

EXAM 2a

EAS1601 How to Build a Habitable Planet

March 13, 2012

- **Answer all questions**
- **Place your name and lab section on each page**
- **This is a closed-book exam; all are expected to comply with Georgia Tech Honor Code**
- **No calculators allowed**
- **Explanations must be clear and concise (no more than two sentences – only the first two sentences will be graded)**
- **You may leave your answers in mathematical form (i.e., it is not necessary to calculate quantities.)**

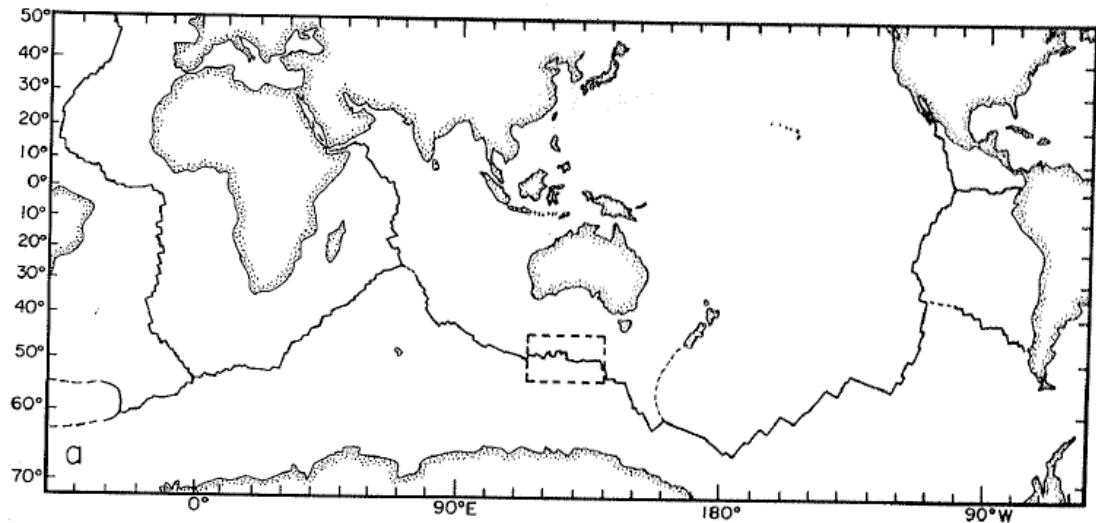
I am aware and in compliance with the Georgia Tech Honor Code

Signature: _____

Name (print): _____

Lab section: _____

- 1) Australia and Antarctica are separated by 7000 km, and separated by seafloor containing the SE Indian Ridge (indicated by dashed box).



- a) (2 pts) Are Australia and Antarctica moving away from each other or towards each other? **Away from each other**
- b) (6 pts) If the full spreading rate of the SE Indian Ridge is 7 cm/yr (half spreading rate 3.5 cm/yr), how old is the oldest seafloor in between Australia and Antarctica? Where is this old seafloor located (mark on the map)?

$= (3500 \text{ km} \times 10^5 \text{ cm/km}) / (3.5 \text{ cm/yr}) = 10^8 \text{ yr} = 100,000,000 \text{ yr} = 100 \text{ million years. Located near Antarctica and near Australia}$

- c) (4 pts) If the last magnetic reversal occurred 800,000 years ago, how far away from the ridge do the rocks with normal magnetism extend?

$= (3.5 \text{ cm/yr}) \times 8 \times 10^5 \text{ yr} = 28 \times 10^5 \text{ cm} = 28 \times 10^3 \text{ m} = 28 \text{ km}$

- d) (4 pts) Is there likely to be any active volcanism in between Australia and Antarctica? Where will it be located?

Yes, on the SE Indian Ridge

- 2) a) (6 pts) Name 3 properties of a system heated from below which would make this system more likely to convect:

high coefficient of thermal expansion, high gravitational constant, large temperature gradient from top to bottom (strong source of heating from below or strong cooling from above OK), large distance from top to bottom, low viscosity, low thermal conductivity

- b) (2 pts) What is the source of heat for mantle convection?

