

**SAS Honors Seminar 259:
Extraterrestrial Life**

10/15/2008

McKay et al. (1996) figure 1

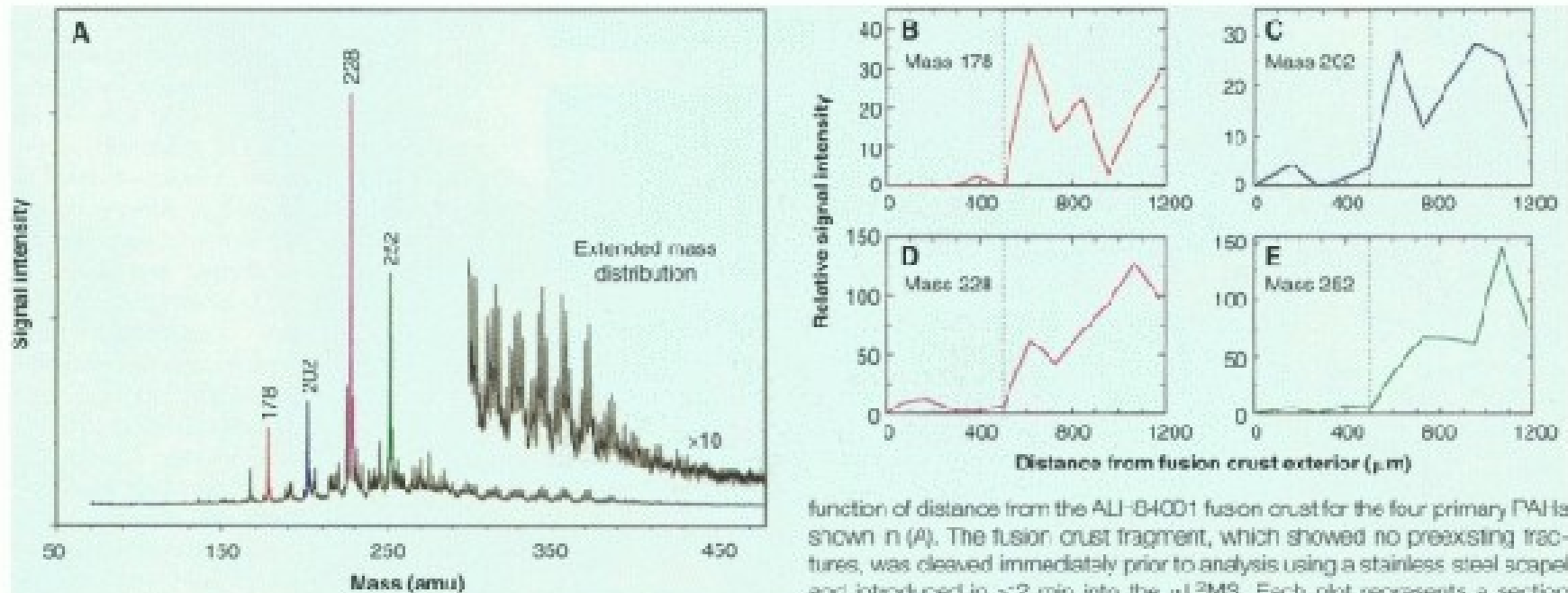
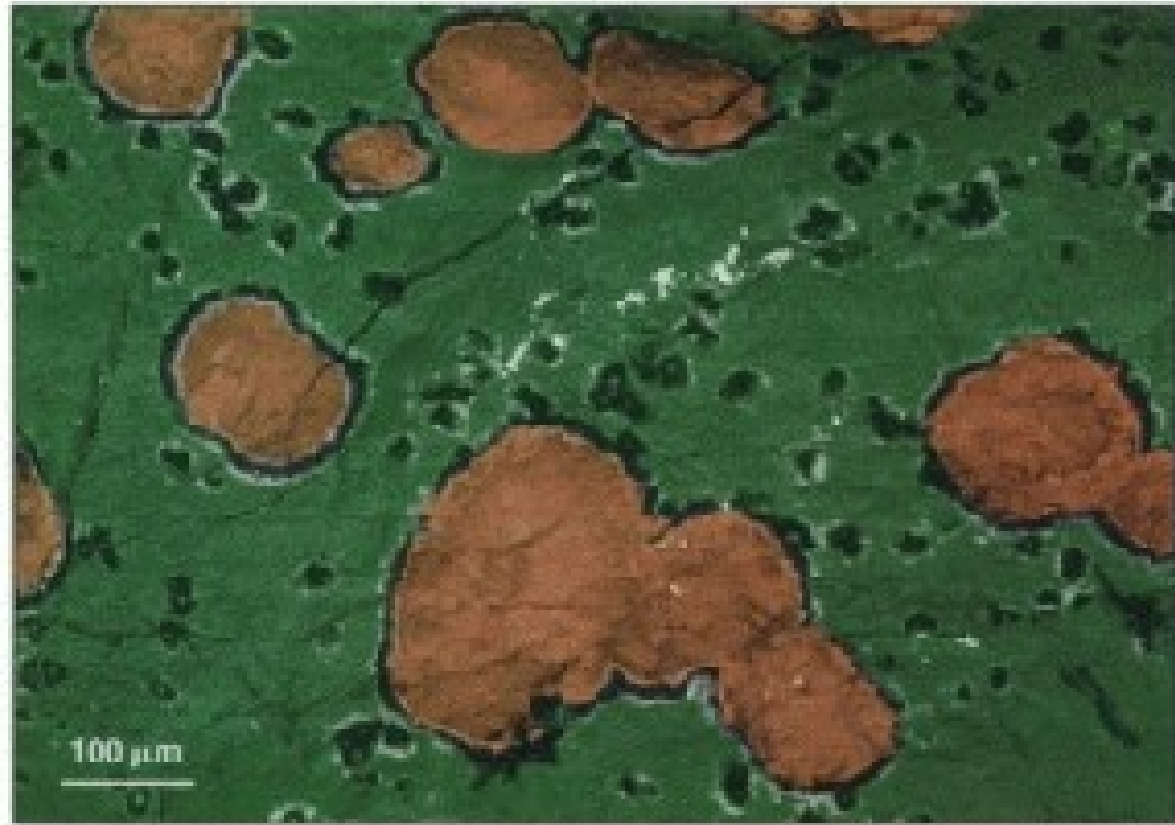


