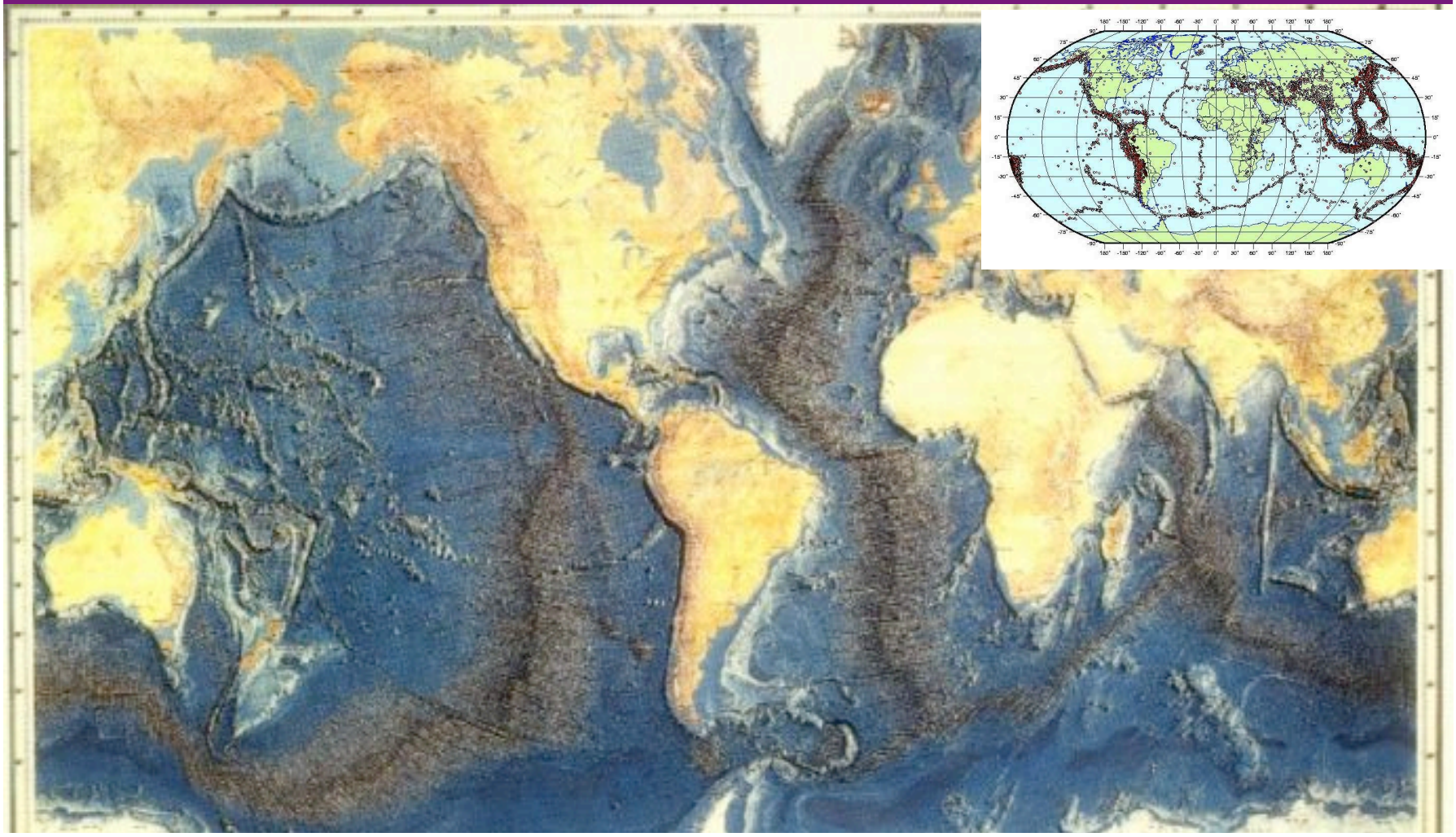


Earthquakes and underwater volcanoes occur along mid-ocean ridges.

