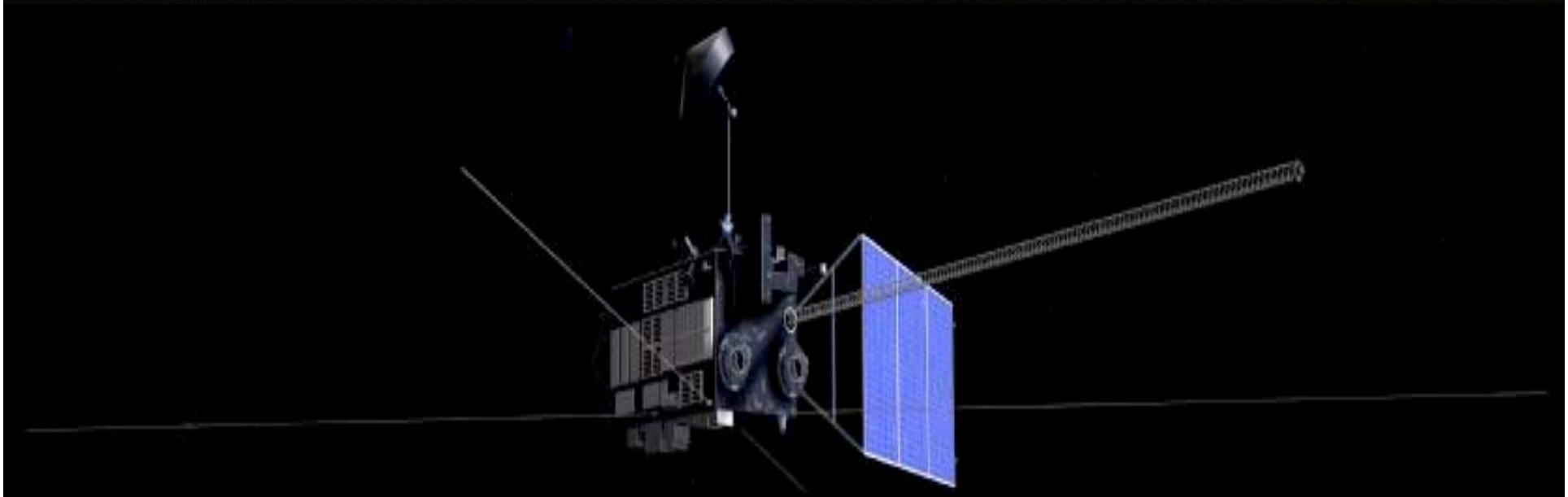
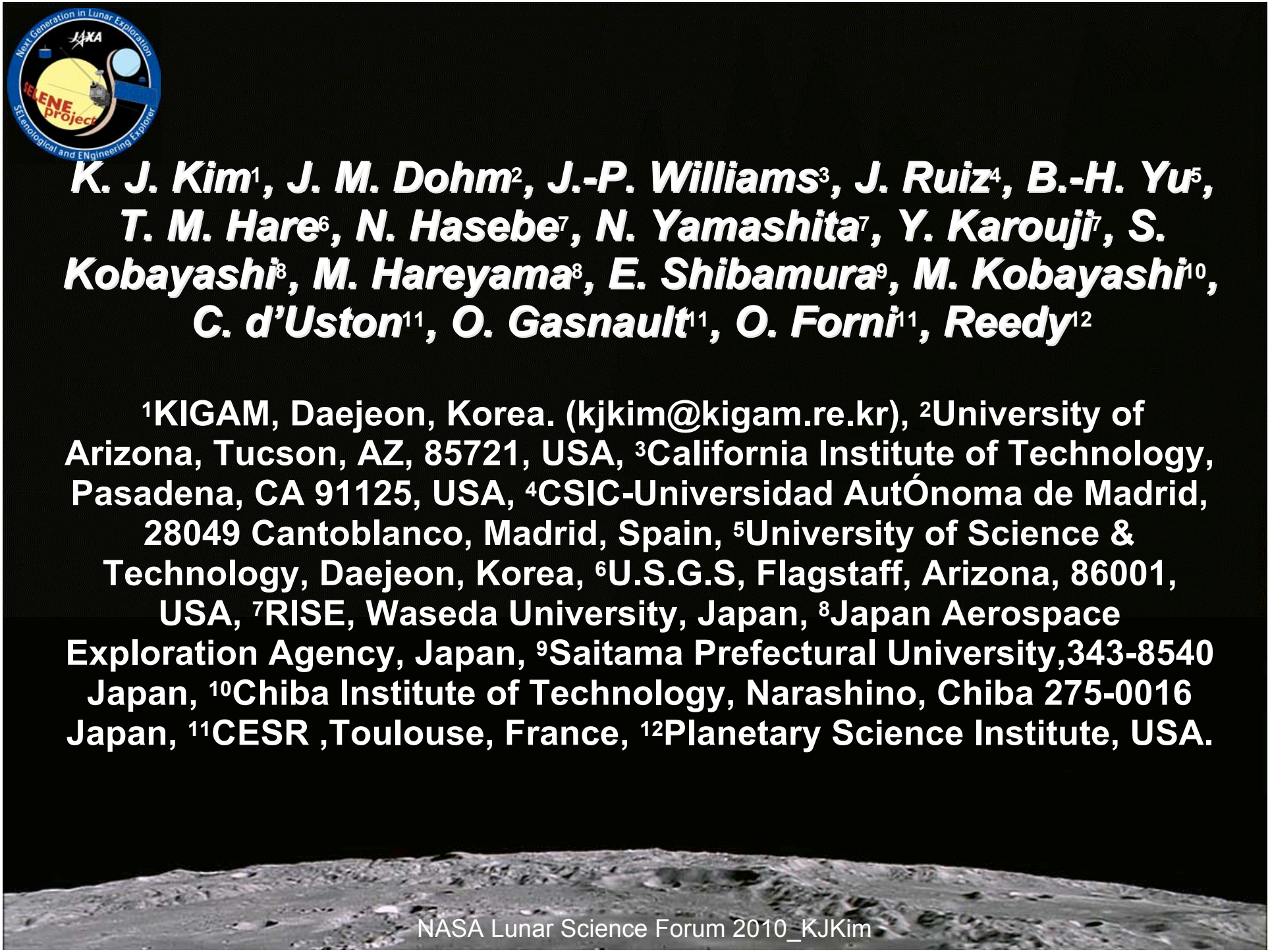
Comparison of PKT and SPA Regions of the Moon Revealed Through KGUYA GRS



Kyeong Ja Kim & co-authors

Korea Institute of Geoscience and Mineral Resources, Korea.



