PS4.4: Mineral powder samples for solar wind ion sputtering experiments relevant for Moon and Mercury (ID: EGU2020-3303)

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powder analogues for Moon and Mercury

Using single minerals helps to understand the underlying processes of alteration

what we expect on the surface:

Moon (Heiken+ 1991)	Mercury (McCoy+ 2018)
high-Fe pyroxene (enstatite)	low-Fe pyroxene (enstatite)
Ca-Fe-Mg pyroxene ('augite')	Ca pyroxene (diopside)
low-Na plagioclase (bytownite)	low to int.* Na plagioclase (labradorite)
minor olivine	minor** olivine
oxides (i.e. ilmenite)	sulfides (i.e. niningerite)

* intermediate Na contents from high Na measurements
** except for High-Magnesium geochemical terrane

what we work with (SEM measurements):

Oxides (1)	Enstatite wt% (2)	Diopside wt% (3)	Bytownite wt% (4)	Wollastonite wt% (5)
SiO_2	55.47 ± 3.91	54.16 ± 0.18	48.01 ± 4.06	52.22 ± 2.37
Al_2O_3	0.70 ± 0.50	b.d.	31.80 ± 2.39	b.d.
FeO	5.22 ± 3.91	2.25 ± 0.52	b.d.	b.d.
MgO	38.61 ± 3.91	20.55 ± 1.65	0.75 ± 0.37	b.d.
CaO	b.d.	23.04 ± 1.12	13.10 ± 3.08	47.78 ± 1.37
Na_2O	b.d.	b.d.	6.34 ± 1.56	b.d.
K_2O	b.d.	b.d.	b.d.	b.d.

Upcoming:
Labradorite (intermediate Na),
Pigeonite (~Enstatite + 10% Wollastonite)

thin films from Pulsed Laser Deposition (PLD)

- fast, relatively simple preparation
- direct precipitation on quartz crystal microbalance (QCM)
- high precision measurements of sputter yield*

- restriction of laser absorption (problem: diopside)
- stoichiometry of sample not preserved completely (see Hijazi+ 2017)
- deposit T limited by quartz crystal (glassy product)
- dissociation of minerals is possible

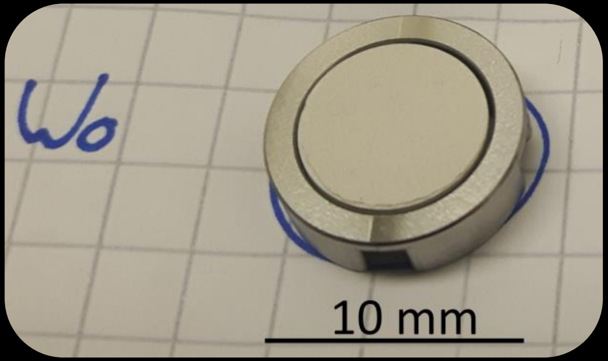
***sputter yield**

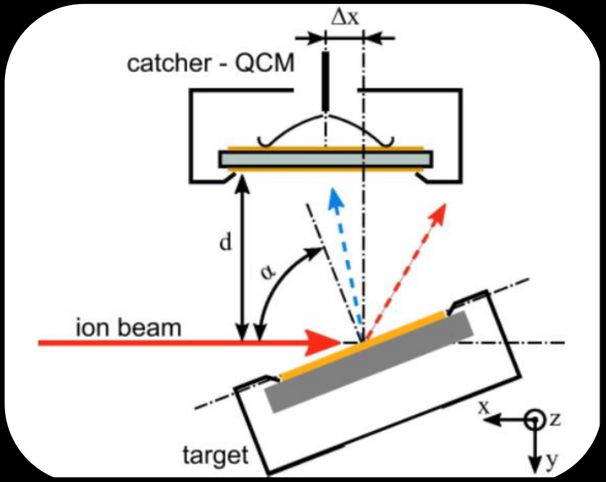
The amount of target material ejected per impinging ion. In reality, those are solar wind ions with ~95% H^+ and ~5% He^{2+}, with traces of heavier elements such as O^{6+}.

pressed powder pellets

- fast, simple preparation
- stoichiometry and crystalline structure preserved
- allows for infrared measurements

- more fragile for transport and during creation*
- more easily contaminated during preparation
- ‘catcher’ QCM → only indirect sputter yield measurements





*enstatite pellets tend to break and bytownite pellets easily fall apart if not sufficiently compressed.

grain size and porosity… of pellets

Moon regolith (Heiken+ 1991, Carrier+ 1991)
- grain size medians of ~40 - 100 µm
- porosity of 42 - 52 %

Mercury's regolith vs Lunar (Domingue+ 2016)
- smoother on micrometer scales
- narrower particle size distribution
- lower mean particle size
- porosity unknown

effect of grain size and porosity on sputtering results will be investigated

Mean grainsizes of powders used are below Lunar medians but could fit well for Mercury.