Plates move away from each other (diverge) at mid-ocean ridges

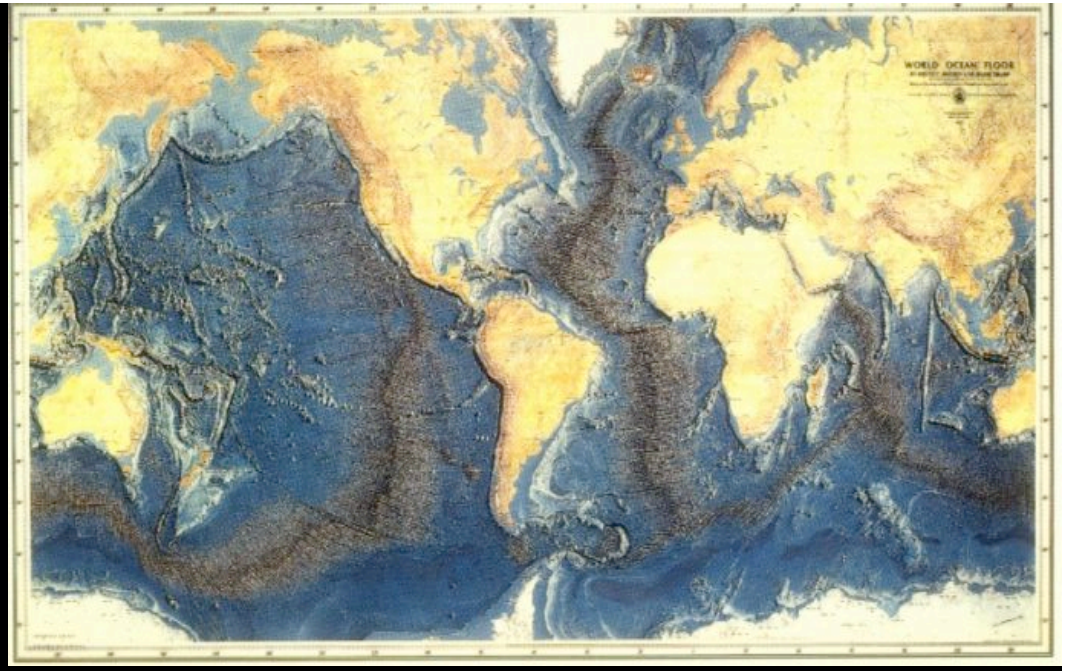


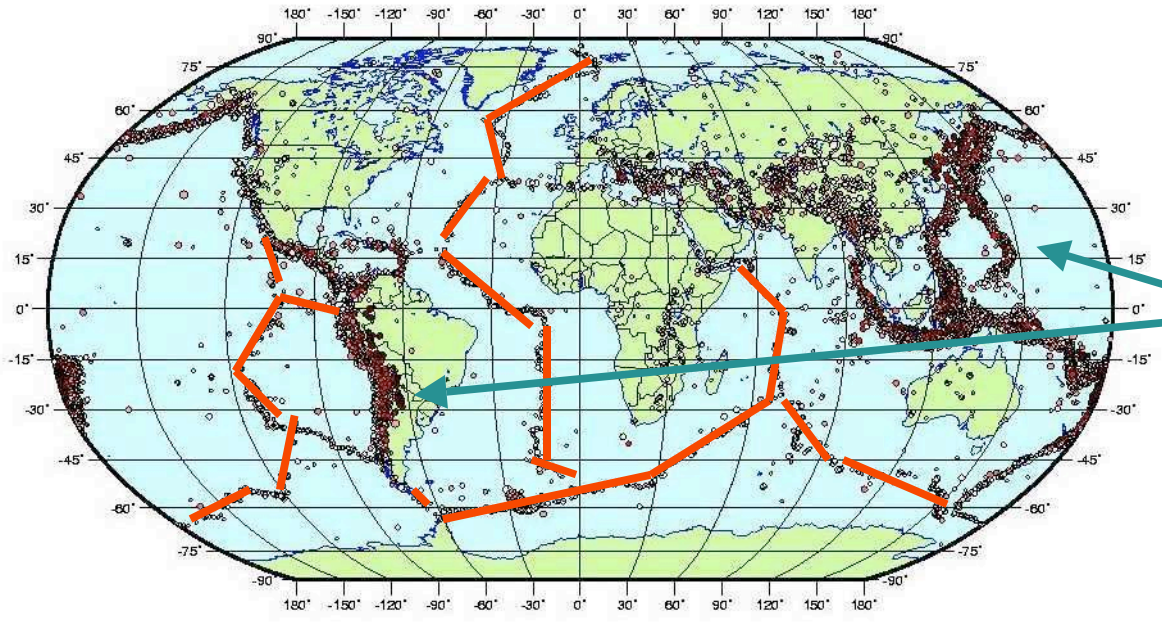
SMALL GROUP ACTIVITY: Color the mid-ocean ridges red on your world earthquake map.



These are places where plates are moving away from each other

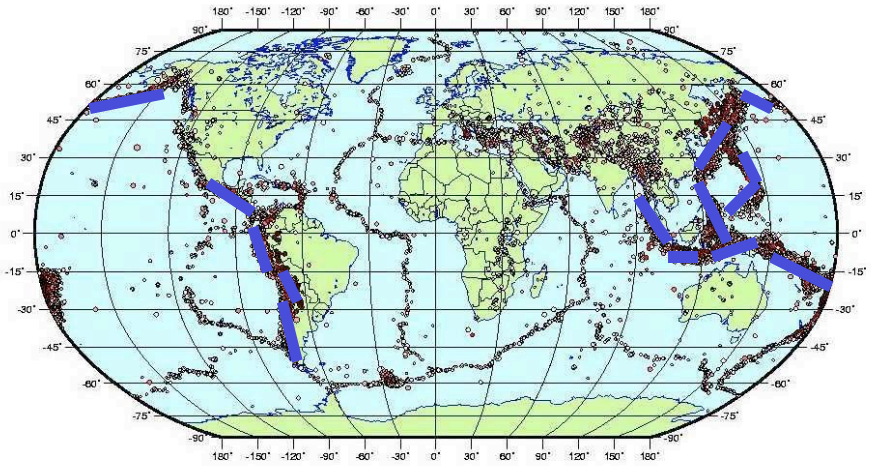
Many of the world's earthquakes occur at mid-ocean ridges, where plates are spreading away from each other.

