ERTH 101 Final Exam (3 hour) [200 points total]

Fall 2004 Name_____

Multiple choice questions (2 pts each):

1. The position of the magmatic arc on a convergent margin (distance of the arc from the trench) is related to
    a. The angle of subduction of the down going slab
    b. The rate of melting of the asthenosphere beneath the arc
    c. The thickness of the continental crust
    d. The distance of the arc from the forearc
    e. The amount of sediment subducted in the trench

2. Continental crust is thicker than oceanic crust because continental crust
    a. Is composed of buoyant granite
    b. Is older
    c. Is formed by magmatic activity
    d. Has hotter asthenosphere under it
    e. Has undergone regional metamorphism

3. Ophiolites are:
    a. Pieces of ocean crust exposed along transform faults
    b. Sections of ocean crust formed in forearc basins
    c. Pieces of ocean crust exposed on land
    d. Pieces of upper mantle exposed in metamorphic core complexes
    e. Sections through accretionary complexes exposed on land

4. The moon is thought to have formed when:
    a. A Mars-sized protoplanet was captured by the Earth's gravitational field; hence the Moon has a different composition than the Earth
    b. A Mars-sized protoplanet collided with the Earth before the Earth had differentiated; hence the Moon has the same composition as the Earth
    c. A Mars-sized object collided with the Earth after formation of the Earth's core—hence the Moon has less iron than the Earth
    d. The Earth and Moon both condensed from the same part of the solar nebula accounting for their similar bulk compositions.
    e. The Moon was blown out of the Pacific Ocean by a massive meteor strike accounting for its lack of iron relative to the Earth.

5. A solid solution series is:
    a. Two or more minerals with the same composition but different crystal structures
    b. The substitution of one ion for another within the same crystal structure
    c. The removal of ions from a crystal structure by dissolution
    d. The disruption of the crystal structure of a mineral by addition of water to the crystal structure
    e. The creation of a solid by deposition of ions in a definite pattern

6. Point bars in rivers are
    a. Sand bars deposited in the bed of a river
    b. Sand bars deposited on the outside curve of a river
    c. Sand bars deposited on the inside curve of a river
    d. Sand bars that form where a river breaks through its levees during a flood
    e. Sand bars that form where a river enters a lake

7. The oxygen and silicon atoms in silica tetrahedra are held together by
    a. Ionic, electron-exchanging, bonds
    b. Van der Waals forces
    c. Covalent, electron-sharing, bonds
    d. The strong electrostatic force
    e. Metallic bonds

8. Compared with fast spreading ridges, slow spreading ridges:
    a. Have lower initial elevation
    b. Have about the same initial elevation
    c. Have thinner sediment cover on the ridge crest
    d. Have gentler slopes on the sides of the ridge
    e. Have smoother surface topography

9. Syn-rift sediments include:
    a. Those formed during the "drift" phase of continental breakup
    b. Salt and coarse-grained clastic sediments filling normal-faulted basins
    c. Reef carbonates and clinoform clastics that are deposited over rifted crust
    d. Andesitic volcanics and volcaniclastic sediments
    e. Passive margin sediments deposited across eroded rift shoulders

10. The formation of deepwater in the oceans is driven by sinking of
    a. cold, fresh waters at high latitudes
    b. cold, salty waters at high latitudes
    c. warm salty water in the tropics
    d. warm fresh waters in the tropics
    e. cold, salty waters in the subtropics

11. The core of the Earth consists of
    a. A solid mass of peridotite
    b. A liquid iron inner core and solid iron outer core
    c. A solid iron inner core and a liquid iron outer core
    d. A solid iron inner core and a liquid peridotite outer core
    e. The cast of the movie "The Core" (or at least this is where the movie belongs!)