K. J. Kim[1], J. M. Dohm[2], J.-P. Williams[3], J. Ruiz[4], B.-H. Yu[5], T. M. Hare[6], N. Hasebe[7], N. Yamashita[7], Y. Karouji[7], S. Kobayashi[8], M. Hareyama[8], E. Shibamura[9], M. Kobayashi[10], C. d'Uston[11], O. Gasnault[11], O. Forni[11], Reedy[12]

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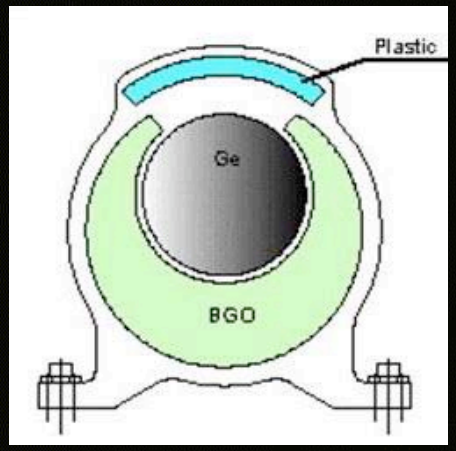
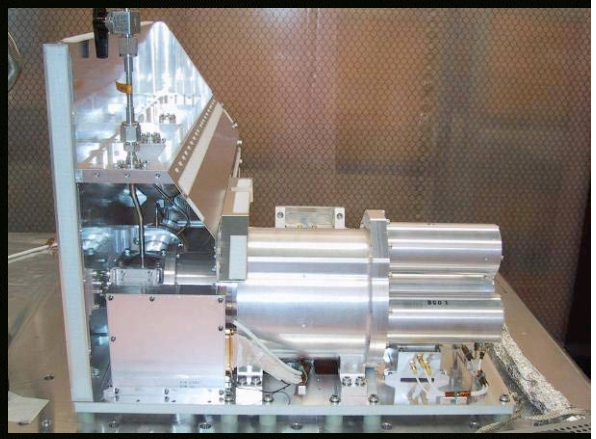
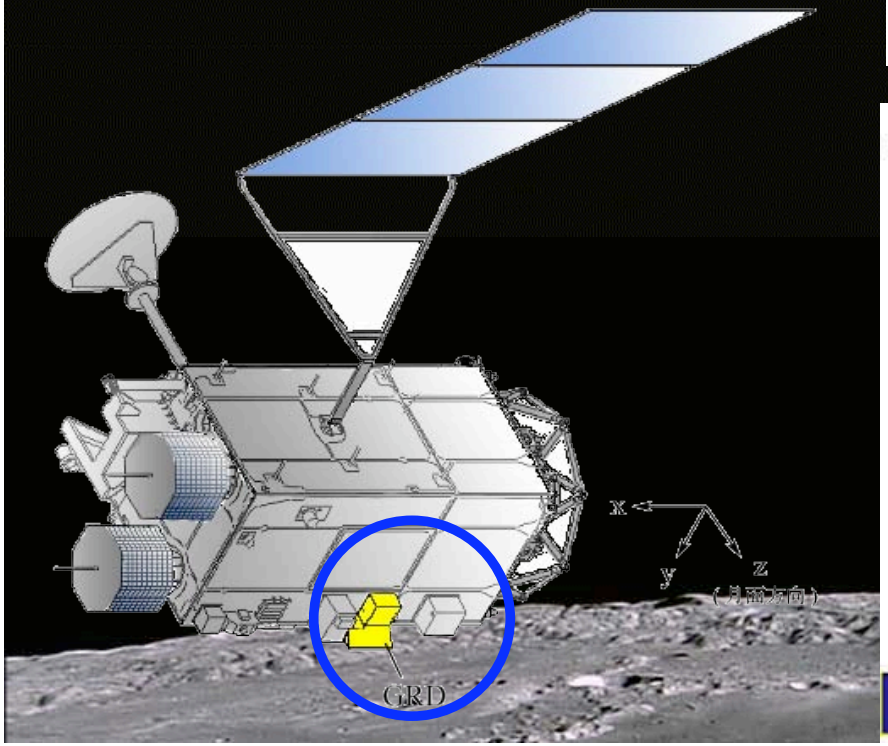
Kaguya Gamma-Ray Spectrometer

- **Main Detector**
  - **HP-Ge(Eurisys Measures)**
- **Anti-Coincidence Detector**
  - **Plastic Scintillator(BICRON)**
  - **BGO (BICRON)**
- **Global mapping of K, U, Th, O, Mg, Al, Si, Ca, Ti, Fe, and H**