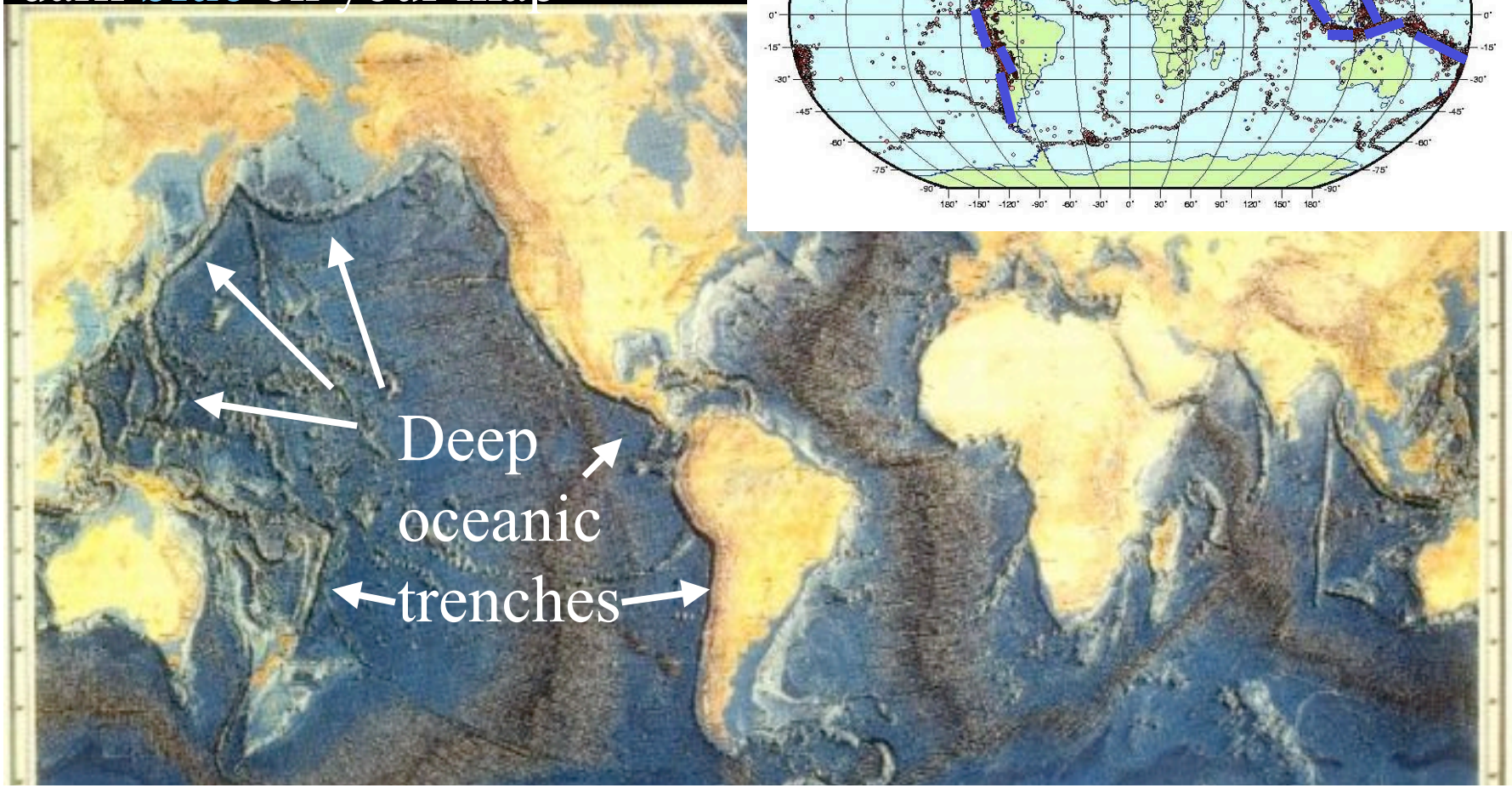




But not all of them. What about these earthquakes? What is unusual about the ocean floor here?

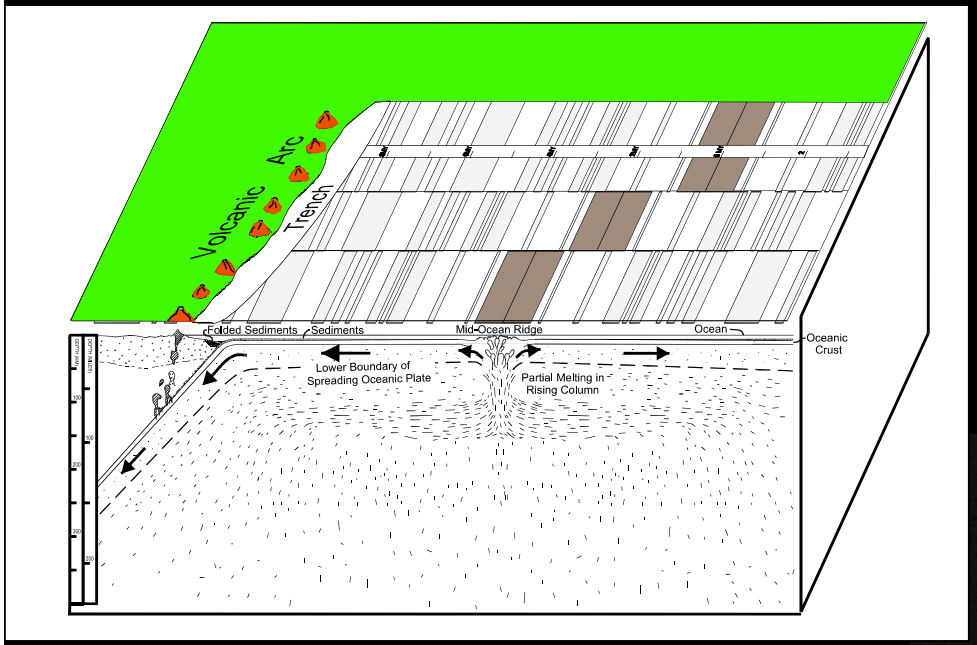
SMALL GROUP ACTIVITY:
Color the deep ocean trenches dark **blue** on your map