12. Rifting of continental crust is associated with:
    a. Thickening the lower ductile crust and thinning of the upper brittle crust
    b. Thinning of the lower ductile crust and thickening of the upper, brittle crust
    c. Thrust faulting
    d. Regional metamorphism of the adjacent rift shoulders
    e. Normal faulting and formation of décollements in the upper crust

13. Based upon the volume of lava extruded, the most extensive, recent volcanism on Earth is associated with:
    a. Divergent margins
    b. Ocean-Continent convergent margins
    c. Transform margins
    d. Hot spots
    e. Continent-Continent convergent margins

14. Earthquakes are rare in:
    a. Subduction zones bat less than100 km depth
    b. Transform faults between 5-20 km depth
    c. Spreading centers between 3-20 km depth
    d. Continental crust in the ductile lower crust
    e. Normal faults in the brittle, upper crust

15. The size of the Earth's core is indicated by the shadow zone for:
    a. Surface waves
    b. P waves
    c. S waves
    d. All seismic waves

16. The rate of movement of tectonic plates primarily is due to the:
    a. Length of subduction zones around a plate
    b. Rate of convection in the upper mantle
    c. Slab surfing
    d. Ridge pull
    e. The amount of volcanism at the spreading ridges

17. The type of igneous rock most frequently enriched in muscovite and gold is
    a. Peridotite
    b. Andesite
    c. Diorite
    d. Granite
    e. Basalt

18. The deepest earthquakes are associated with:
    a. Divergent margins
    b. Convergent margins
    c. Transform margins
    d. Continental rifts
    e. Listric normal faults

19. The oldest ocean crust is about
    a. 0.18 Ma
    b. 1.8 Ma
    c. 18 Ma
    d. 180 Ma
    e. 1800 Ma

20. Tectonic terranes include pieces of:
    a. Volcanic arcs,
    b. Oceanic plateaus
    c. Ocean crust
    d. Seamounts
    e. All the above

21. Chemical weathering of silicate rocks
    a. Absorbs CO2 and reduces greenhouse warming
    b. Releases CO2 and enhances greenhouse warming
    c. Has no affect on atmospheric CO2 but reduces oxygen available for photosynthesis
    d. Has no effect on atmospheric CO2 but drives up the concentration of other greenhouse gases.
    e. Dehydrates minerals forming (for example) pyroxenes from amphiboles

22. Mature sandstones
    a. Are composed mostly of well rounded, well sorted quartz
    b. Contain abundant feldspar
    c. Contain abundant quartz and angular rock fragments
    d. Are poorly sorted and have angular grains
    e. Are to be expected in alluvial fans and glacial till

23. During glacial epochs, global sea level is:
    a. higher because of reduced evaporation
    b. higher because continents are depressed by ice
    c. unchanged compared to today
    d. lower because evaporation is higher
    e. lower because water is stored on land in ice sheets

24. The distance mountain glaciers can flow is dependent upon
    a. The gradient of the glacier's bed
    b. The balance between snowfall and ablation
    c. The balance between formation of firn and summer snowfall in cirques
    d. The amount of rock carried by the glacier as till
    e. The rate of melting at the base of the glacier

25. A good aquifer is
    a. Sandstone with high porosity but low permeability
    b. Sand with high porosity and high permeability
    c. Gravel or sand with high permeability and low porosity
    d. Claystone
    e. An anticline of well cemented sandstone or conglomerate

26. Many peaks in the Rocky Mountains are composed of Precambrian granite that rests on top of Mesozoic sediments. What kind of faults separate the two rock types?
    a. Low angle normal faults
    b. Thrust faults
    c. Transform faults
    d. Strike-slip faults
    e. High angle normal faults

27. Continents have grown
    a. Incrementally by accretion around the edges mostly between 2.5-1 Ga
    b. Rapidly by accretion of cratons mostly before 2.5 Ga
    c. Mostly after 1 Ga by continent-continent collisions
    d. Mostly in the past 500 Ma by accretion of exotic terranes
    e. Uniformly over the past 4.5 Ga by magmatic activity rather than by terrane accretion

28. Which of the following sequence of rocks indicates increasing temperature and pressure of metamorphism?
    a. Slate-phyllite-shale-schist-gneiss
    b. Gneiss-slate-phyllite-schist-shale
    c. Shale-schist-gneiss-slate-phyllite
    d. Shale-phyllite-slate-schist- gneiss
    e. Shale-slate-phyllite-schist-gneiss

29. Fracture zones in the ocean crust are
    a. Seismically active with shallow focus earthquakes
    b. Usually sites of volcanic eruptions far from the spreading ridge
    c. Thrust faults formed by movement of oceanic crust on a spherical Earth
    d. Inactive former strike-slip faults
    e. All of a,b and c.