Decay of long lived radionuclides

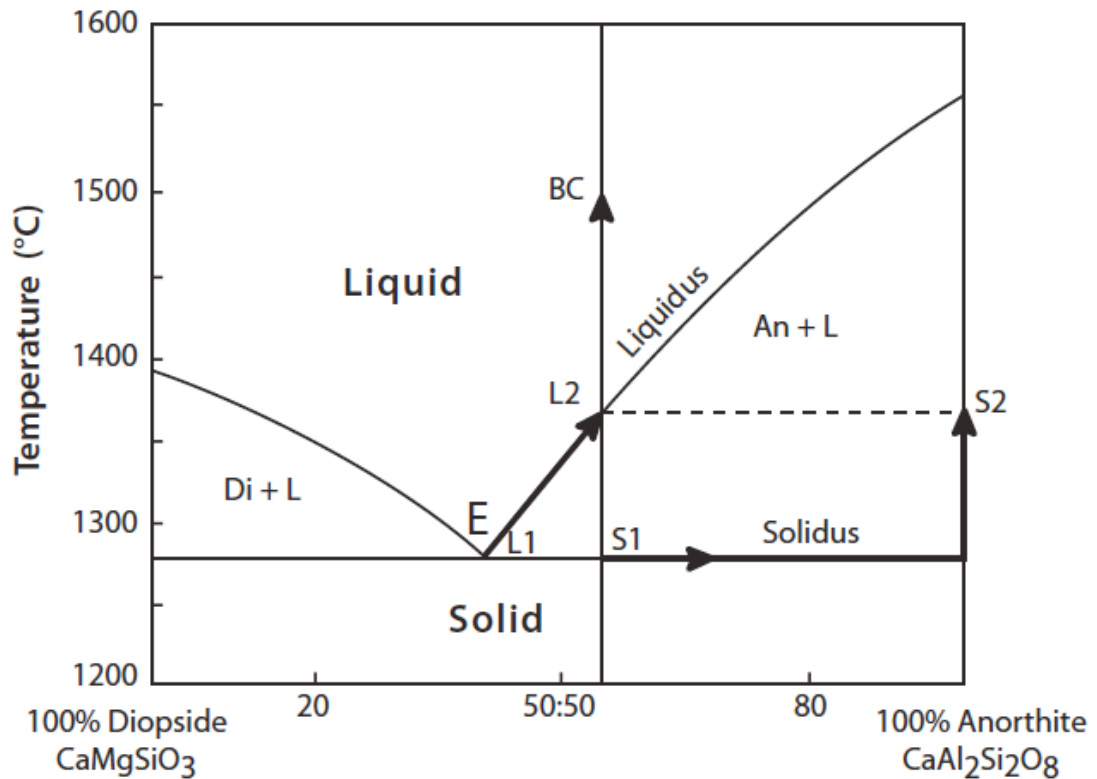
- c) (4 pts) Where are the upwelling branches of mantle convection? Give one example of where there is upwelling from the base of the mantle today.

Hot spots are the surface manifestations of the rising plumes of mantle material. Hawaii, Iceland or any other location on Slide 40 of Mantle convection lecture

- e) (4 pts) Where are the downwelling branches of mantle convection? Give one example of an area where there is downwelling today.

At subduction zones. Any active subduction location is OK (Off Oregon/Washington Coast, W. Coast of S. America, near Japan, etc.)

- 3) Consider the following phase diagram for a two component mixture of Diopside and Anorthite



- (3 pts) If we started with a solid rock that was 20% Anorthite, and 80% Diopside what would be the composition of the first melt to form?
40% Anorthite (60% Diopside) (>30, < 45 OK)
- (3 pts) At what temperature would this first melt form?
1280°C
- (3 pts) What is the bulk composition of the system (% Anorthite) at 1300°C?
20% Anorthite
- (3 pts) What is the composition of the melt at 1300°C?
35% Anorthite (>20, < 40 OK)
- (3 pts) What is the composition of the solid phase at 1300°C?
0% Anorthite (100% Diopside)
- (3 pts) What is the composition of the melt at 1600°C?
20% Anorthite