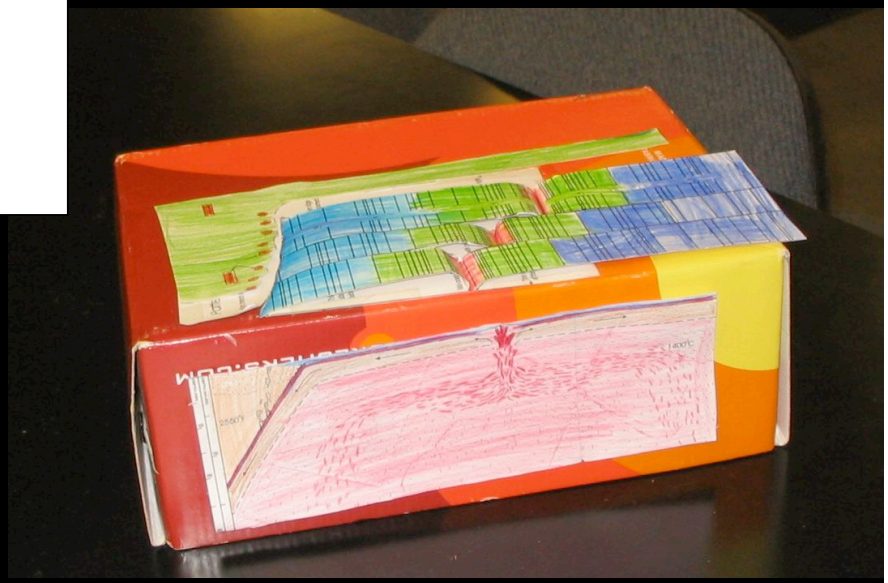




What do you think is happening to cause earthquakes at the deep oceanic trenches (and volcanoes nearby)?

Table 1: Build a shoe-box model showing both subduction and sea-floor spreading





Lahr, J. C., How to build a model illustrating sea-floor spreading and subduction, U.S. Geological Survey Open-File Report 99-132, 16 pp., 1999.