30. Batholiths form when
    a. Plutons intrude and metamorphose country rock
    b. Large sills create regional metamorphism
    c. Many plutons intrude other plutons
    d. The deep continental crust exposed by brittle thinning of the upper crust
    e. Basaltic magmas undergo fractional crystallization and differentiation.

31. Brittle deformation of rocks is favored in all situations EXCEPT:
    a. Low confining pressures
    b. Low temperatures
    c. Shallow depths of burial
    d. High temperature under regional stress
    e. High rates of strain (rapid deformation)

32. Chemical weathering by ground water is promoted by the presence of
    a. Suspended load
    b. Acidic water
    c. An abundance of clay minerals
    d. Cold conditions in the recharge area
    e. A high dissolved load

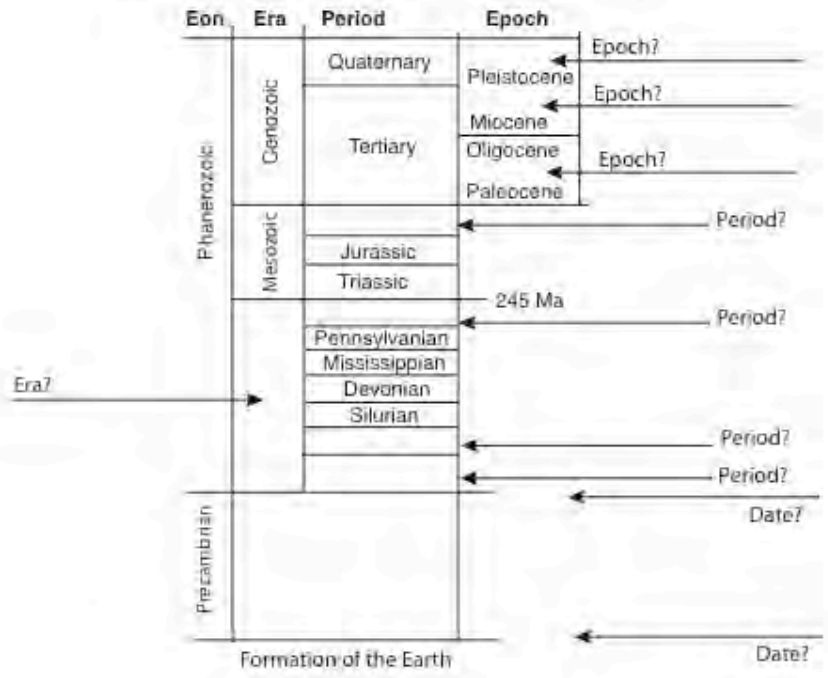
33. The base level of a stream is:
    a. The elevation below which a stream cannot erode sediment
    b. The elevation of the bottom of a stream channel
    c. The level at which a stream's gradient is steepest
    d. The elevation at which clay begins to dominate the sediment load
    e. The point at which a stream's velocity is maximized

