Lunar surface elemental maps from |X ray fluorescence measurements.

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Lunar surface elemental maps from |X ray fluorescence measurements. S. Narendranath and Netra |S Pilllai, Space Astronomy Group, U R Rao Satellite Centre, Bengaluru, India , kcshyama@isac.gov.in, netra@isac.gov.in

Introduction: X-ray fluorescence (XRF) measurements have been a well-known technique to remotely map the surface elemental composition of airless bodies. The XRF lines from elements are unique in their energy making the identification straight forward. Spatial resolutions of the order of tens of kilometers on the lunar surface have been achieved using this technique. Signals are triggered only when there are solar flares which limit coverage. However, the XRF line measurements from elements are unique making the identification straight forward since line energies are clean markers of presence of elements and inversion techniques provide greater confidence in abundance estimates.

The first such measurement from Apollo 15 and 16 cover about 10% of the Moon for Mg, Al and |Si. The published results are in terms of Mg/Si and Al/Si ratios from empirical relation of the intensity ratios to elemental concentration in returned samples [1,2]. With a good understanding of the response of the detectors, the counts can be converted to flux (photons/s) which is a better measure of the variation in composition. Ultimately elemental maps in wt% with associated errors are required to reveal compositional variations across the lunar surface.

There are several parameters such as the shape of the incident solar spectrum (that triggers XRF) matrix effects, particle size and geometrical parameters that complicate the conversion of flux into abundances in wt%. Much of these have been dealt with in two XRF experiments flown in 2004 and 2008, ie DCIXS on SMART-1 and C1XS on Chandrayaan-1. We have here compiled the published results [3,4,5,6,7] on elemental weight % these instruments and presented them as elemental maps laid over Clementine visible albedo images.

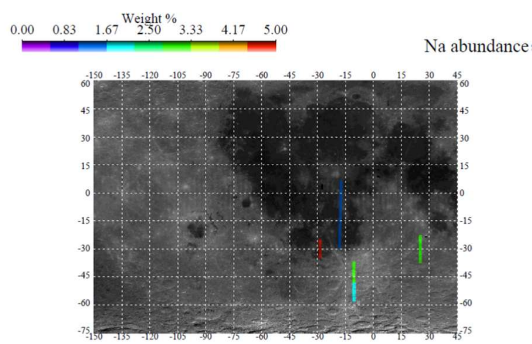
Though still sparse in coverage it is to be noted that XRF measurements being direct is one of the best ways to determine abundances and hence this effort.

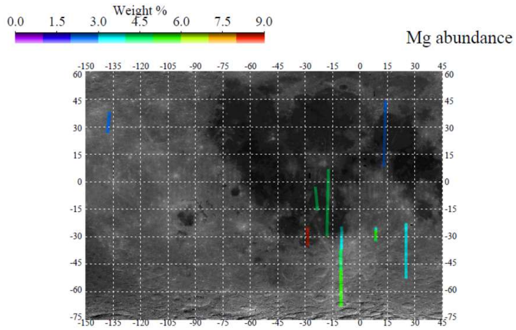
Elemental maps: Elemental maps are generated from NIR spectra with methodologies that rely on correlations with ground truths. Gamma ray measurements too measure elemental abundances but often is not a direct estimate especially for the refractory elements. Abundances derived from X ray measurements are thus very relevant. We have not included a map of Ti since there is only one track with abundance of 3 ± 2 wt% consistent with the expected values in the mare region observed. Fe is also sparsely measured as it is triggered only strong solar flares (typically GOES class C or above). Figures 1 to 5 show the elemental maps for Na, Mg, Al, Si and Ca as measured by DCIXS and C1XS. Full resolution images and tables with values are uploaded in the research gate profile of both authors.

Sodium : We have put together the available measurements of Na though sparse because of its implications. The Na measurements are from C1XS alone.

CLASS on Chandrayaan-2: The Chandrayaan-2 Large Area X ray Spectrometer (CLASS) is an X ray fluorescence spectrometer with a 12.5 x 12.5 km spatial resolution and a larger collection area than previous such experiments. This would provide the much needed observations for many more areas of the Moon.

References [1] Adler et al. (1973) *LPSC, 4,* 2783–2791. [2] Adler. et al. (1972) *LPSC., 3,* 2157-2178. [3] Grande. et al. (2007) *PSS, 55,*494-502. [4] Swinyard et al. (2009) *PSS,* 57, 744-750. [5] Narendranath et al, (2011) *Icarus, 214,*53-66 [6] Weider et al. (2011) *PSS*, 59, 1393 [7] Athiray et al. (2014), *PSS*, 104, 279-287

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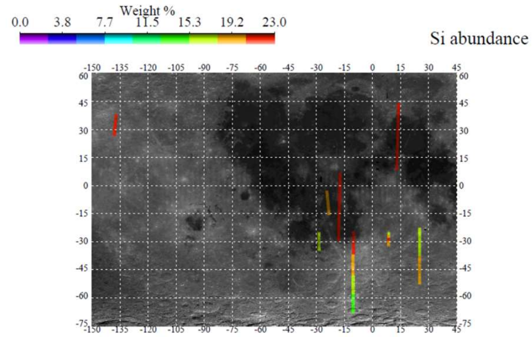
Mg abundance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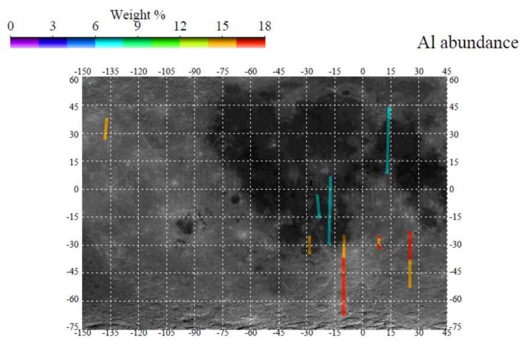
Si abundance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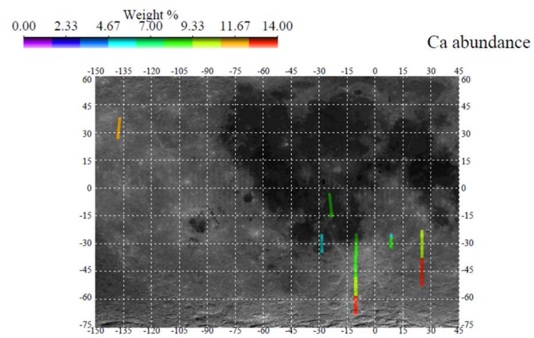
Al abundance


Weight %
0.00 2.33 4.67 7.00 9.33 11.67 14.00
Ca abundance