GEO4-1403 Petrological and Geochemical Evolution of the Earth

EXAM

Thursday 08 November 2018, 09.00-12.00, Ruppertgebouw WIT

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*Answer **five out of eight questions**. You can choose which questions to answer.*

All questions are worth 10 marks each

Write your answers on the paper attached. Use both sides of the sheets.

In each answer, give as much detail as you can about petrological and geochemical evidence that supports the key processes in question.

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1. (a) Explain what is meant by mass independent fractionation in the oxygen isotope system (b) How can variations in multiple oxygen isotopes (^{16}O, ^{17}O, ^{18}O) be used to help determine the distance from the sun at which meteorites formed in the solar system? (c) Do differences in oxygen isotope ratios exist between the Moon and Earth and what does this tell us about the origin of the moon?

2. (a) Mineral evolution is a relatively new approach of studying the formation and appearance of minerals. In this approach the mineral history is divided into three eras based on formation mechanism. What are these eras, from when till when did they span, and what are the mechanisms associated with each era?

   (b) Meteorites are classified based on their mineralogy and petrology. What can you tell about the processing (and related to that, the relative age) of a meteorite if the meteorite contains: (b1) chondrules, (b2) phyllosilicates, (b3) ringwoodite.

   (c) What can you tell about the processing of a rocky body or planet if you find the following mineral groups on the surface: (c1) serpentine, (c2) granitoids?

3. Describe how magmatic/volcanic rock types found in Archean greenstone belts were distinctive to those found on the modern Earth. Give examples of (a) mafic and (b) felsic rocks in your answer. What were their main compositional, textural and geochemical features and how were they linked to differences in tectonics, melting and crystallization processes.

4. (a) Describe three different approaches in geology or geochemistry that can be used to determine the appearance of the first life in the geological record. Give the advantages and disadvantages of each approach.

   (b) Using these approaches describe the point in the geological record when you would argue that the first robust evidence for life becomes available. At what age did this happen? Give an example of a location and the types of rocks where this was found.

5. (a) Describe the main lines of geological and geochemical evidence that suggest that the near-surface environment of the Earth transitioned from fully anoxic conditions in the Archean to partially oxygenated after the Great Oxygenation Event.

   (b) Which geochemical evidence can be used to apply quantitative constraints on the increase in pO_2 levels in the ancient atmosphere. Describe in as much detail as you can how this proxy works.

6. (a) What is a large igneous province (LIP)? Give the most important characteristics that define an event as a LIP and briefly describe its relationship to global tectonic processes.

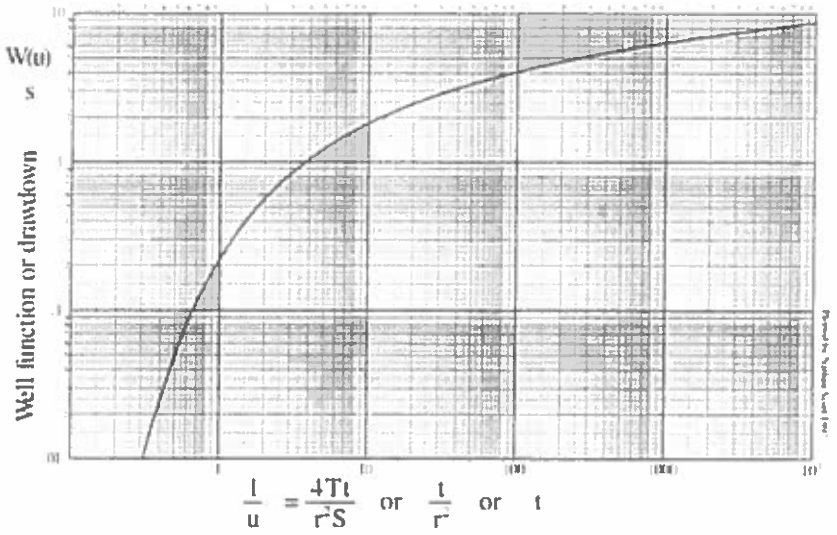
   (b) How would you distinguish geochemically between the role of impactors and mass volcanism as causes for mass extinction events?

7. (a) When did crust-mantle separation first begin on Earth and what geochemical evidence can be used to most strongly support this?

   (b) What lines of evidence can be used to argue that plate tectonics was distinctive on the early Earth when compared to what we observe today?

8. (a) Describe in as much detail as you can how you would distinguish the igneous rock type *blueschist* in hand specimen and under the optical microscope.

   (b) Blueschists are indicative of a particular type of geological setting. What is this? and why are blueschists only found in rocks of Neoproterozoic age and younger?



Formula sheet

Transient flow

$$h_0 - h = \frac{Q}{4\pi kD} W(u)$$

$$u = \frac{r^2 S}{4kD(t - t_0)}$$

$$W(u) = \int_u^\infty \frac{e^{-m}}{m}\, dm$$

$W(u)$ as series expansion

$$W(u) = -\gamma - \ln u + u - \frac{u^2}{4} + \frac{y^3}{18} - \frac{u^4}{96} \ldots$$

where $\gamma = 0.5772157...$ (Eulers constant) For $u << 1$ we truncate the series expansion

$$W(u) \approx -\gamma - \ln u$$

Storativity

$$S = S_s D$$

where S_s denotes specific storativity
Radial flow in a confined aquifer

$$h(r) = \frac{Q}{2\pi kD} \ln\ r + C$$

Radial flow in an unconfined aquifer

$$h^2(r) = \frac{Q}{\pi k} \ln\ r + C$$