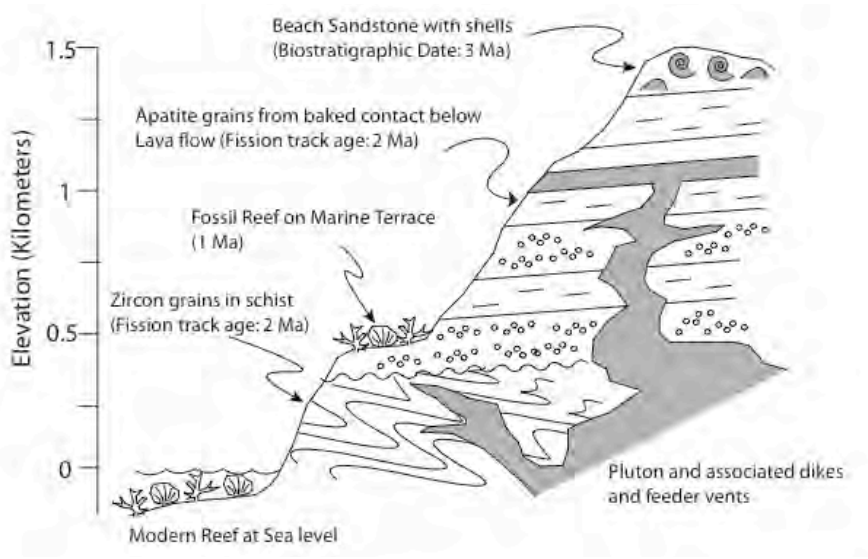
34. Andesites are typically found in what tectonic setting:
    a. Hot-spot volcanic islands
    b. Continental rifts
    c. Divergent margins
    d. Island arcs
    e. Passive margins

35. The asthenosphere around a subducting slab is:
    a. Colder than the asthenosphere at the same depth elsewhere
    b. Hotter than surrounding mantle owing to partial melting
    c. About the same temperature as the surrounding asthenosphere because of decompression
    d. Hotter than the surrounding mantle owing to release of water from the slab
    e. Colder than the subducting slab because of water pulled into the mantle by subduction

Short Answer questions

36. Fill in the geologic eras, periods, and epochs on the diagram below. Also indicate the ages of the boundaries between the eras in millions of years, on the left hand side. **(10 pts & 10 blanks)**





1. You are working in New Guinea (a rapidly uplifting island because of convergent margin tectonics) and have found the following possible tie points for estimating uplift rates (see diagram above): (1) a fossiliferous beach sandstone at the top of a 1.5 km high mountain (with a biostratigraphic age of 3 Ma); (2) an apatite grain from a baked contact below a lava flow (at 1 km elevation) with a fission track age of 2 Ma; (3) a fossil reef on an exposed marine terrace at 0.5 km elevation with a uranium-thorium age of 1 Ma, and (4) a zircon from metamorphic rocks at 0.25 km elevation with a fission track age of 2 Ma**. (9 pts)**

    a. What is the rate of uplift for the mountain range over the past 3 my years (You can answer in the form: XX km uplift / million years) ?

    b. Are all the dated tie points equally reliable? Why or why not?

    c. About what elevation was the lava flow formed if the uplift rates for the beach sandstone and the coral reef are correct?

37. How do the Earth's crust, mantle and core differ in composition? Explain why this difference occurs **(6 pts)**

38. The rate of movement on the San Andreas Fault is about 2 cm/year but the full rate of motion between the Pacific plate and the North American Plate is ~5 cm/year? What accounts for the difference? **(6pts)**

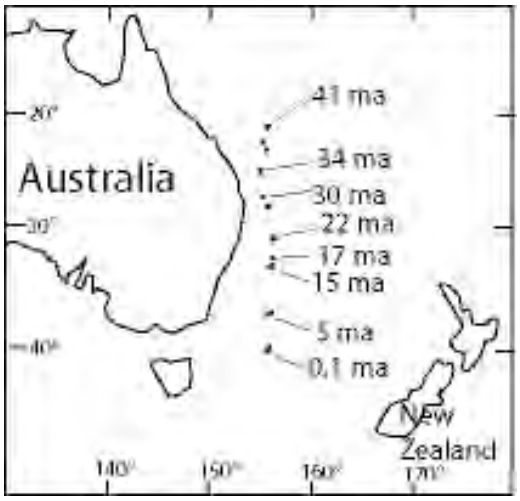
39. The ocean crust shows distinct changes in seismic velocities that have been described as seismic layers 1, 2, 3a, and 3b, with layer 1 having lower velocities than layer 3b. Draw a sketch that illustrates what the rock equivalents of these seismic layers are thought to be. Where is the Moho on your diagram? **(10 pts)**

40. Give two reasons why quartz is abundant in sedimentary rocks, even in those derived from parent rock types that have relatively small amounts of quartz in them. **(6 pts)**

41. The chain of seamounts off the east coast of Australia have K-Ar and Ar-Ar dates that are oldest to the north and youngest to the south. Only the youngest volcano is still active **(6pts).**

    a. Why do the extinct volcanoes show this age progression?

    b. Which direction (North, South, East or West) is the Australian Plate moving relative to the source of volcanism?