Fig. 1. (A) Averaged mass spectrum of an interior, carbonate-rich, fracture surface of ALH84001. The spectrum represents the average of 1290 individual spectra defining an analyzed surface region of 750 by 750 μm mapped at a spatial resolution of 50 by 50 μm . **(B through E)** PAH Signal intensity as a

function of distance from the ALH84001 fusion crust for the four primary PAHs shown in (A). The fusion crust fragment, which showed no preexisting fractures, was cleaved immediately prior to analysis using a stainless steel scalpel and introduced in <2 min into the $\mu\text{L}^2\text{MS}$. Each plot represents a section perpendicular to the fusion crust surface, which starts at the exterior and extends a distance of 1200 μm inward. The spatial resolution is 100 μm along the section line and is the average of a 2 by 2 array of 50 by 50 μm analyses, with each analysis spot being the summed average of 5 time-of-flight spectra.

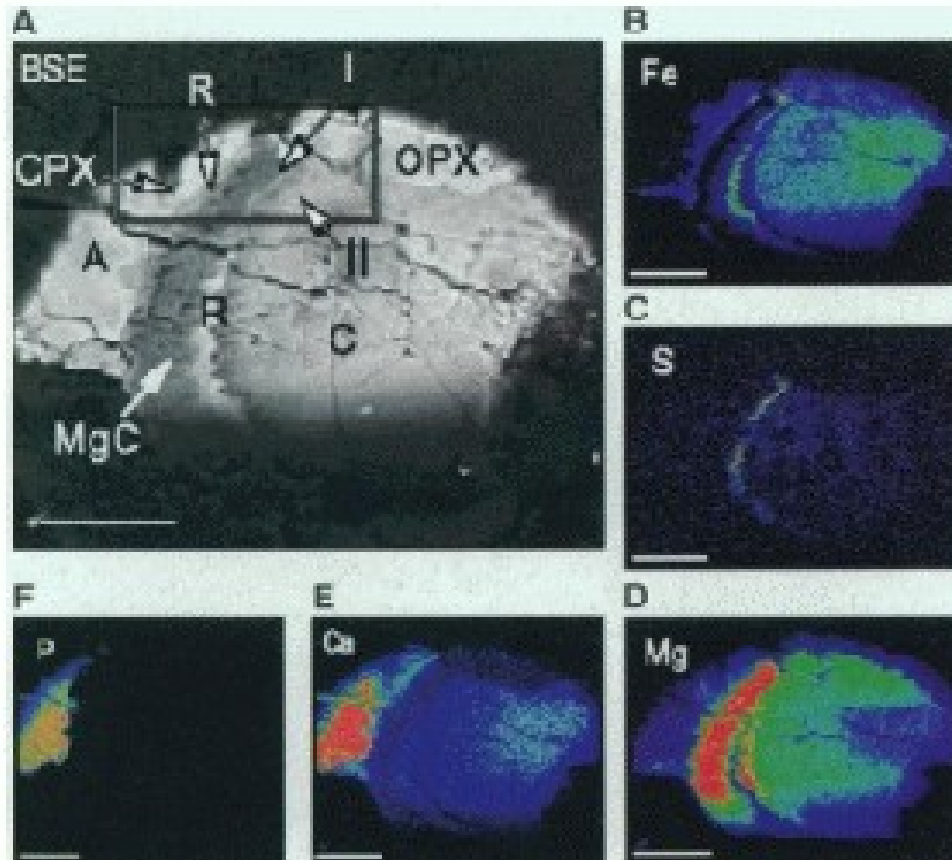
McKay et al. (1996) figure 2

Fig. 2. False-color backscatter electron (BSE) image of fractured surface of a chip from ALH84001 meteorite showing distribution of the carbonate globules. Orthopyroxene is green and the carbonate globules are orange. Surrounding the Mg-carbonate are a black rim (magnesite) and a white, Fe-rich rim. Scale bar is 0.1 mm [False color produced by C. Schwandt]



McKay et al. (1996) figure 3

Fig. 3. BSE image and electron microprobe maps showing the concentration of five elements in a carbonate from ALH84001. The element maps show that the carbonate is chemically zoned. Colors range through red, green, light blue, and deep blue, reflecting the highest to lowest element concentrations. Scale bars for all images are 20 μm . (A) BSE image showing location of orthopyroxene (CPX), clinopyroxene (CPX), apatite (A), and carbonate (MgC, C). Iron-rich rims (R) separate the center of the carbonate (C) from a Mg-rich carbonate (MgC) rim. Region in the box is described in Figs. 5 and 6. (B) Iron is most abundant in the parallel rims, $\sim 3\mu\text{m}$ across, and in a region of the carbonate $\sim 20\mu\text{m}$ in size. (C) Highest S is associated with an Fe-rich rim; it is not homogeneously distributed, but rather located in discrete regions or hot spots in the rim. A lower S abundance is present throughout the globule in patchy areas. (D) Higher concentrations of Mg are shown in the Fe-poor outer region of the carbonate. A Mg-rich region (MgC), $\sim 6\mu\text{m}$ across, is located between the two Fe-rich rims. (E) Ca-rich regions are associated with the apatite, the Fe-rich core of the carbonate, and the clinopyroxene. (F) P-rich regions are associated with the apatite