An average of 20 % porosity is much lower than on the Moon.

Low grain sizes or large pressures are necessary to produce glue-free pellets. This is a compromise for obtaining the stability needed for transport and irradiation experiments.

New procedure will allow for lower compression, but we do not expect much larger porosities.

mineral pellets allow for IR spectra

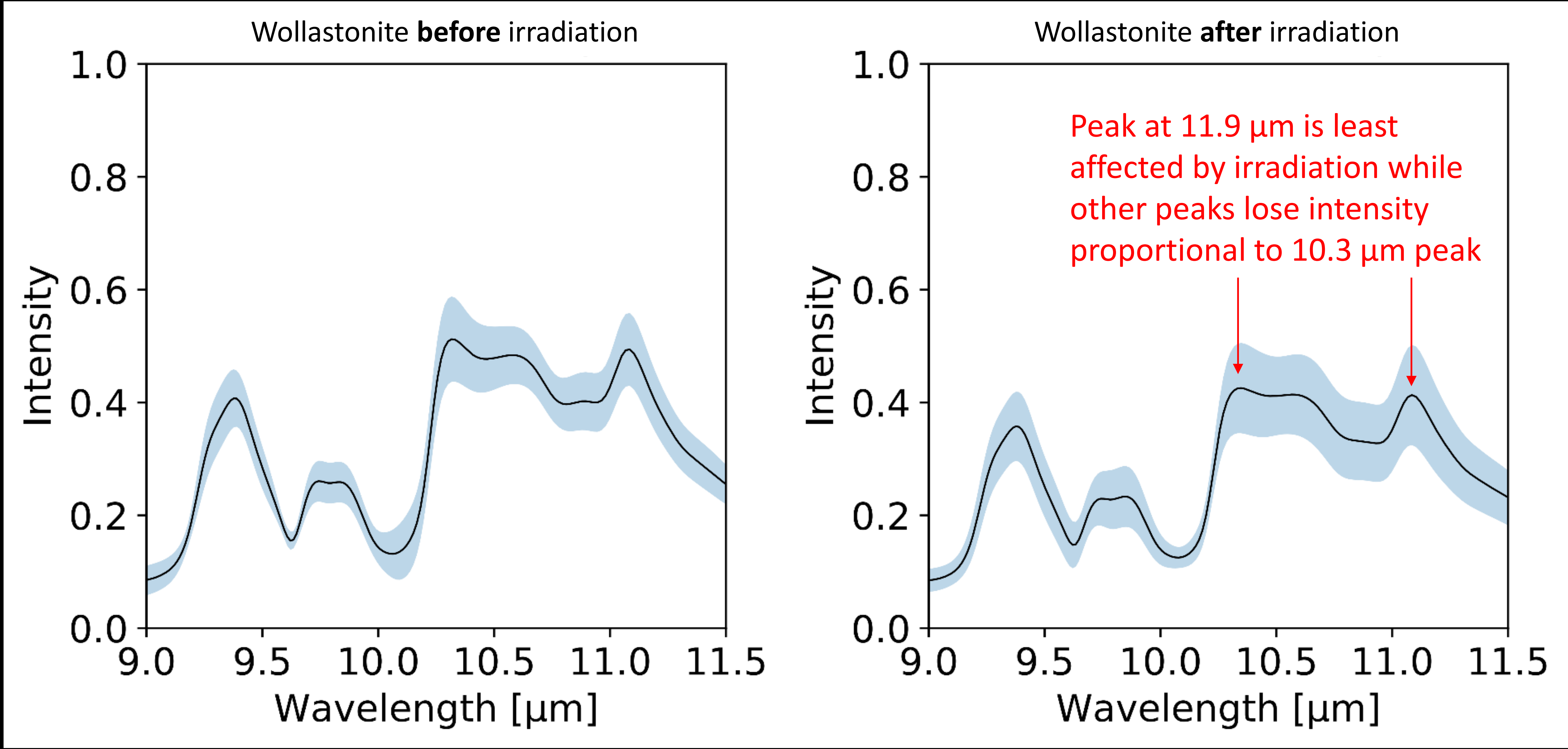
- measurement before and after solar wind irradiation
- comparable to IR spectra taken from space (BepiColombo MERTIS range: 7 – 14 µm)

bepicolombo

First results from wollastonite show that:

- IR signal is smoothed, removing minor extrema
- extrema between 9.75 – 10.9 µm are shifted to larger wavelengths
- elevated intensity loss at pre-irradiation maxima (10.3 µm)

overall intensity change, loss of loc. maxima



Note: range was chosen to highlight extrema; black line = mean over 10 measurements; blue area = 2SD.

next steps for sputter yield measurements

determine (wherever applicable) the

- impact of crystallinity,
- grain size dependency,
- angle dependency, and
- implantation behavior

by comparing PLD with pellet results.