42. The largest volcano on the rocky planets of our solar system is an enormous Martian shield volcano called Olympus Mons that is 700 km across and 23 km high (see oblique photo below**). (6 pts)**

    a. What kind of lavas probably built this volcano?

    b. Were the lavas erupting from Olympus Mons sourced from the Martian crust or mantle?

    c. Steep-sided, strato-volcanoes are rare on Mars, what does this imply about the composition of the Martian crust?

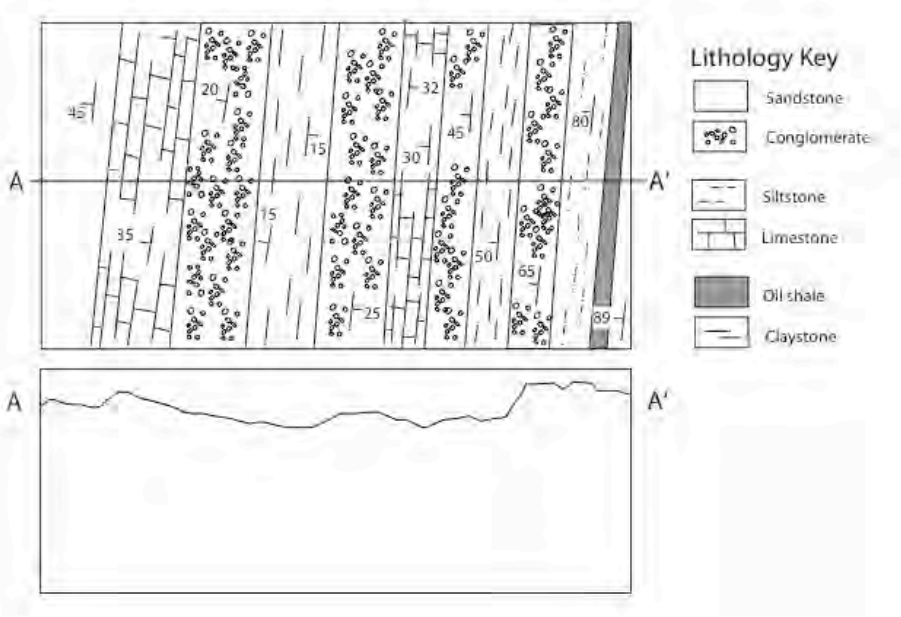
43. Draw a cross-section along the profile A-A' (diagram below; **10 pts**)

a. Draw and arrow and to the youngest rocks on the map.

b. Are all the conglomerate beds the same?

c. Are all the shale beds the same? (Excluding the oil shale from consideration)

d. If you were to drill for oil, what would be your first target? (Think about where the best trap and associated seal rocks might be. Indicate your favored drill site with an X on the map or a vertical line on the cross-section.) The oil shale, by the way, has about 5 wt % organic carbon—too little to constitute an oil reservoir itself but oil might be formed, under the right conditions, from this oil shale.



44. What are three events that must occur to generate economic oil deposits? (6 pts)

45. What are three lines of evidence that California was on a convergent margin during the Mesozoic? **(6 pts)**

46. Many oceanic plateaus date from the Cretaceous, and Cretaceous spreading rates seem to have been substantially higher for 10s of millions of years than is the case today. **(6 pts)**