McKay et al. (1996) figure 4

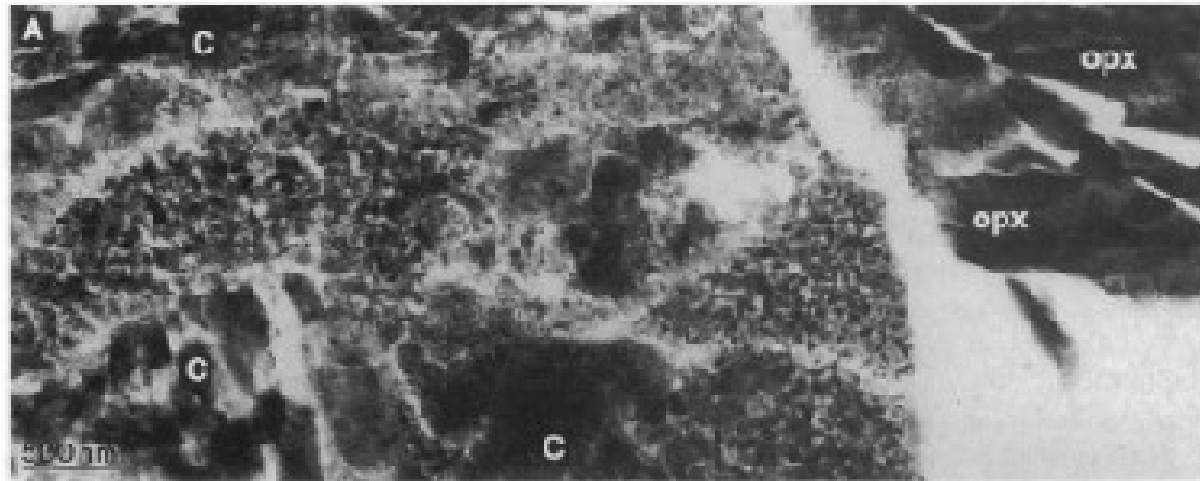
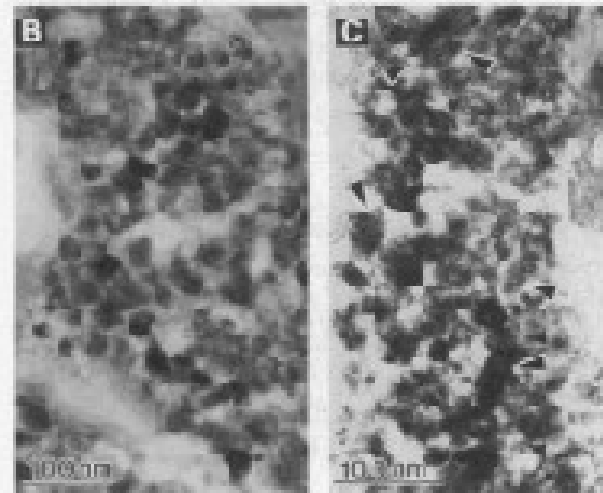


Fig. 4. TEM images of a thin section obtained from part of the same fragment shown in Fig. 3A (from the region of arrow I, Fig. 3A). (A) Image at low magnification showing the Fe-rich rim containing fine-grain magnetite and Fe-sulfide phases and their association with the surrounding carbonate (C) and orthopyroxene (opx). (B) High magnification of a magnetite-rich area in (A) showing the distribution of individual magnetite crystals (high contrast) within the fine-grain carbonate (low contrast). (C) High magnification of a pyrrhotite-rich region showing the distribution of individual pyrrhotite particles (two black arrows in the center) together with magnetite (other arrows) within the fine-grained carbonate (low contrast).