http://pubs.usgs.gov/of/1999/ofr-99-0132

etnies

X-ACTO FOLD-OUT DISPLAY

Rotating Groups

Table 1: Elastic rebound and the earthquake cycle

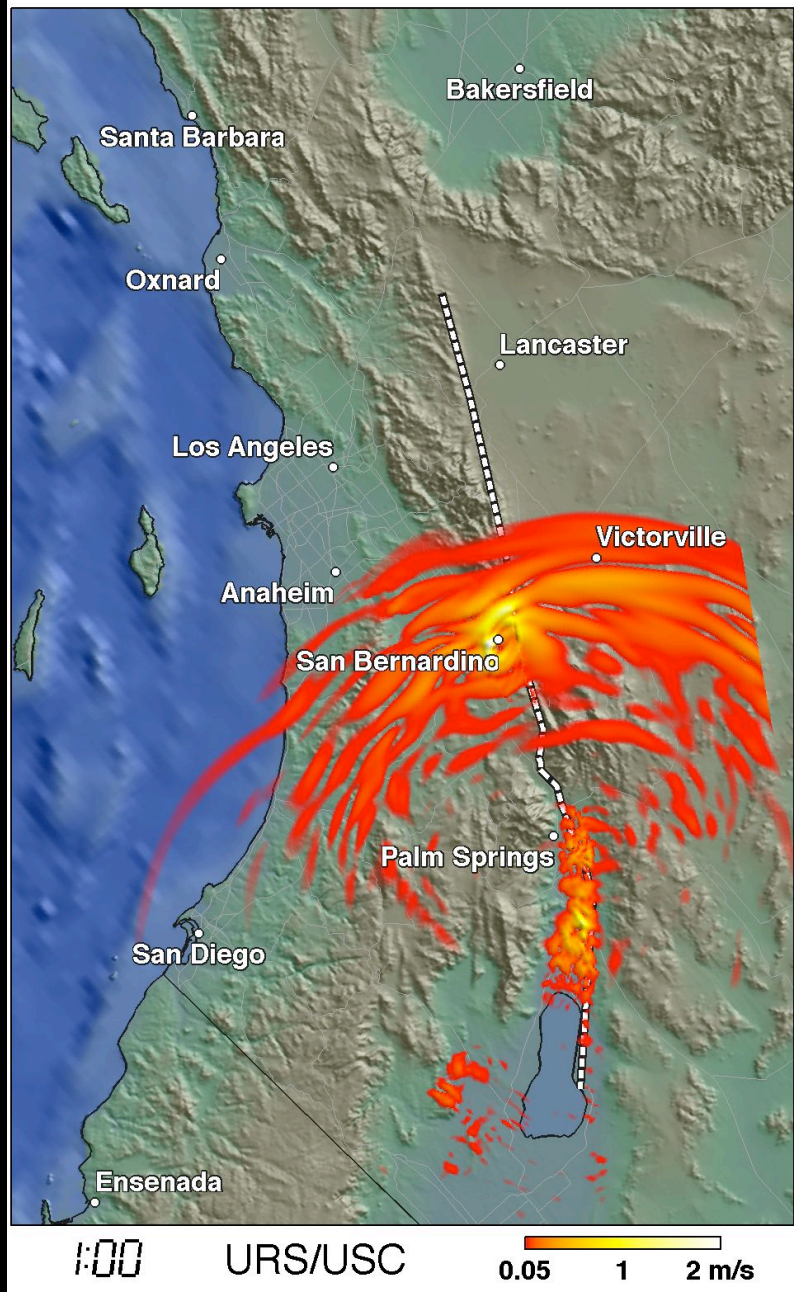
Table 2: Liquefaction demonstration

Table 3: Tsunami demons-tration

http://quake.usgs.gov/research/deformation/modeling/eqmodel.html

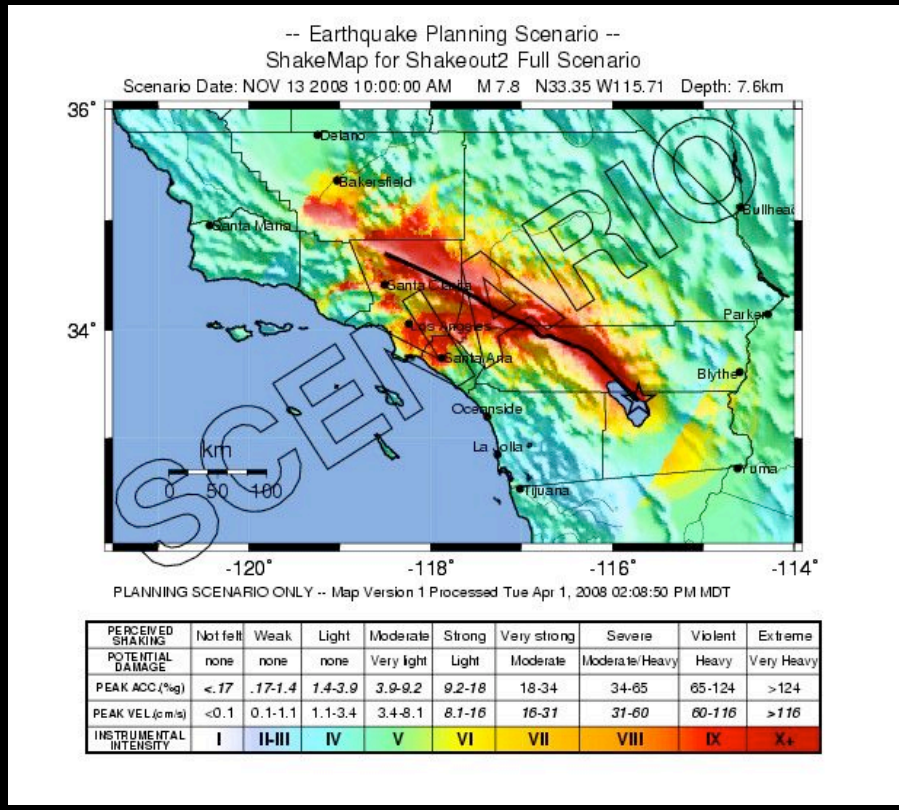
ShakeOut

- Geol 210
  - Undergraduate, general education course on earthquakes
  - 72 students per quarter
  - ShakeOut drill will occur during our class
  - Nov. 13, 2008, 10:00 am



ShakeOut

- Geol 210
  - Modify existing in-class and homework exercises to be relevant for ShakeOut
    - Estimating earthquake magnitude from fault length
    - Estimating strength of shaking from magnitude and distance



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	*8.1-16*	*16-31*	*31-60*	*60-116*	*>116*
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

ShakeOut

- Geol 210
  - New journaling exercise(s) on how the ShakeOut scenario earthquake (and aftershocks) would affect students' lives
  - Resources
    - http://pubs.usgs.gov/of/2008/1150/ (312 pp)
    - Sue Perry's "Golden Guardian 2008 Scenario Situational Assumptions"
      - San Bernardino County (25 pp. plus tables)
      - Riverside County

- Have you been able to get home? When? How?
- If not, where did you stay?