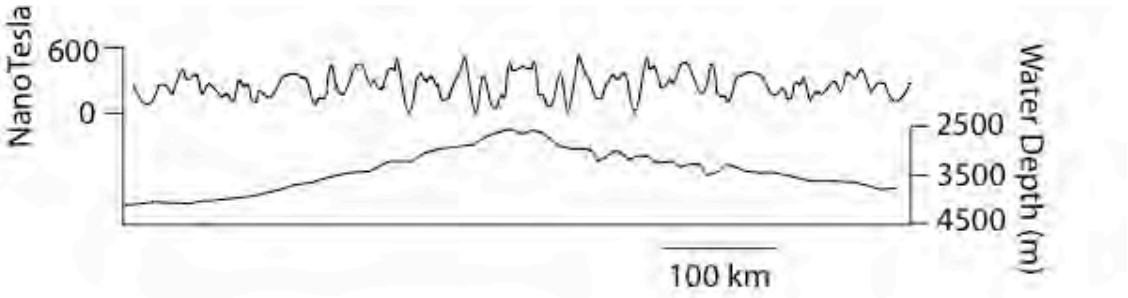
    a. What are the consequences of higher rates of formation of ocean crust for Cretaceous sea level?

    b. Why?

47. Describe the major controls on the formation and distribution of deserts on Earth **(6 pts)**

48. The profile below was created by the research ship, R/V Ewing in 1985 on a cruise across the South Atlantic from S. Africa to Brazil. The upper profile shows

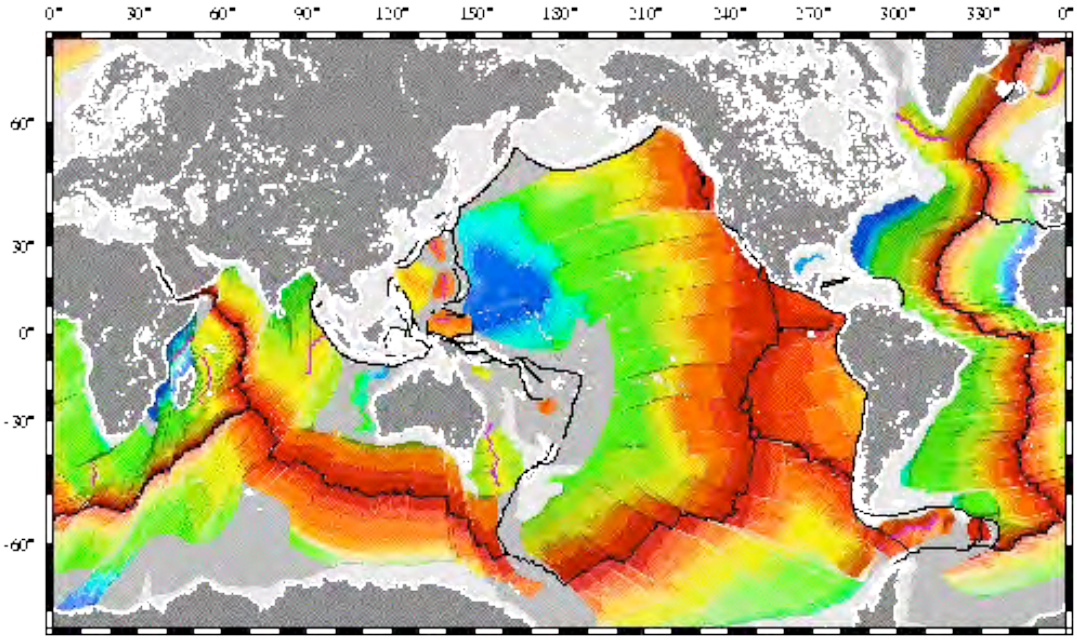
the strength of the magnetic field --Magnetic anomalies (in nTesla)--on the ocean floor whereas the lower profile shows the bathymetry--depth of the sea floor (in meters). **(6 pts)**



a. What produces the pattern of strong and weak magnetic anomalies on the ocean floor?

b. Why does the pattern of magnetic anomalies appear to be duplicated on either side of the highest peak?