4) Choose the best answer (3 points each)

- ___c___ The two most abundant gases in our atmosphere are
- a) H and He
 - b) O₂ and CO₂
 - c) N₂ and O₂
 - d) O₂ and H₂O
- ___b___ For a mixture of gasses, the lighter molecules
- a) have a lower average speed than the heavier molecules
 - b) have a higher average speed than the heavier molecules
 - c) have about the same speed as the heavier molecules
- ___c___ Which is NOT a probable source for the water in the earth's oceans
- a) trace volatiles in bulk chondrite material from which the earth formed
 - b) comets arriving during the final stages of planet formation
 - c) particles arriving on the solar wind
 - d) carbonaceous chondrites arriving during the final stages of planet formation
- ___c___ Most of the original He in the earth's atmosphere is gone, but Jupiter has largely retained its Helium. Which of the following are responsible for this discrepancy?
- a) The earth is closer to the sun
 - b) the escape velocity for earth is low compared to the giant planets
 - c) both of the above
 - d) neither of the above

- 4) a) (4 pts) When is the earliest time for which we have evidence that photosynthetic life existed on earth?

3.5 billion years ago (3-4 bya OK)

- a) (8 pts) Explain how banded iron formations form and why their presence early in earth's history demands both low oxygen levels in the atmosphere and the presence of life in the ocean.

Fe is dissolved in oxygen free water. When the Fe rich water is oxygenated, the Fe precipitates out, Fe settles to the sea floor. Ultimately these layers are preserved as the Fe bands in banded iron formation. Low oxygen levels are necessary for there to be Fe dissolved in seawater. Photosynthetic life is necessary to provide patches of oxygen where the Fe will precipitate out.

- b) (4 pts) Name and describe one other piece of evidence for early life on earth.

Fossils of blue green algae

Stromatolites- structures created by blue green algae

Carbon isotopes in rocks diverge—low ratios in rocks originating from organic matter, high ratios from rocks originating from seawater

6) (3 pts each) Choose the best answer

___b___ Which of the following is NOT a characteristic of Mars?

- a) Very little water
- b) Strong magnetic field
- c) No ozone layer to protect from UV
- d) Very little oxygen in atmosphere

___d___ Which of the following is NOT evidence for liquid water on Mars?

- a) Clay minerals
- b) Channel like structures
- c) Lake deposits
- d) Iron oxides

___d___ Gullies found on Mars that look like water carved features are most active during what season?

- a) Spring
- b) Summer
- c) Autumn
- d) Winter

___b___ Clay minerals on Mars:

- a) Have been found in recent seasonal flows on warm slopes
- b) Are found only in the most ancient, heavily impact-cratered rocks
- c) Imply acidic conditions during Mars's middle (Hesperian) period
- d) Have a distribution consistent with groundwater upwelling and evaporation

7) Choose the best answer (3pts each)

___d___ Most of the carbon on earth is

- a) in the atmosphere
- b) in the ocean
- c) in plants and soils
- d) in rocks

___b___ Which of the following processes do NOT help to keep the atmosphere's oxygen content within a narrow range over geologic time:

- a) At high oxygen levels, organic matter will spontaneously combust
- b) At low oxygen levels, forest fires will be more frequent
- c) At high oxygen levels, burial of organic carbon in the ocean will decrease
- d) At low oxygen levels, burial of organic carbon in the ocean will increase

Name _____ Lab section _____

- ___c___ The long-term fluxes of carbon to and from the silicate rock reservoir provide a negative feedback that stabilizes earth's climate because:
- a) increased temperatures lead to increased calcification rates
 - b) increased temperatures lead to decreased calcification rates
 - c) increased temperatures lead to increased weathering rates
 - d) increased temperatures lead to decreased weathering rates
- ___c___ The faint young sun paradox is resolved because
- a) the early sun was likely stronger than we thought
 - b) the early earth was likely closer to the sun
 - c) the early earth was likely to have had more greenhouse gases in the atmosphere
 - d) the early earth likely had a higher albedo than present