Honors Seminar 259 — cheat sheet for10/15/2008 — Andrew Baker

McKay et al. (1996)

You should read the whole article– but read the *last* paragraph first, since this will give you guidance on the key pieces of evidence the authors are assembling. Key questions:

1. In the last two sentences of the article, the authors state, "None of these observations is in itself conclusive evidence for the existence of past life. Although there are alternative explanations for each of these phenomena taken individually, when they are considered collectively, particularly in view of their spatial association, we conclude that they are evidence for primitive life on early Mars." What are your thoughts on the logic used here?

2. How do we know that ALH84001 came from Mars? (Hint: take a look at footnote 3.)

3. How do we know that the carbonate globules in ALH84001 were not formed while the meteorite was sitting in the Antarctic ice?

4. How do we know that the PAHs in ALH84001 were not introduced while the meteorite was sitting in the Antarctic ice?

5. What is the significance of each of the following statements?

   p 924 "...we are searching for martian biomarkers on the basis of what we know about life on Earth."

   p 925 "Because Antarctica is in the less industrialized Southern Hemisphere, we may expect that concentrations of PAHs in Antarctic ice lie between these two limits."

   p 927 "...neither simultaneous precipitation of Fe-sulfides and magnetite along with dissolution of carbonates nor sequential dissolution of carbonate at a later time without concurrent dissolution of Fe-sulfides and magnetite seems plausible in simple inorganic models..."

   p 928 "A lunar rock chip carried through the same procedures and examined at high magnification showed none of the features seen in Fig. 6."

   p 928 "In general, the terrestrial bacteria microfossils are more than an order of magnitude larger than the forms seen in the ALH84001 carbonates."

Key terms:

- **alkylation** = addition of an alkyl (CH_3) group to a molecule
- **annealing** = process in which a rock's properties change as it is subjected to slow heating
- **anthropogenic** = having an origin related to human activities
- **aromatization** = conversion of a non-aromatic compound to an aromatic compund (i.e., one whose structure features a benzene ring)

- **authigenic** = having been formed in the place where it is found
- **backscatter electron** = BSE = a particular flavor of scanning electron microscopy that is sensitive to differences in atomic number
- **biogenic** = having an origin related to life
- **biomineralization** = production of minerals (e.g., bones or teeth) by a living organism
- **carbonate** = any molecule incorporating the carbonyl (CO_3^{2-}) ion
- **CM2** = a category of carbon-rich meteorite that contains water, organic material, and *chondrules* (small, round, mineral grains that were once molten liquid)
- **chondrite** = any meteorite containing *chondrules* (small, round, mineral grains that were once molten liquid)
- **coprecipitation** = simultaneous precipitation of more than one substance
- δ^{13}**C** = the difference between the $^{13}C/^{12}C$ ratio in a given sample, and the ratio's standard value
- **desorption matrix blank** = a surface from which an embedded substance *could* be released if present
- **diagenesis** = change that happens to a sediment after it has been laid down but before it has been (completely) converted to rock
- **diffraction pattern** = image that results due to the bending of a beam of electrons by and around a sample (this is often used to deduce certain properties of a molecule's structure)
- **domain** = a region in a magnetic substance in which the magnetic moments of individual atoms are all pointing in the same direction (typically, a given sample will have several different "domains" whose magnetic fields all point in different directions)
- **electron microprobe** = technique that determines the chamical composition of a small sample by bombarding it with an electron beam
- **euhedral** = adjective describing a crystal with sharp, well-defined faces
- **ferroan** = iron-rich
- **friable** = easy to break into smaller pieces
- **fusion crust** = outer coating left on a meteorite due to heating as it passes through the atmosphere
- **geochromatographic mobilization** = the separation of a mixture of compounds into its consituents, due to the interaction of that mixture as it move through a wet mineral medium

- **heterocycle** = a ring structure within a molecule that contains at least one carbon atom and at least one non-carbon atom
- **homologous** = adjective describing molecules that differ only in the number of repeating sub-units
- **isomeric** = having identical chemical compositions but different molecular structures
- **lattice defect** = the departure of a crystal from perfect regularity
- **magnesite** = magnesium carbonate ($MgCO_3$)
- **magnetite** = an iron oxide mineral with the chemical formula Fe_3O_4
- **mass spectrometer** = instrument that can be used to calculate the distribution of molecular masses in a sample mixture
- **monoclinic system** = convention for describing the geometry of a crystal in terms of vectors of unequal length
- **nanophase** = having a size less than $100\,\mathrm{nm} = 10^{-7}\,\mathrm{m}$
- **petrography** = the descriptive investigation of the detailed properties of rocks
- **polycyclic aromatic hydrocarbon** = PAH = large organic molecule featuring a number of six-carbon-atom rings
- **precipitate** = a solid substance that condenses out of a liquid solution in which it (or its consistuents) have been suspended
- **pyrolysis** = decomposition of organic compounds due to heat, in the absence of oxygen
- **pyrrhotite** = an iron sulfide mineral
- **scanning electron microscopy** = SEM = technique that images a surface at very high resolution by bouncing a beam of electrons off it
- **secondary minerals** = minerals that are formed at a later date than the larger rock in which they are found
- **Shergotty-Nakhla-Chassigny** = SNC = a set of twelve meteorites believed to have originated on the surface of Mars
- **stereo light microscopy** = looking at a sample with an "ordinary" microscope
- **superparamagnetic** = adjective describing the magnetic properties of a particular class of materials that behave like magnets only after a magnetic field is applied to them (and which have many small highly magnetic, but randomly oriented domains)
- **transmission electron microscopy** = TEM = technique that images a thin slice of a substance by firing a beam of electrons through it
- **volatilization** = process by which a substance is coverted to vapor