MEASURING MAGNETIC FIELDS AT OCEAN WORLDS. J. R. Espley[1], G.A. DiBraccio[1], and J. R. Gruesbeck[1] [1]NASA's Goddard Space Flight Center (Code 695, Goddard Space Flight Center, Greenbelt, MD 20771, Jared.Espley@nasa.gov)

Summary: Magnetic field measurements have been a vital part of Solar System exploration for decades. Measuring magnetic fields at ocean worlds will yield important science results. Magnetometers are very low resource instruments (even with magnetic cleanliness). We welcome interest in collaborations for future missions.

Ocean World Magnetometer Science Topics: Magnetic fields tell us about a world's:

- plasma environment (magnetosphere, ionosphere)
- volatile escape (e.g. plumes, atmospheric erosion),
- distribution of conducting materials (e.g. water, metal)

Example Ocean Worlds Destinations: The potential future targets for magnetic field investigations are abundant (figures 1a-d). As examples, we could detect and characterize subsurface water or magma oceans (e.g. Callisto, Enceladus, Europa, Io, Miranda, Pluto, etc.). We could detect and characterize (via ion cyclotron waves) the types of ions escaping from plumes and atmospheric erosion (e.g. Enceladus, Europa, Titan, etc.) We could detect and characterize unusual magnetospheric interactions (e.g. Pluto, Titan, etc.).

Magnetometer instrumentation: A variety of measurements techniques have been used to measure magnetic fields in space. However, to-date, the most successful type of instrument has been the fluxgate magnetometer, especially the standard sized ones (e.g. Juno, MAVEN, and Parker). As part of their success, fluxgate magnetometers have always had modest system requirements. However, there is a new set possible mission opportunities that are truly resource-constrained such as SmallSats (e.g. as secondary payloads with primary spacecraft) or small landers (e.g. the Europa lander). Figure 2 shows the basic instrument specifications for the currently available Goddard magnetometers.

Spacecraft Accommodations - Booms, Magnetic Cleanliness, and Requirements: Spacecraft components can often produce signals that are detectable by magnetometers; such signals could interfere with the natural signals that we are trying to measure. In order to avoid such signals, programs of magnetic cleanliness (i.e. minimizing magnetically permeable material and/or current producing systems) are often implemented. Such programs can become onerous for spacecraft providers if not done in a selective way. Collaborative approaches between the spacecraft team and experienced magnetometer instrument teams can often allow for relatively easy magnetic cleanliness programs. Often times, the easiest approach is simply a relatively long boom to keep the sensor away from the spacecraft. Such booms do cost spacecraft resources (mass, volume, and budget) but often these costs are very modest and allow comparatively lax magnetic cleanliness programs. In all cases, the most appropriate solution will depend on the science requirements. An experienced magnetometer instrumentation team can easily help craft this appropriate approach and keep the overall impact of the magnetic investigation modest compared to the very significant science results.

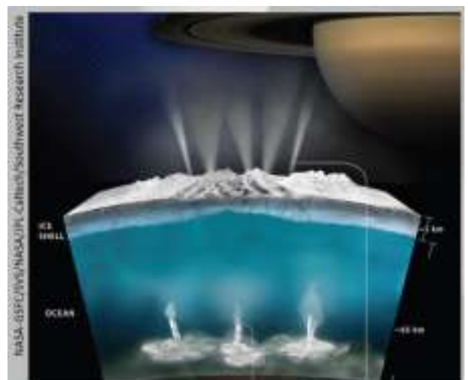

Fig 1a. Subsurface water oceans

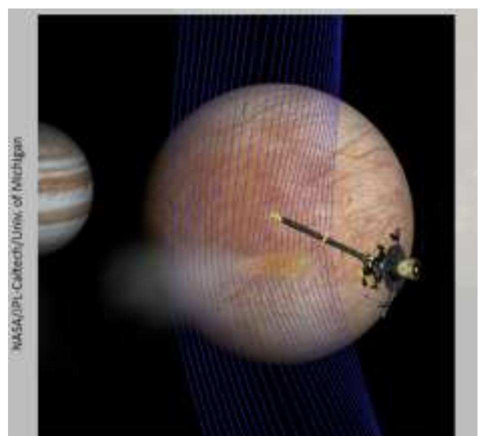

Fig 1b. Ion cyclotron waves from escaping plumes

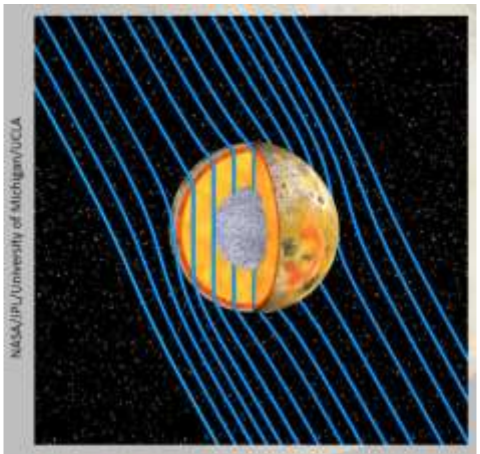

Fig 1c. Conducting interiors

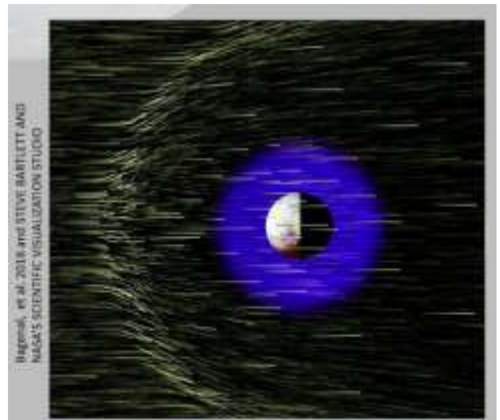

Fig 1d. Unusual ocean world magnetospheres

Figure 2	Fluxgate	Small fluxgate	Magnetoresistive
Heritage	Juno, MAVEN, Parker	POGS, GTOSat	None/Limited
Capability	**~< 0.01 nT**	**~ 0.1 nT**	**~10 nT**
Sensor Mass	400 g	30 g	<1g
Total Mass (electronics, sensor, cabling, and thermal but not boom)	~ 1 kg	< 500 g	<< 1 kg
Power	~1 W	<0.5 W	<0.1 W
Radiation Tolerance:			
Sensor	5+ Mrad TID		?
Electronics	100 krad TID		?