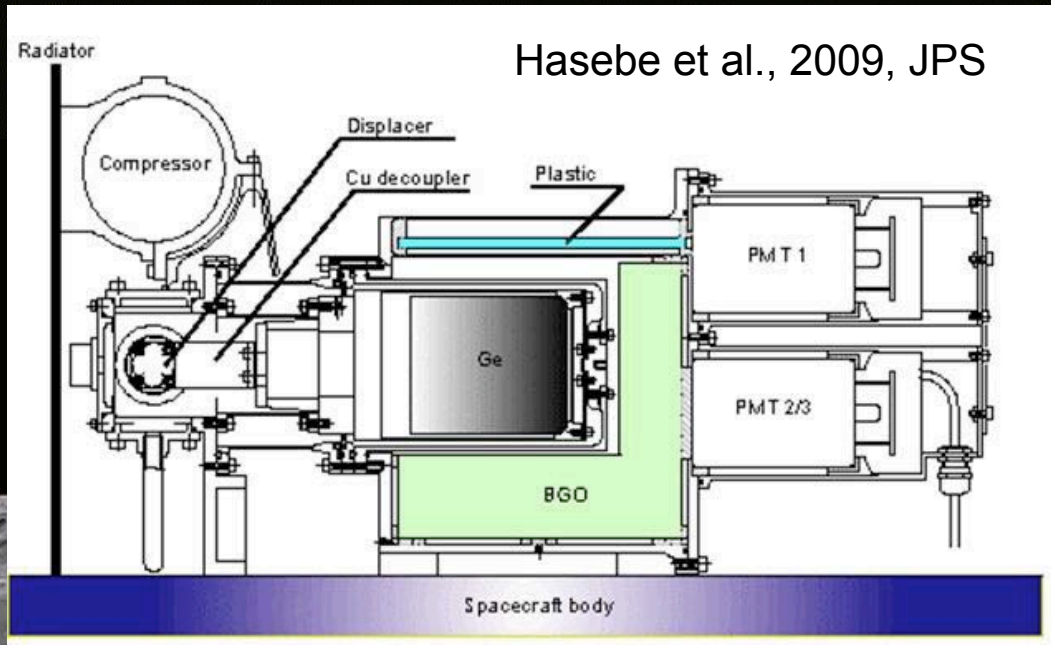
KAGUYA GRS with high energy resolution







Hasebe et al., 2009, JPS



Comparison with missions in the past

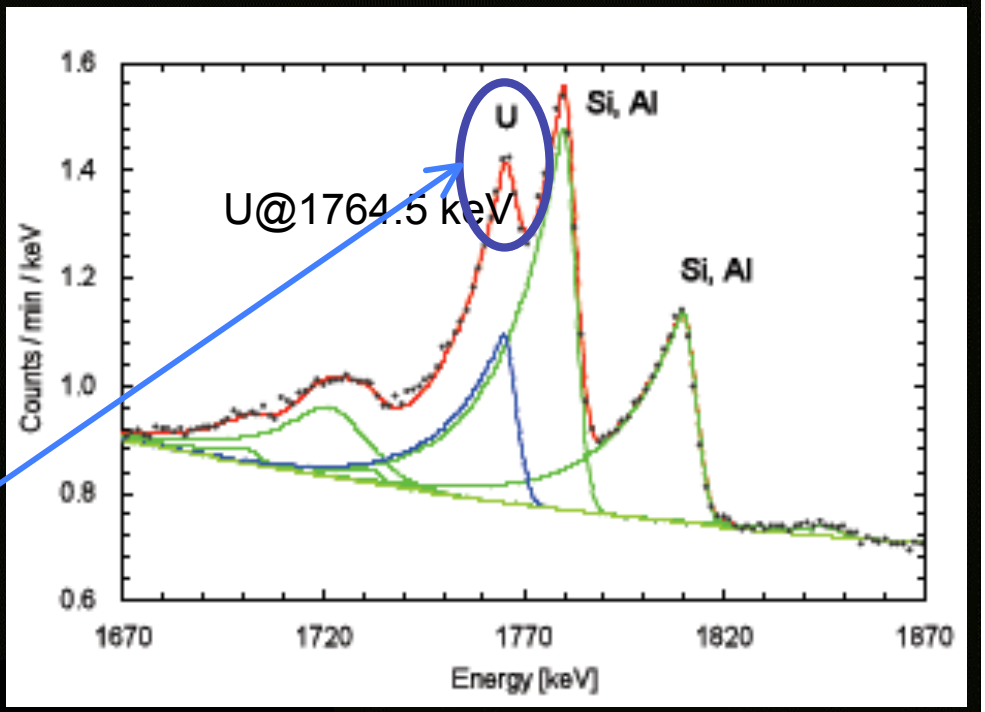
Mission	Launch	Main detector		Anticoincidence detector	Mount
		Material	Size [mm]		
Apollo 15/16	1971/ 1972	NaI(Tl)	ϕ76×76	PS	7.6m boom
Lunar Prospector	1998	BGO	ϕ71×76	PS	2.5m boom
Kaguya	2007	Ge	Φ65 x 77	BGO+PS	on SC body

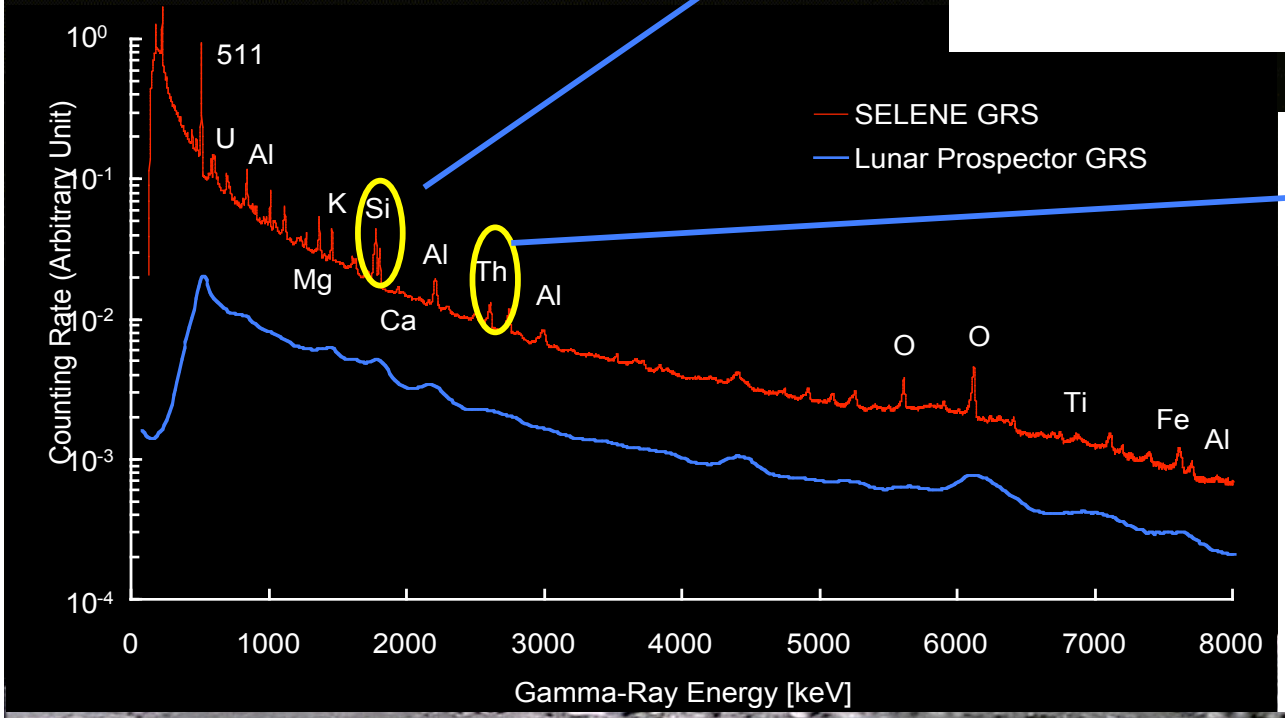
	NaI(Tl) ϕ3″ ×3″	BGO ϕ3″ ×3″	Ge 250 cm^3
Density (g/cm^3)	3.67	7.13	5.33
Efficiency*	1	1.8	0.6
FWHM@1.33MeV [keV]	46	74	3
Figure of merits*	1	1.4	4.2