McKay et al. (1996) figure 5

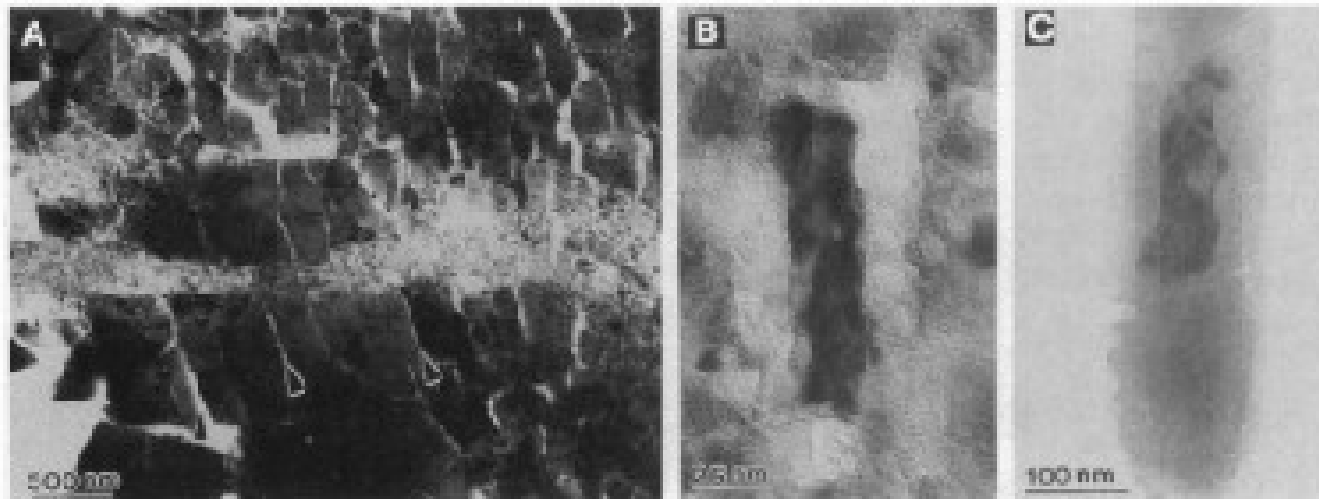


Fig. 5. TEM images of a thin section showing the morphology of the Fe-sulfide phases present in Al H84001 and a terrestrial soil sample. Iron sulfide phase (greigite?— Fe_3S_4) is located in a magnetite-poor region separate and distinct from the magnetite-rich rims (Fig. 3A, arrow II). (A) TEM of a thin section showing a cross section of a single carbonate crystal (large black regions; the apparent cleavage features are due to knife damage by ultramicrotomy). A vein of fine-grained carbonate (light gray) is observed within the large carbonate crystal. Possibly greigite and secondary magnetite (fine dark crystals) have been precipitated in this fine-grained matrix. There is a direct relation between the presence of carbonate dissolution and the concentration of the fine-grained magnetite and Fe-sulfide phases. This region shows fewer Fe-rich particles, while regions shown in Fig. 4 contain abundant Fe-rich particles. The cleavage surface of the carbonate crystal does not show any dissolution features (arrows); there is no evidence of structural selective dissolution of carbonate. (B) A representative elongated Fe-sulfide particle, located in the dissolution region of the carbonate described in (A), is most likely composed of greigite. The morphology and chemical composition of these particles are similar to the biogenic greigite described in (C). (C) High magnification of an individual microorganism within a root cell of a soil sample showing an elongated, multicrystalline core of greigite within an organic envelope.

