PEAKS IN KAGUYA GAMMA-RAY SPECTRA AND GAMMA RAYS USED TO GET ELEMENTAL ABUNDANCES.

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Introduction: Over 200 peaks have been identified in the spectra from the germanium (Ge) detector of the Kaguya (SELENE) Gamma-Ray Spectrometer (KGRS) [1]. These peaks in KGRS spectra have been fitted by many of the authors. The sources of most of these peaks have been identified. Some of these peaks have been or will be used to map the abundances of several elements over the Moon's surface [e.g., 2,3].

In [1], many background peaks from the Ge detector, the bismuth germanate (BGO) around the main Ge detector, and the Al structure of the KGRS were discussed. Analyses were done on the gamma-ray spectra measured while the KGRS was pointed away from the Moon in Dec. 2008, in which most gamma rays from the Moon were attenuated by the mass of the spacecraft and the KGRS [4]. Backgrounds for U, Th, and Ca peaks were studied [5]. Knowing the sources of as many peaks as possible is necessary to avoid using a peak with major background contributions or without background corrections for elemental mapping.

Peaks in Kaguya Gamma-Ray Spectra: In many cases, some of the peaks of gamma rays in Kaguya spectra are clearly resolved from other peaks and features. The peak at 1461 keV from the decay of ^{40}K is far from other peaks (Fig. 1). The 911 and 2615 keV peaks used for thorium are also well resolved [2,3].

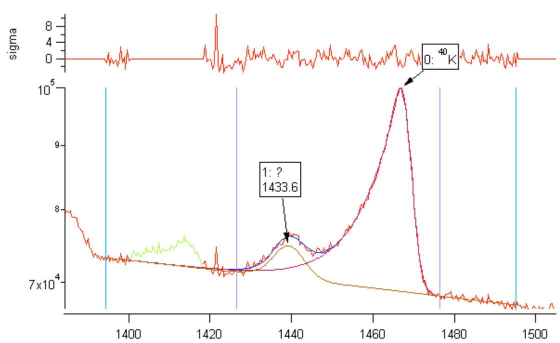

Fig. 1. Peak for potassium at 1461 keV. The peak at 1434 keV is from excited ^{52}Cr, mainly made in Fe.

At higher energy, peaks are broader and have long radiation damage tails below the peak, and it is often harder to resolve peaks at higher energies. The 7631-7645 keV Fe capture doublet have considerable overlap (Fig. 2), and some analyses, especially for small lunar regions, only used one peak.

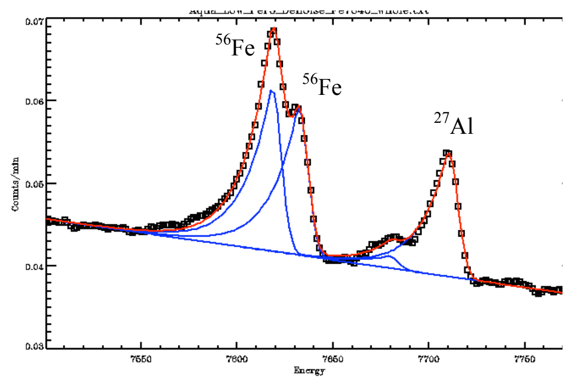

Fig. 2. Peaks for the iron neutron-capture doublet at 7631 and 7645 keV (left) and the Al neutron-capture gamma ray at 7724 keV.

There are 2 major neutron-capture gamma rays for Si. The peak for the 3539 keV gamma ray is well resolved, as shown in Fig. 3. The other major ^{28}Si(n,γ) peak at 4934 keV is also well resolved.

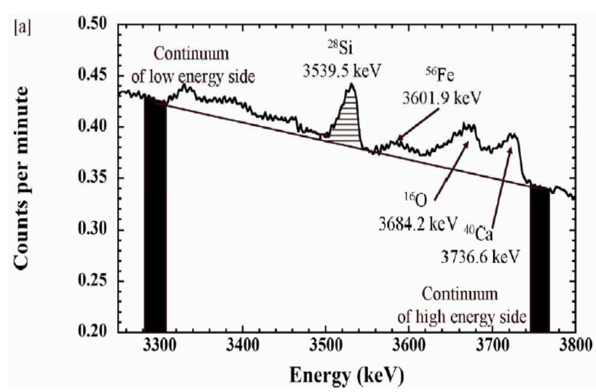

Fig. 3. KGRS peaks around the 3539 keV gamma ray used for Si.

The 1369 keV peak from excited ^{24}Mg is fairly well resolved. The problem in using this peak to map Mg that it is also made in good yields from Si, Al, and Na, and those contributions need to be removed before getting Mg results.