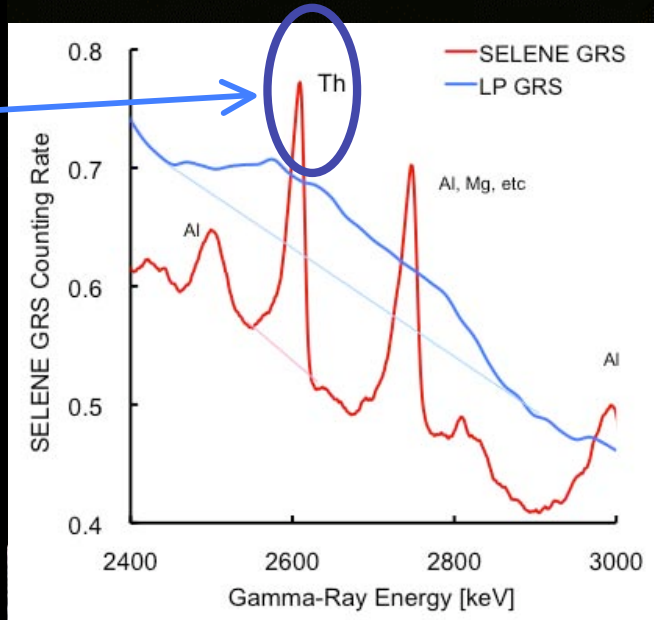
normalized to NaI(Tl)

Evidence of Excellent Identification

Fitting analyses of gamma-ray lines in the energy spectra of KGRS from
U at 1765 keV and
Th from 2615 keV.