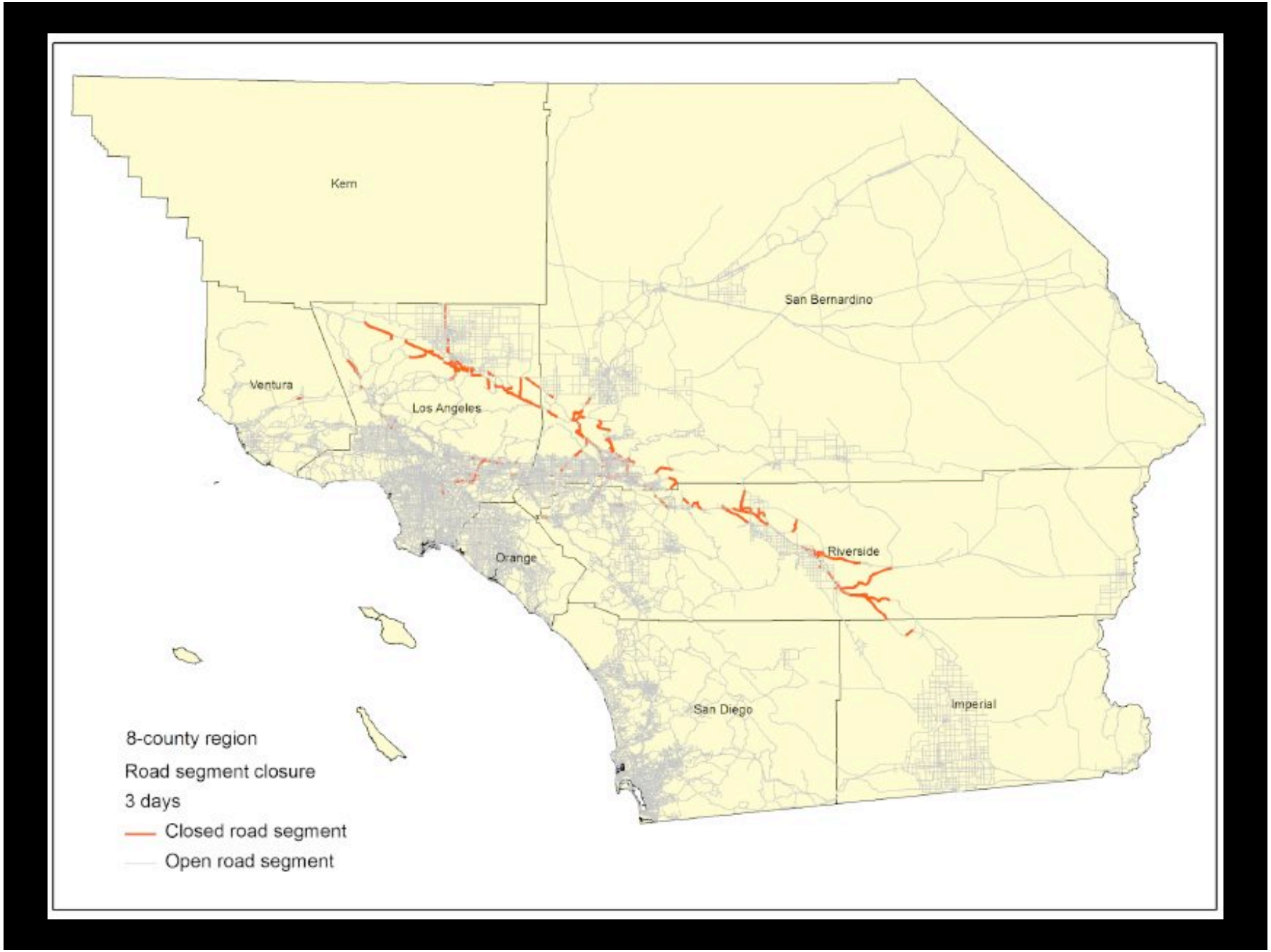
TRANSPORTATION

Fault Surface Rupture

Damage from fault surface rupture takes two or more months to repair. These include I-15, State Highway 66, Waterman Blvd, CA highways 30 and 138. (For complete list of roads that cross the fault where it ruptures, and amount of offset, see ShakeOut Scenario Appendix D, Fault Crossings.)

Highway Shaking Damage

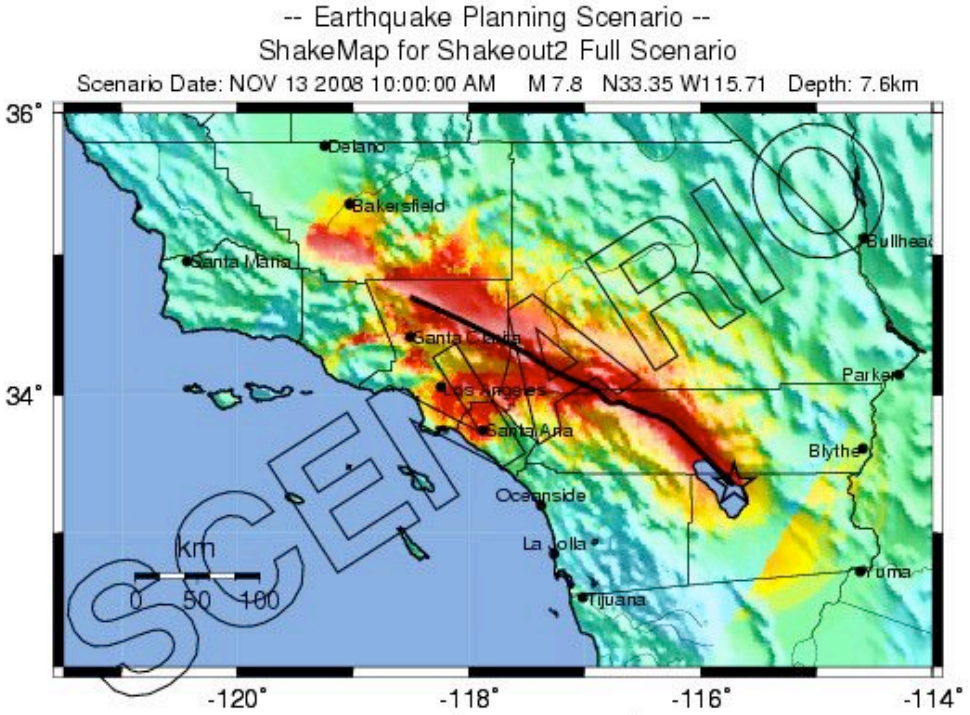
Concentrated highway bridge damage due to ground shaking occurs in Cajon Pass and along the I-10, I-15, I-215, California Highways 30 and 138. It will take up to seven months to restore highway segments affected by bridge damage, fault offsets, landslides and liquefaction, and bridge rebuilding is the critical factor in reopening a highway segment. Irreparable bridge damage will take 5-7 months to rebuild, and one month to open the roads beneath the bridges. Extensive damage and moderate damage will take weeks and days to repair, respectively. (See Highway Closures Over Time maps and tables.)


Kern
San Bernardino
Ventura
Los Angeles
Orange
Riverside
San Diego
Imperial
8-county region
Road segment closure
3 days
Closed road segment
Open road segment


Barstow
San Bernardino
I-15
Cajon Pass
s Angeles
Orange
Riverside
Indio
I-10
Closed for 2-7 weeks
San Diego
Imperial

ShakeOut

- What was the MM intensity of shaking at your home?
- What type of damage did your home sustain, and is it safe to live in?