The Al gamma ray at 1014 keV is also well resolved. The problem for mapping Al is the large backgrounds from the many kilograms of Al near the Ge detector.

Some peaks are far enough from an adjacent peak that they can be resolved and can be fitted well, such as the 1764 keV gamma ray used for U [3], see Fig. 4. The peak at 1779 keV usually used to map Si is also made in the Al of the structure of the KGRS, so its use for Si requires background reduction.

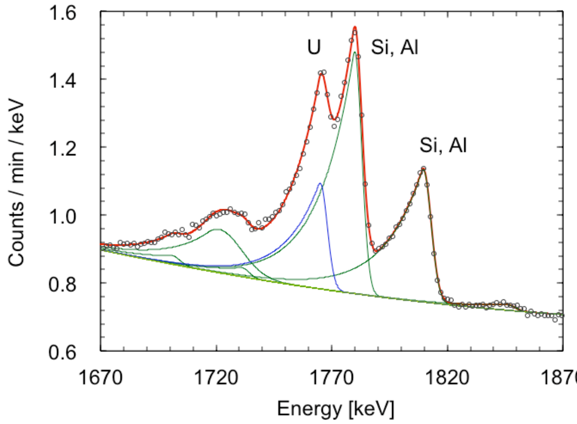

Fig. 4. Spectrum around the 1764 keV peak used for U (blue). The peak at 1779 keV is made by ^{28}Si(n,nγ) reactions and the decay of ^{28}Al made in structural Al.

In many parts of the Kaguya gamma-ray spectra, several peaks are close together. Being close together often makes it hard to identify all peaks in a group of peaks (Figs. 5 and 6). The inelastic-scattering peak for Ca is resolvable from the other peaks in Fig. 5 and was used to map Ca [6].

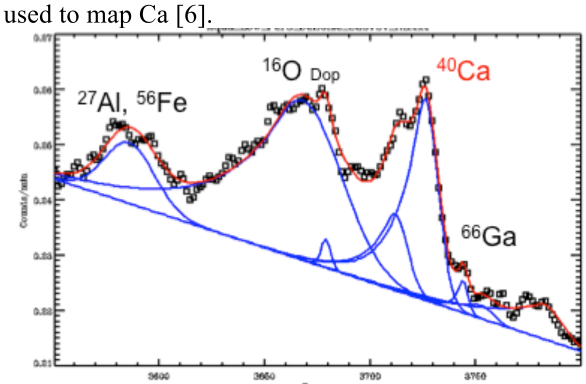

Fig. 5. Many peaks near and below the 3737 keV peak used for calcium. Sources of larger peaks are given [6].

There are many peaks at the lower energies, including broad 'sawtooth' peaks made in the Ge detector (Fig. 6), which make peaks at these energies hard to use for elemental studies.

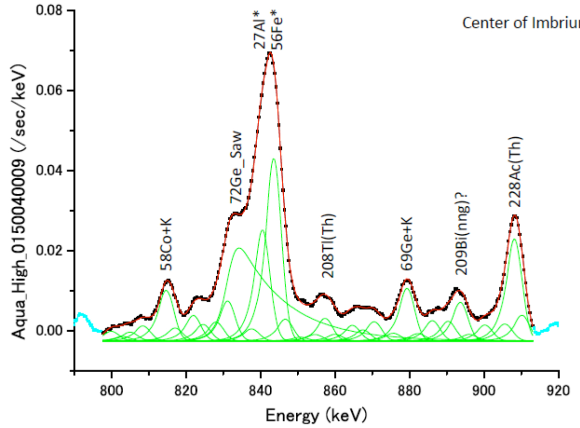

Fig. 6. There are many peaks that overlap from 800 to 910 keV, making it hard to use these gamma rays. The big peak at 843 keV is from Al, and the peak at 847 keV from Fe is weak. Both of those peaks are on a wide 'sawtooth' feature from Ge starting at 834 keV.

Summary: The nature of peak fits in Kaguya GRS spectra is discussed. The peaks for gamma rays used to map several elements in the lunar surface were presented and discussed. Peaks that are fairly well resolved from other peaks were or are being used for many lunar elements, such as K, Th, U, Al, Si, Ca, Ti, Mg, and Fe.

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References: [1] Reedy R. C. et al. (2009) *LPS XL*, #1788. [2] Kobayashi S. et al. (2010) *Space Science Reviews, 154*, 193-218. [3] Yamashita N. et al. (2010) *Geophys. Res. Lett.*, *37*, L10210. [4] Yamashita N. et al. (2010) *European Planet. Sci. Congress 5*, #580. [5] Yamashita N. et al. (2011) *LPS XLII*, #2405. [6] Yamashita N. et al. (2011) *Earth Planet. Sci. Lett.*, submitted.