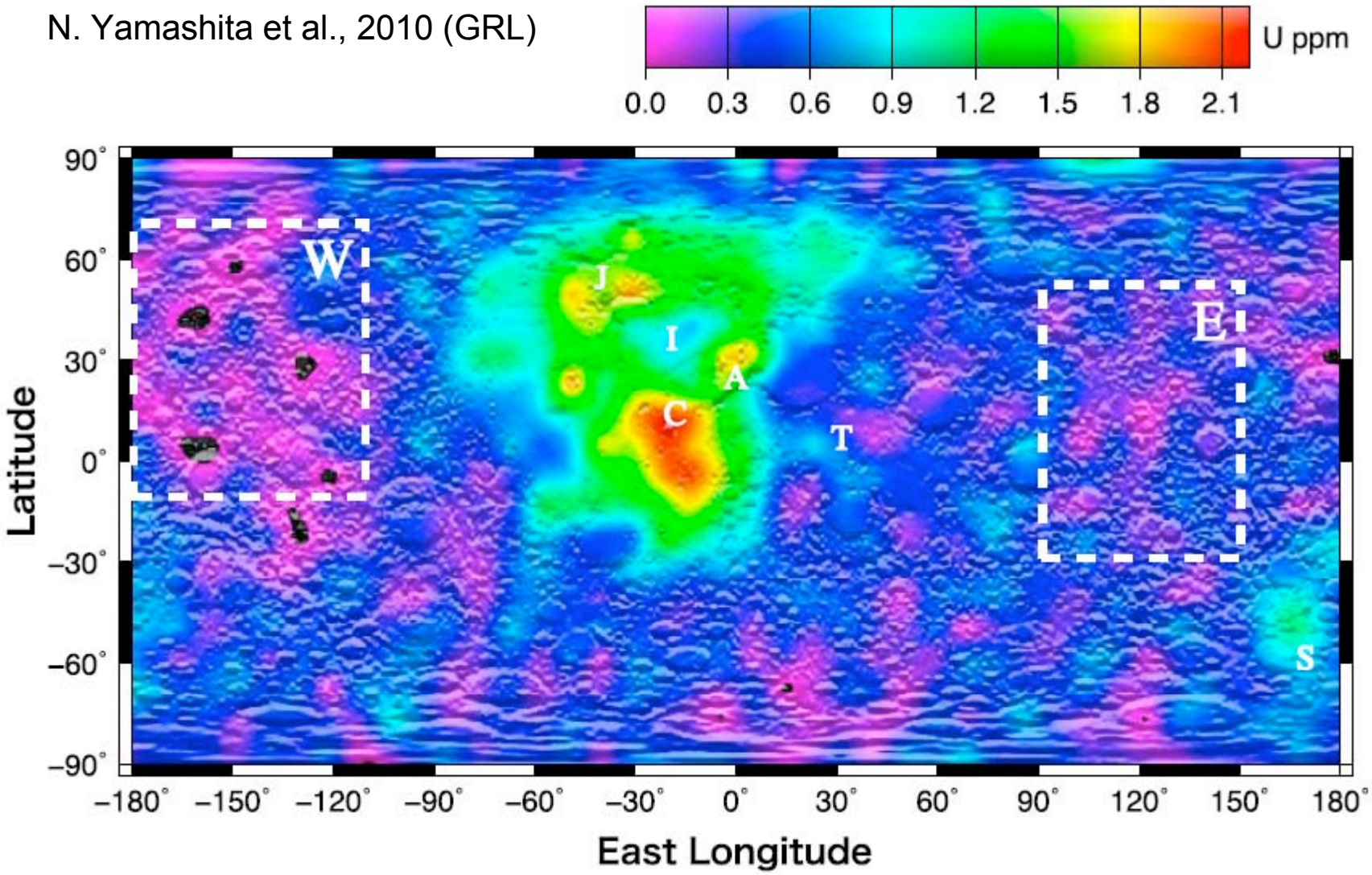




Hasebe et al., 2009, JPS

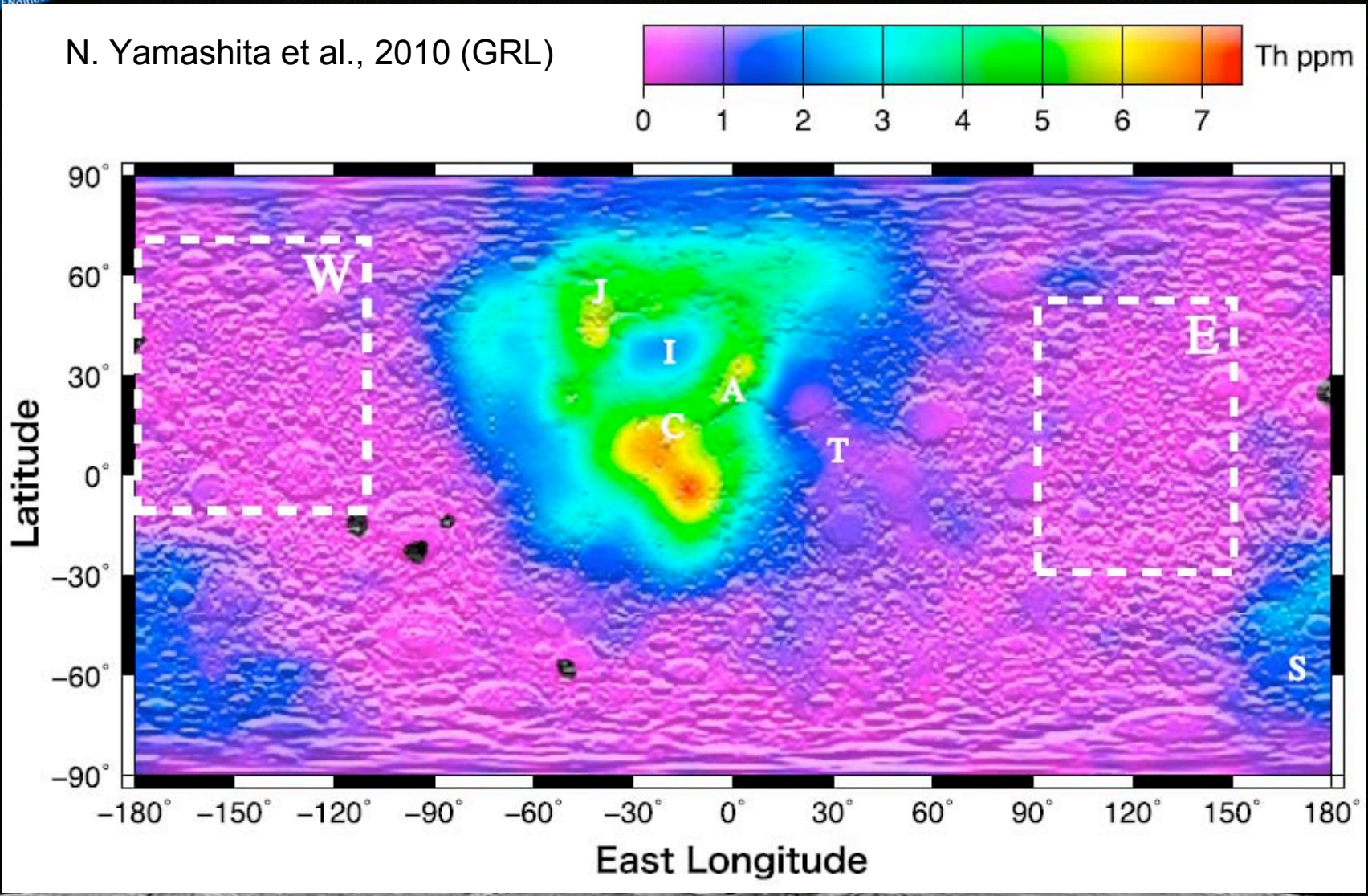
U Map by Kaguya Gamma-Ray Spectrometer

N. Yamashita et al., 2010 (GRL)



Th Map by Kaguya Gamma-Ray Spectrometer

N. Yamashita et al., 2010 (GRL)



Methodology

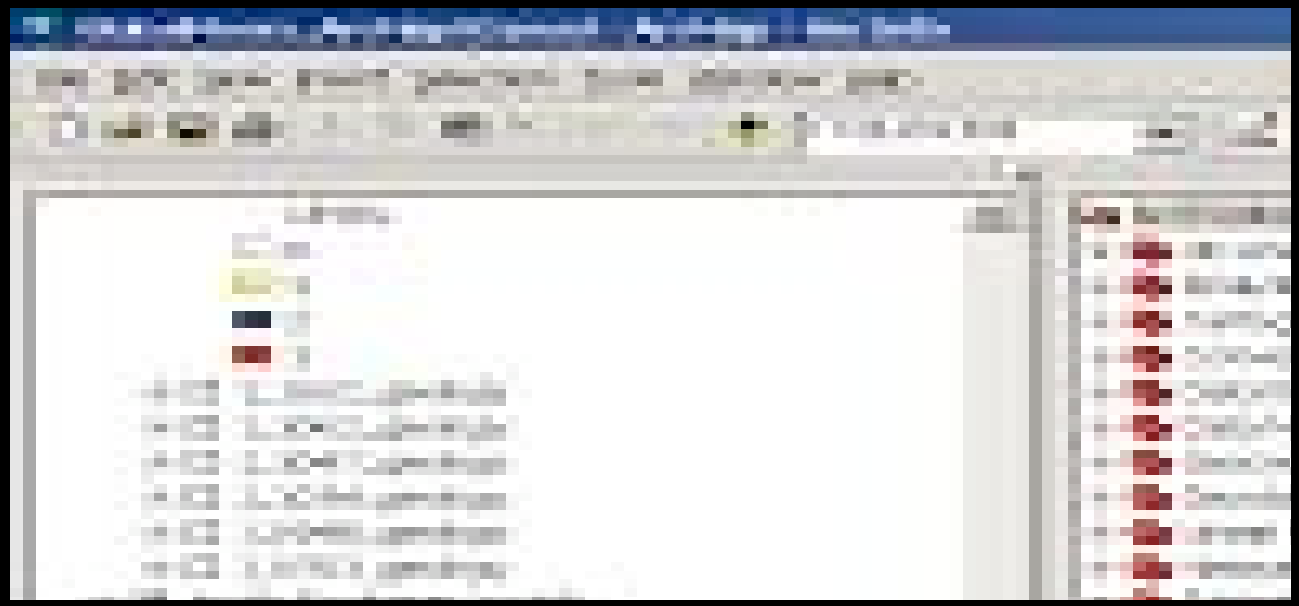
Comparison among Procellarum and South Pole Aitken Basin Regions

< Comparative analysis among lunar geology and Kaguya elemental information >

1. Define regions of scientific interest
2. Compile of Apollo-based stratigraphic information of sites
3. Compile elemental information of sites of the scientific interest
4. Perform comparative analysis among the stratigraphic and elemental information (i.e. cookie cut out)
5. Interpret surface evolution through time

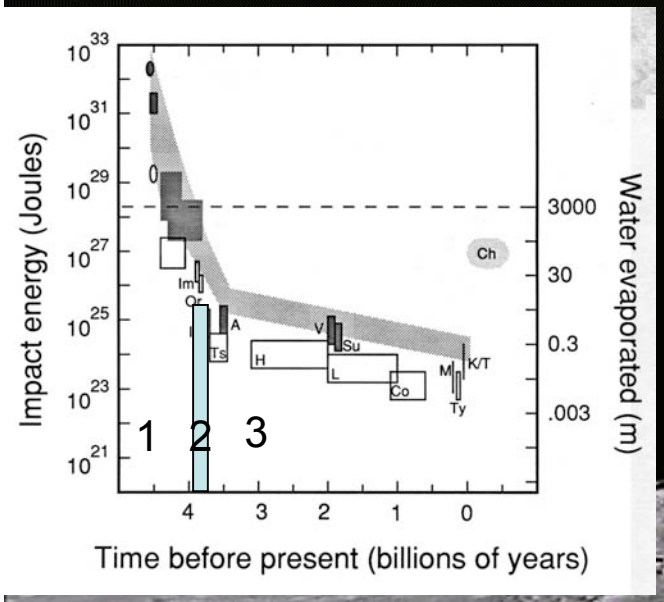
An ArcView lunar GIS mapping system introduced.