49. Draw a sketch to show the location of major metamorphic facies that are typical of different parts of a convergent margin and associated subducting slab. We are looking for a cross-section of a convergent margin labeled with areas that are typical of each metamorphic facies. Your choices include: Greenschst, Blueschist, Partial melting (Granulite), High Temperature/High Pressure (Amphibolite), and Zeolite **(5 pts).**



50. The map above shows the age of the sea floor-- different colors indicate crust of different ages. Grey areas are continents, marginal seas or oceanic plateaus of varying ages **(8 pts)**

    a. Which colors indicate the youngest crust?

    b. Place the following ocean basins in relative age form the youngest to the oldest: (1) The Greenland Sea (between Greenland and Norway), (2) The North Atlantic and (3) The South Atlantic.

    c. What is the relative speed of crust formation in the North Atlantic compared to the ocean basin south of Australia?

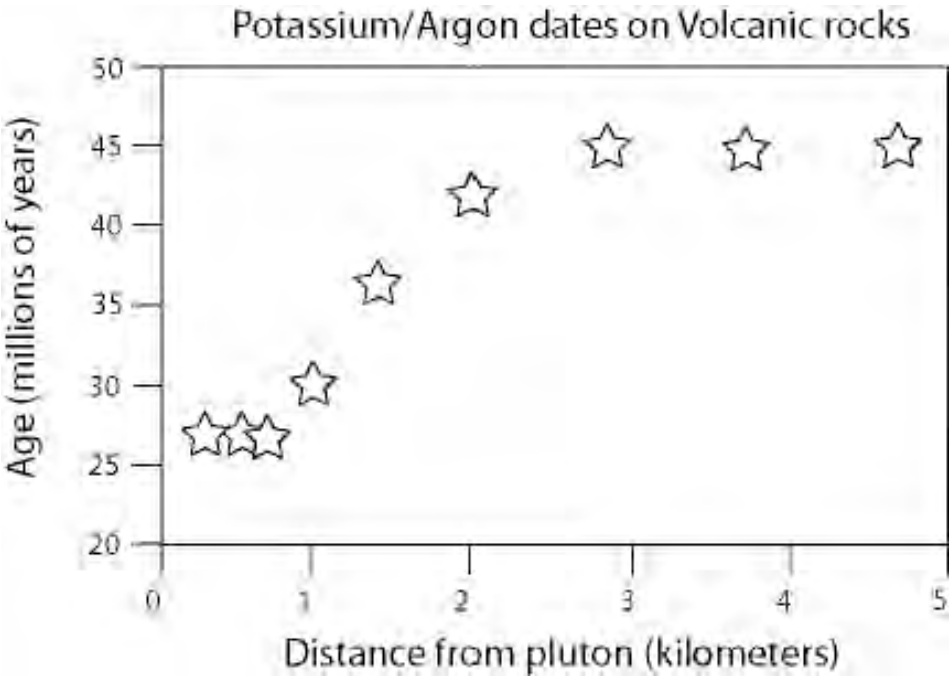
    d. Ocean floor colored green is of Cretaceous age (~120-65 Ma). Which of the following ocean basins had the FASTEST rate of seafloor spreading in the Cretaceous? (Circle the best one)
        a) South Atlantic
        b) North Pacific
        c) Indian Ocean
        d) North Atlantic

51. What is the difference between suspended load, dissolved load and bed load in a river? **(6 pts)**

52. What are two key factors that control how rapidly rocks weather (By the way, there are lots more than two): Briefly explain each factor. **(6 pts)**

53. Deep sea sediments deposited on ocean crust frequently show a sequence from umbers at the base (these are metal and sulfide-rich sediments resting directly on top of pillow basalt), to carbonate ooze and siliceous ooze in the middle of the sequence and red clay at the top. What accounts for this sequence? **(6pts)**

Extra Credit Problem (9 pts). This problem is entirely optional. However, extra credit can be very useful if you end up falling near the boundary for a grade, so take a guess even if you don't have a clue what the answer might be….



1. Volcanic rocks have been intruded and contact metamorphosed by a pluton. A series of K/Ar dates on the metavolcanics are shown above as 'stars'. **(9 pts)**

    a. Assuming all the volcanic rocks were originally the same age, when were they erupted?

    b. What is the age of the pluton? (Or, to put it another way, when were the volcanics metamorphosed?)

    c. Why do the ages of the metavolcanic rocks tend to get older with distance from the pluton?