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PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	*8.1-16*	*16-31*	*31-60*	*60-116*	*>116*
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

ShakeOut

- How long was the electric power out at your home?

Power

Most areas will immediately lose power. Restoration is as follows:

Day	% with electrical service
1	40
3	85
21	100

ShakeOut

- For how long was clean water unavailable at your home?

Water

Outages and restoration depend on intensity (MMI) of ground motion. (see Scenario Shakemap. for intensity distribution)

For MMI < VI, no disruption of service.

For MMI VI and VII, 20% of customers will lose water service, with restoration as follows:

Day	% with water service
1	20
14	100

For MMI VIII, IX, X, 50% of customers will lose service, with restoration as follows:

Day	% with water service
1	50%
14	60%
21	70%
28	78%
5 wks	85%
6 wks	90 %
8 wks	95%
6 months	100%

ShakeOut

- How many fatalities occurred in the city where you live?

SAN BERNARDINO COUNTY

	Fatal Injuries	Non-Fatal Injuries						
	Fatalities	Trauma Injuries (Requires trauma care & hospitalization)	Other Hospitalized Injuries (Non-trauma)	*Total Hospitalized Injuries*	Injuries Requiring Emergency Department (ED) Visits (without hospitalization)	Injuries Treated on an Outpatient Basis	Total Injuries	*Hospital Visits Requiring EMS transport*
City	#	#	#	#	#	#	#	#
UNINCORPORATED	7	2	13	15	557	1,035	1,614	32
ADELANTO	0	0	0	0	8	17	25	0
APPLE VALLEY	0	0	0	0	14	29	43	0
BARSTOW	0	0	0	0	1	2	3	0
BIG BEAR LAKE	0	0	0	0	2	4	6	0
CHINO	2	0	3	3	124	232	361	7
CHINO HILLS	0	0	0	0	23	46	69	1
COLTON	10	2	13	15	430	756	1,211	30
FONTANA	4	1	6	7	285	536	832	15
GRAND TERRACE	0	0	0	0	20	38	58	1
HESPERIA	0	0	0	0	34	69	103	1
HIGHLAND	6	1	8	9	292	514	821	20
LOMA LINDA	4	1	6	7	216	387	614	14
MONTCLAIR	2	0	3	3	130	244	379	7
NEEDLES	0	0	0	0	0	0	0	0
ONTARIO	3	1	6	7	309	590	909	16
RANCHO CUCAMONGA	4	1	8	9	346	652	1,011	19
REDLANDS	18	4	23	27	795	1,394	2,234	56
RIALTO	9	2	15	17	562	1,016	1,604	36
SAN BERNARDINO	52	13	72	85	2,520	4,460	7,117	172
TWENTYNINE PALMS	0	0	0	0	0	1	1	0
UPLAND	3	1	4	5	190	354	552	11
VICTORVILLE	0	0	0	0	26	55	81	1
YUCAIPA	3	1	7	8	262	477	750	16
YUCCA VALLEY	0	0	0	0	3	7	10	0
TOTAL	**128**	**30**	**187**	**217**	**7,149**	**12,914**	**20,408**	**454**

ShakeOut

- What is the nearest hospital to your home that can accept new patients?

San Bernardino

Hospital	City	Licensed Acute Care Beds	Type of ED	Trauma Designation	Status*
ARROWHEAD REGIONAL MEDICAL CENTER	COLTON	373	Basic	Level II	Red
BARSTOW COMMUNITY HOSPITAL	BARSTOW	56	Basic		Red
BEAR VALLEY COMMUNITY HOSPITAL	BIG BEAR LAKE	30	Standby		Black
CHINO VALLEY MEDICAL CENTER	CHINO	126	Basic		Black
COLORADO RIVER MEDICAL CENTER	NEEDLES	25	Basic		Green
COMMUNITY HOSPITAL OF SAN BERNARDINO	SAN BERNARDINO	321	Basic		Red
DESERT VALLEY HOSPITAL	VICTORVILLE	83	Basic		Yellow
HI-DESERT MEDICAL CENTER	JOSHUA TREE	179	Basic		Yellow
KAISER FND HOSP - FONTANA	FONTANA	440	Basic		Red
LOMA LINDA UNIVERSITY MEDICAL CENTER	LOMA LINDA	671	Basic	Level I Adult/Ped	Red
MONTCLAIR HOSPITAL MEDICAL CENTER	MONTCLAIR	102	Basic		Red
MOUNTAINS COMMUNITY HOSPITAL	LAKE ARROWHEAD	35	Standby		Yellow
REDLANDS COMMUNITY HOSPITAL	REDLANDS	176	Basic		Red
SAN ANTONIO COMMUNITY HOSPITAL	UPLAND	283	Basic		Red
ST. BERNARDINE MEDICAL CENTER	SAN BERNARDINO	463	Basic		Red
ST. MARY REGIONAL MEDICAL CENTER	APPLE VALLEY	186	Basic		Yellow
VICTOR VALLEY COMMUNITY HOSPITAL	VICTORVILLE	99	Basic		Yellow

Status:
Green = May have some damage, but functioning at or near normal levels
Yellow = Some damage, but able to continue functioning; Can take on limited new cases
Red = Significant damage; Can take on no new cases; Closing hospital doors; Need no outside assistance
Black = Need to evacuate; Need outside assistance to evacuate