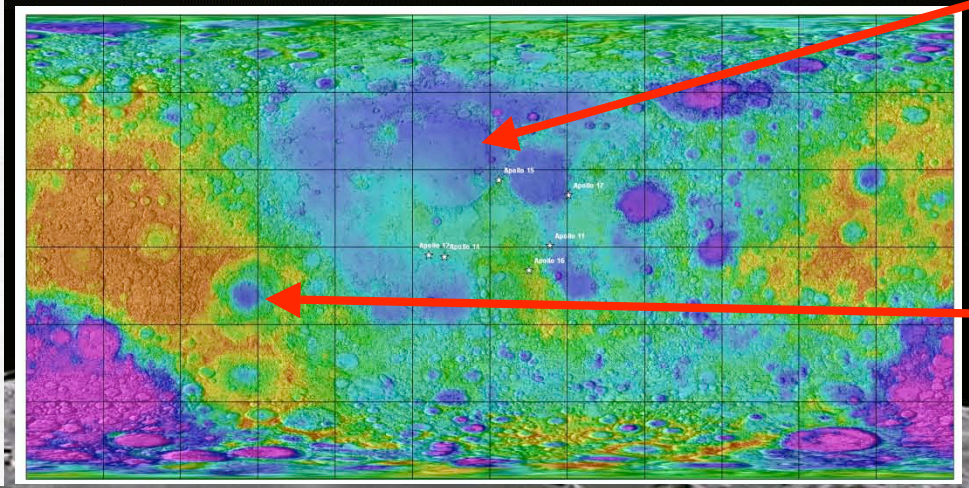
Planetary GIS-Interactive Map Analysis Program: PGIMAP



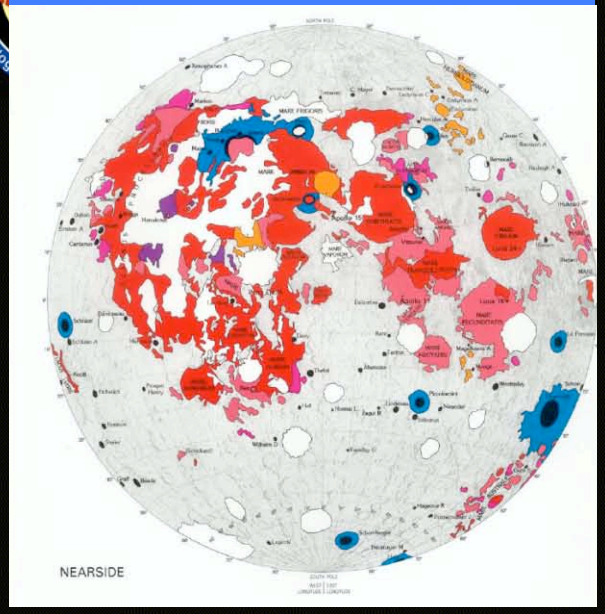
Age information of the Moon

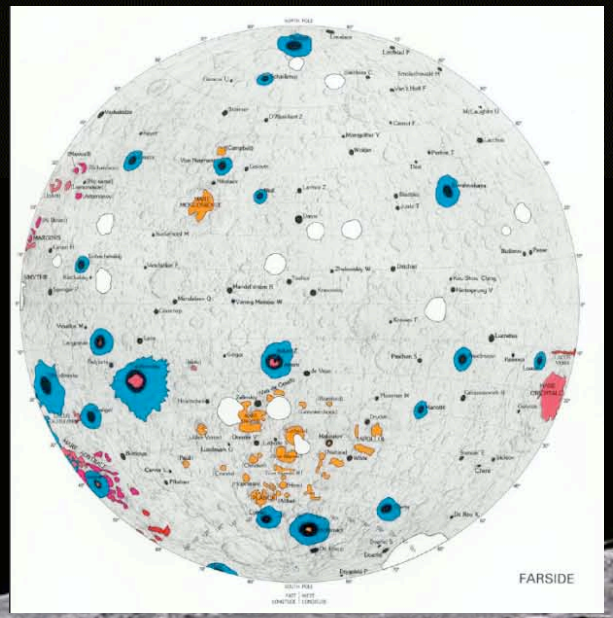
Stage	Age	Period	
1	4.5 - ~4.0 GA	Period of heavy bombardment	
2	~3.9 - ~3.7 GA	Period of Late Heavy Bombardment (~3.9 - ~3.7 GA), including possible period of impact catastrophism	
3	~ <3.7 GA	Post late heavy bombardment, mare volcanism (~ <3.7 GA)	