McKay et al. (1996) figure 6

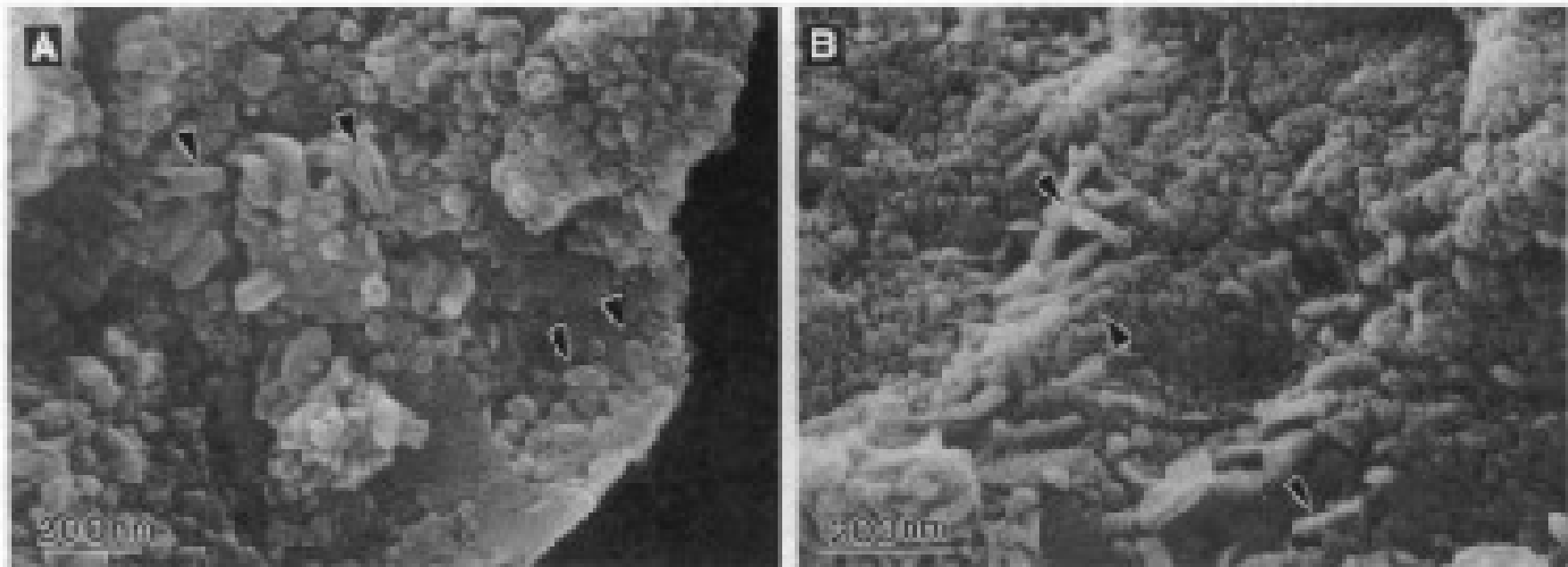


Fig. 6. High-resolution GDM images showing ovoid and elongate features associated with ALI-84001 carbonate globules. **(A)** Surface of Fe-rich rim area. Numerous ovoids, about 100 nm in diameter, are present (arrows). Tubular-shaped bodies are also apparent (arrows). Smaller angular grains may be the magnetite and pyrrhotite found by TEM. **(B)** Close view of central region of carbonate (away from rim areas) showing textured surface and nanometer ovoids and elongated forms (arrows).

Reading for Monday (10/20)

Bennett & Shostak 11.3 – discussion of Earth's possible uniqueness, including galaxy-scale factors

Lineweaver et al. (2004) – definition of a **Galactic habitable zone in the Milky Way**

Leitch & Vasisht (1998) – why even living in the “Galactic habitable zone” is not always a piece of cake!

Web site will have a cheat sheet for the latter two articles.

About next Monday...

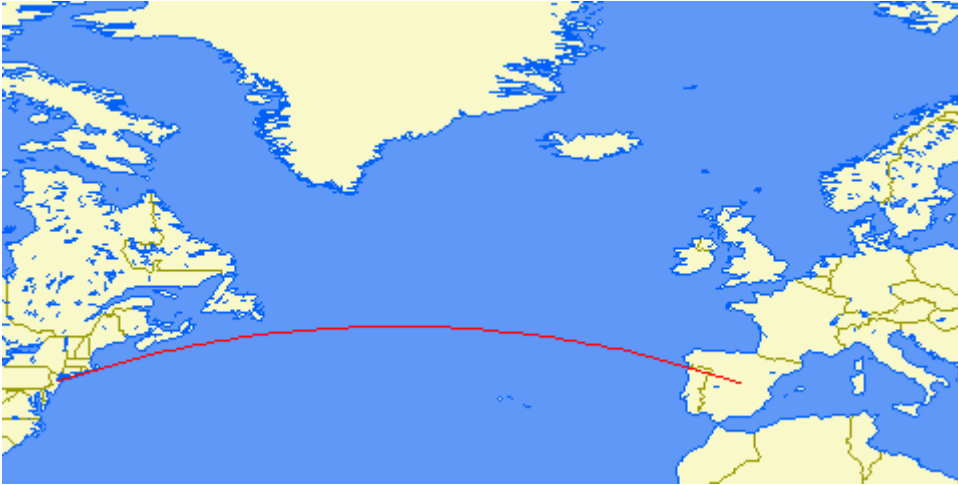


Guest teacher = Ross Fadely (Rutgers undergraduate, and now Ph.D. student working with Prof. Keeton on gravitational lensing; ask him about lensing-based planet searches)

Response papers will be returned.

Any hardcopy reading for next Wednesday (Europa!) will be distributed.

About next Wednesday...



**Continental flight 63
(Madrid-Newark)**

Plan to meet at usual time.

I will leave a message with ??? if it looks like I will be late.