Reading Guide to "Hydrothermal Vents and the Origin of Life"[1]

Most important: What questions do you have that we have not covered here? Write them down and bring them to class.

Bring your copy of the paper with your notes to class!

Please answer wherever possible with reference to specific figures, tables or sentences in the paper. Cite any outside source you use. Show your work where relevant.

Please send me your answer to questions 3 and 4 by noon Monday 5 February. These need not be pretty or fancy; hand-written notes which you scan are fine. Make your answer as complete as possible. You will get feedback on this; I'm not sure if I'll put a grade to it or not. Bring your answer to class on Monday too, ready to update/revise.

1. Some terminology to define:
   (a) Mafic vs. ultramafic
   (b) Magma
   (c) Magma chamber
   (d) Gradient (in the chemical context)
   (e) Chemiosmosis
   (f) Chemiosmotic coupling
   (g) Anerobic vs. aerobic organisms (and how does "obligate" fit in?)
   (h) AMO
   (i) Autotroph
2. As chemists/biochemists interested in the origin of life, why do we care about hydrothermal vents? Be as specific as possible. Hint: What products in the serpentinization scheme (shared separately) are of interest to potential life forms?
3. Make a table describing the geochemical, chemical and physical differences between black smokers, white smokers and off-axis vents. Create this on a separate piece of paper that you can add to as you learn more.
4. What properties / features / aspects of the vent systems as they currently operate (i.e. your answer to question 3) would have been irrelevant in the Hadean? Make a note on your table.
5. Which reactions in Table 1 would have been relevant in the Hadean?
6. The paper states (pg 808) that "AMO is not energetically feasible unless sulphate-reducing bacteria . . . are present to use H_2 that is generated from the anerobic oxidation of CH_4." What reaction in Table 1 are they talking about?
7. What is the significance of the pH gradient observed in hydrothermal vents?
8. Undisturbed, gradients disappear (give an every-day example). Why? What sustains the gradients in hydrothermal vents?
9. Explain this statement from the paper: "The chemistry of life is the chemistry of reduced organic compounds. . ."
10. What is the difference between a methanogen and a methanotroph? How are these organisms relevant to the hydrothermal vent system? Which category dominates now? Which category is relevant pre-LUCA?
11. Are the organisms found on the stacks at Lost City consuming or creating methane?

[1] Martin *et. al. Nat. Rev. Micro.* vol. 6, pgs 80-5-814 (2008).

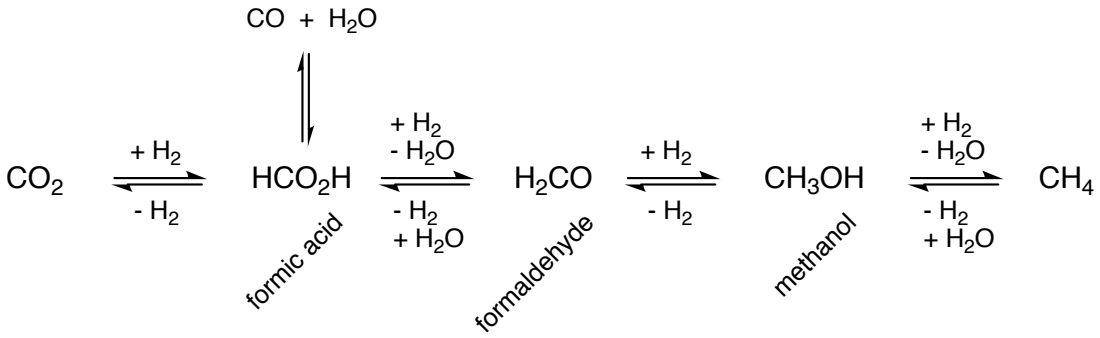
Answers to the questions below due by 3 pm Friday 9 February

12. Lost City systems are described as having "...almost no dissolved CO_2." Why is this? Where would CO_2 come from? Where did it go? Write reactions describing what happens.

13. On the other hand, in black smokers dissolved CO_2 is quite abundant. Why would that be? Write equations describing what happens.

14. In serpentinization, we find that some minerals are actually mixtures in which different metals can substitute for each other. For instance, the mineral brucite which is $Mg(OH)_2$ is sometimes presented as $(Fe, Mg)(OH)_2$ which means that iron and magnesium ions can trade places (though if we go all the way to $Fe(OH)_2$ that's a different mineral). Does this make sense in terms of the ionic radii for these metals?

15. The scheme below shows the full range of oxidation states for carbon (And it's anerobic! A different scheme could be written if we allowed O_2).



(a) Calculate the oxidation state of carbon in each compound.

(b) Which compound is most reduced? Most oxidized?

(c) Calculate ΔG° for each reaction.

(d) What is ΔG° for the whole process?

(e) In a hydrothermal vent, will standard conditions apply? Comment briefly but with specifics.