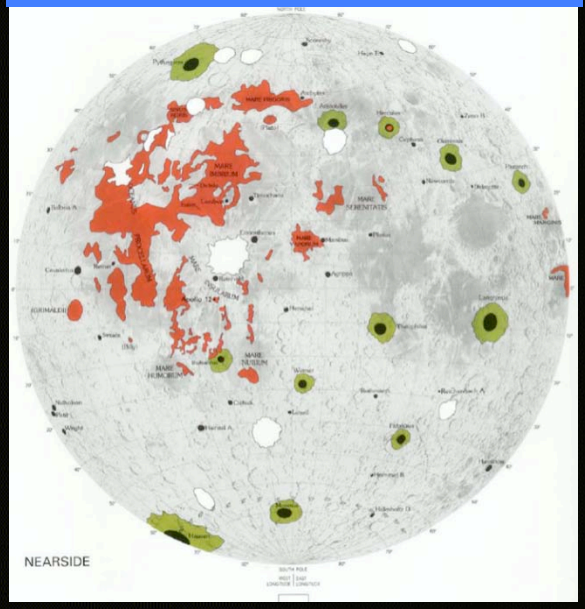


Stage 3: Upper Imbrian System



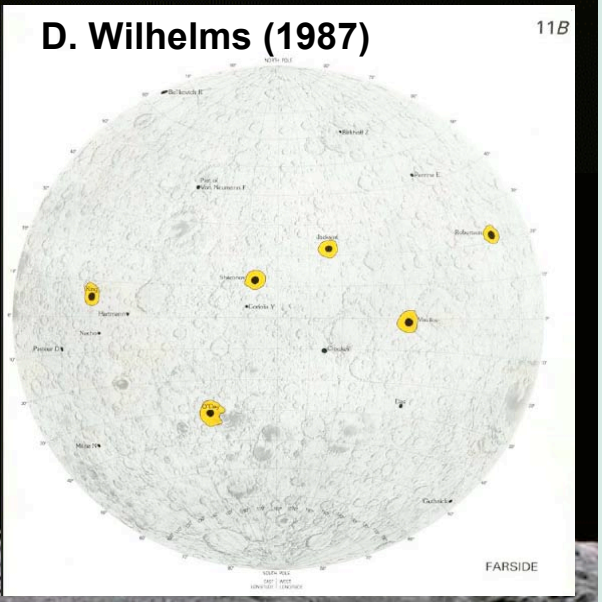


Stage 3: Eratosthenian System

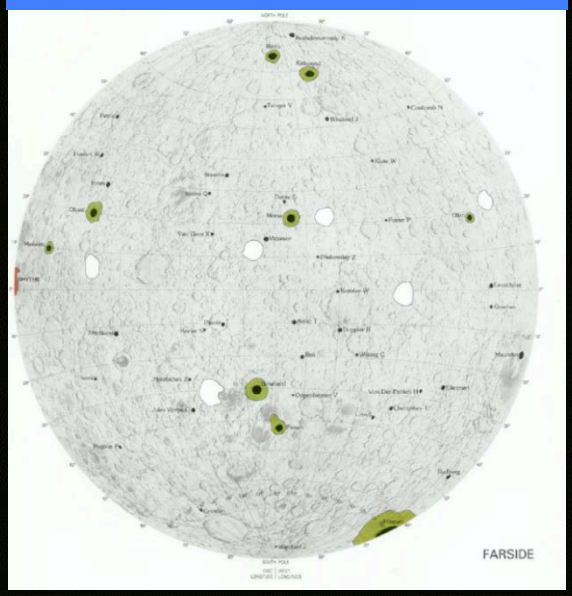


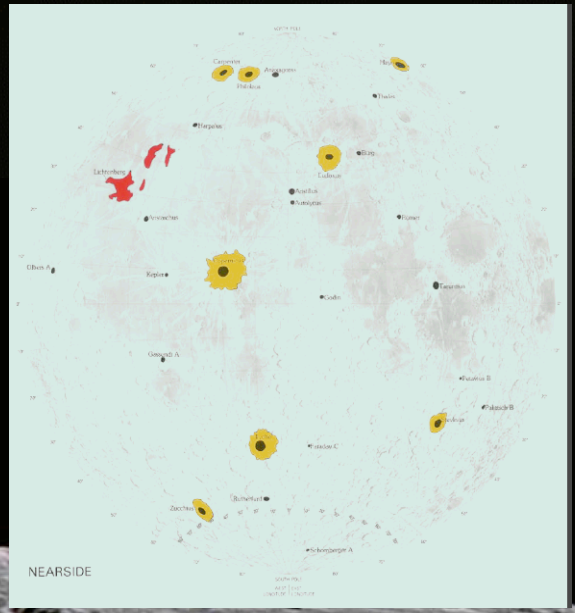
D. Wilhelms (1987)

11B



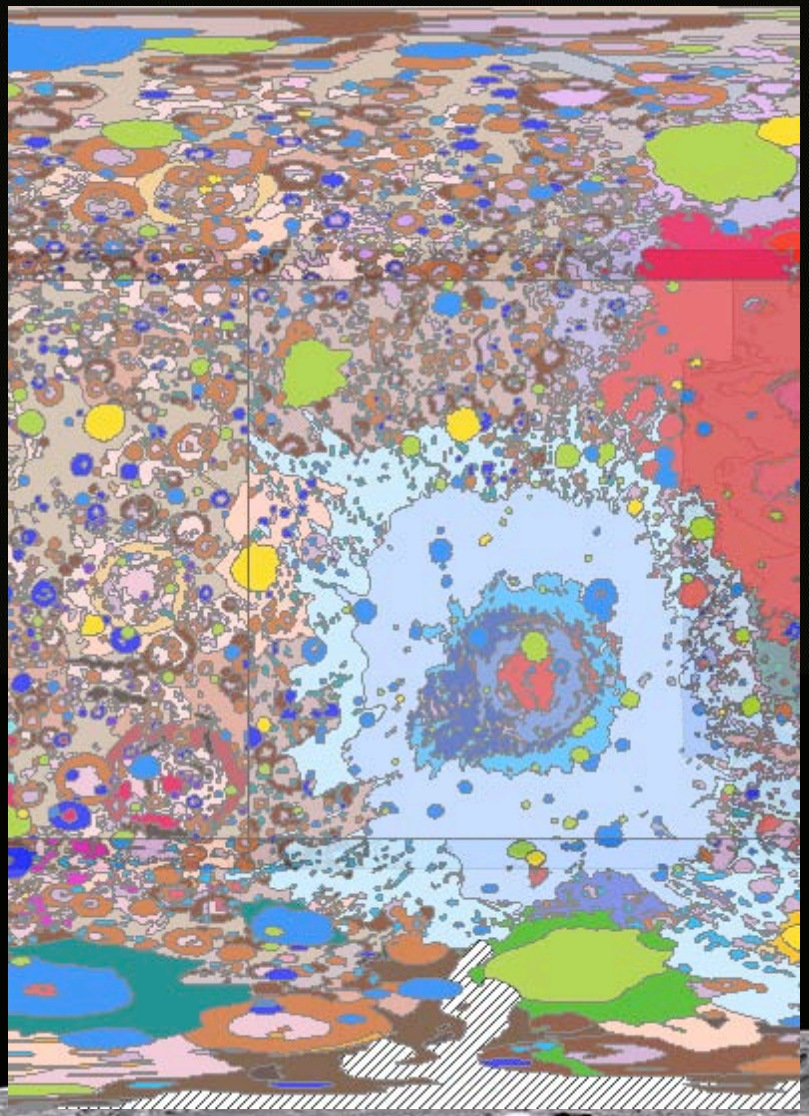
Stage 3: Coperinican System

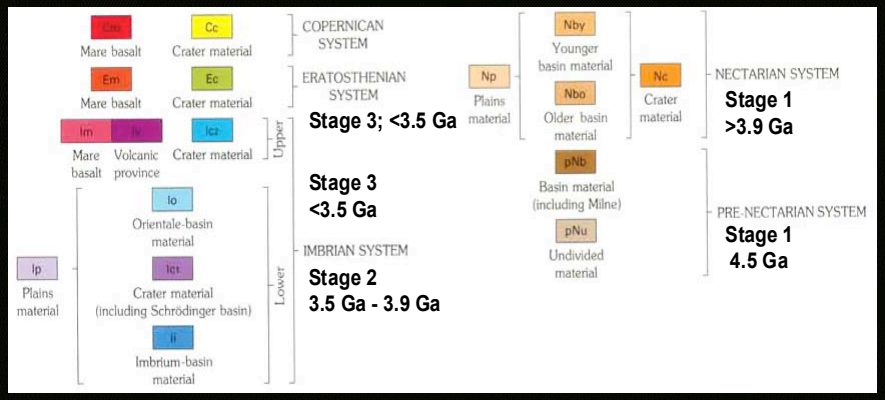




GIS based geologic map

Wilhelms and McCauley, 1971; Wilhelms and El-Baz, 1977; Scott et al., 1977; Stuart-Alexander, 1978; Lucchitta, 1978; Wilhelms et al., 1979.