ShakeOut

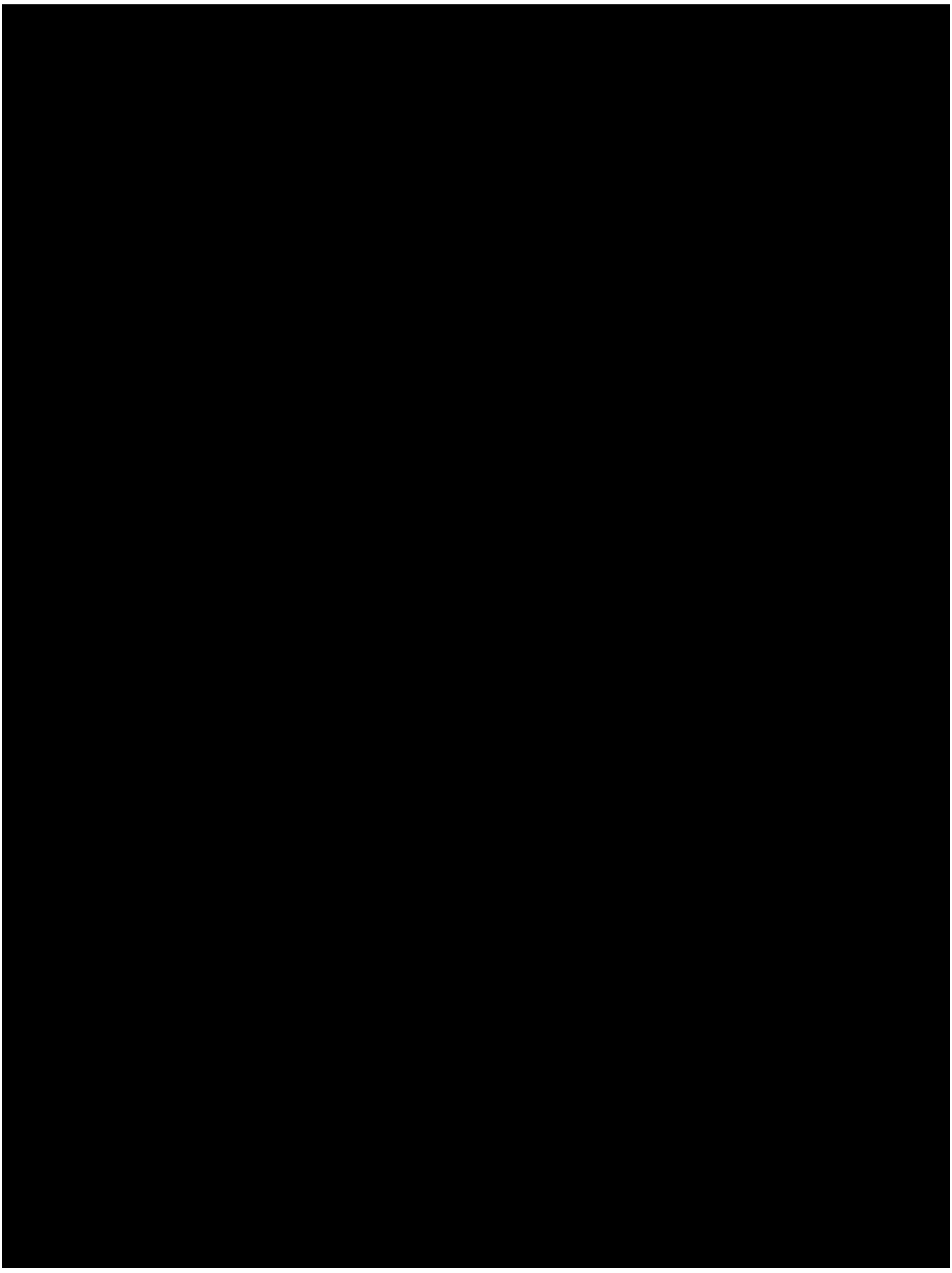
- Where were your family members at the time of the quake?
  - Have you been able to get in contact with all family members?
  - When? How?

Table Physical damage to telecommunications facilities and quantities of facilities affected.

Region	Location	CO/ MTX/ Remotes	Cell sites	911 PSAP centers	No service	Normal service	Extent of no service
1	Within approximately 30 km of the Ontario Airport.	15-20	40+	5-8	1 day	2 days	10,000-20,000 addresses NE of I-10/I-210
3	Eastern San Bernardino Valley (Colton, San Bernardino, Highland, Redlands)	15-20	40+	8-10	2-4 days	4-5 days	40,000-50,000 addresses

ShakeOut

- How much gas was in your tank?
- How much cash did you have on hand?
- What did you eat for the first few days?
- Where did you get water?
- What other changes affected your daily life?
- How many fatalities occurred in the city where you live?
- What is the nearest hospital to your home that can accept new patients?



ShakeOut

- Have you been able to get home? When? How?
  - If not, where did you stay?
  - What was the MM intensity of shaking at your home?
  - What type of damage did your home sustain, and is it safe to live in?
  - How long was the power out at your home?
  - Where were your family members at the time of the quake?
    - Have you been able to get in contact with all family members?
    - When? How?
  - How much gas was in your tank?
  - How much cash did you have on hand?
  - What did you eat for the first few days?
  - Where did you get water?
  - What other changes affected your daily life?
  - How many fatalities occurred in the city where you live?
  - What is the nearest hospital to your home that can accept new patients?

http://quake.usgs.gov/research/deformation/modeling/eqmodel.html