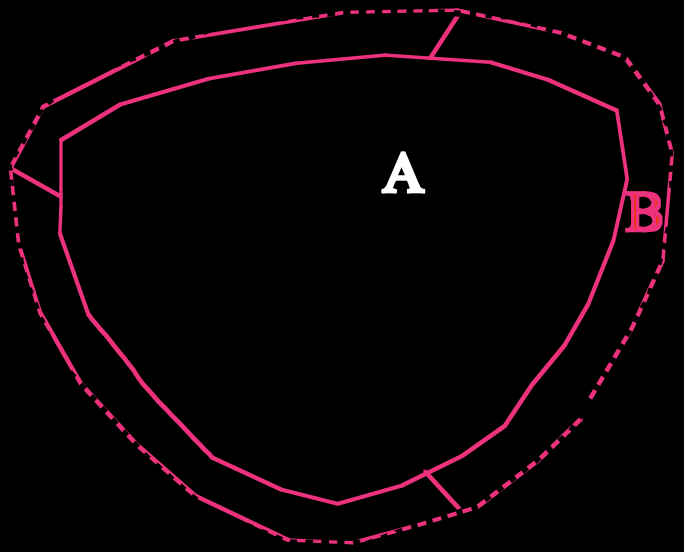


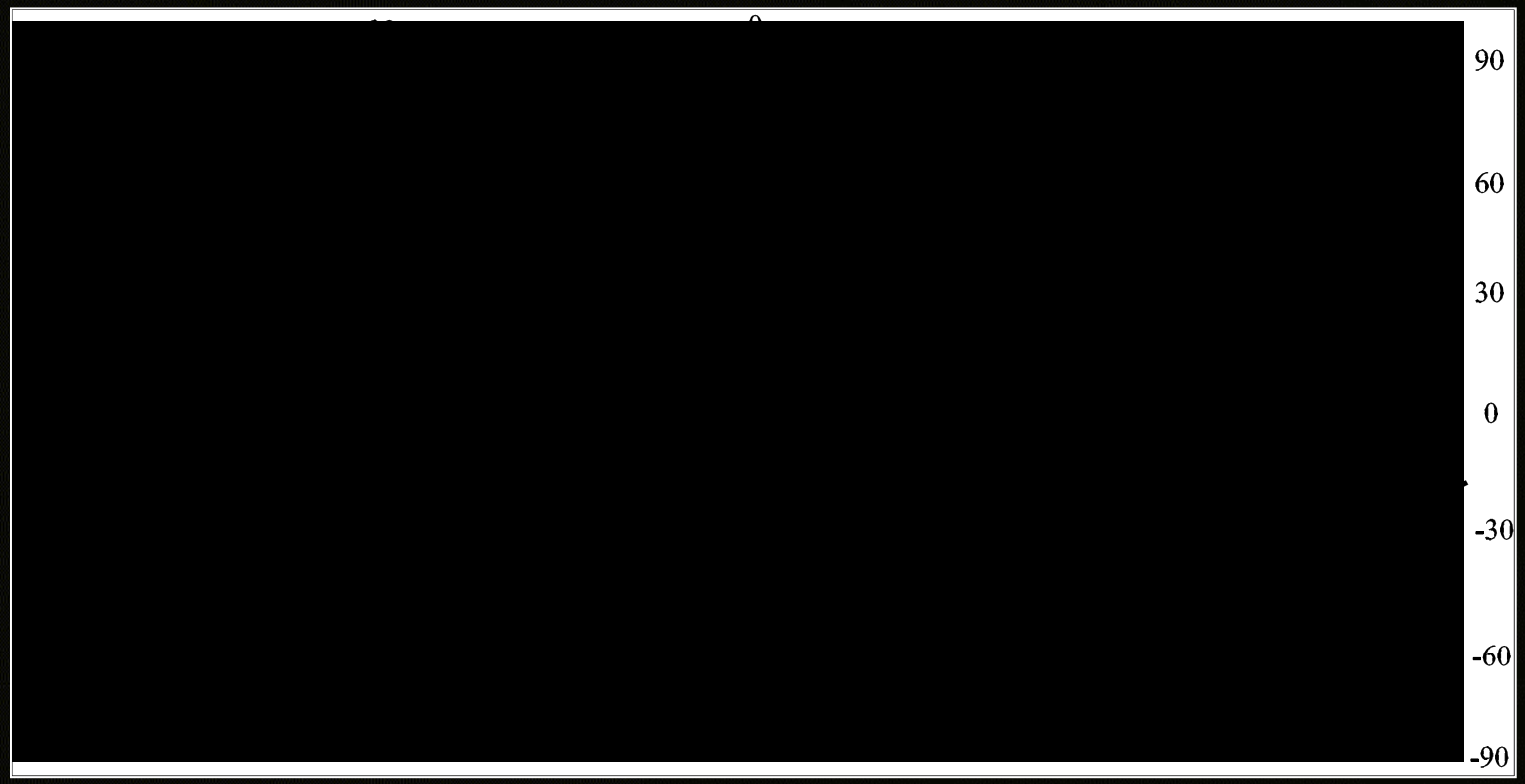


Stage	Map units
1	CC, Cc1, Cc2, Ccc, CEch, CEci, CEd, Cehf, Cf, Cld, Cp, Csc, Ec, Ecc, Eld, Elm, Elph, Em, Emd, Emp, Esc, Ic, Ic2, Icc, Icc2, Ics, Id, Ifc, Im, Im1, Im2, Imd, Ip2, Irc, Isc, It
2	Ia, Ial, Iap, Ic1, Icc1, Ich, Ici, Ico, If, Ig, Ih, Ihe, Ihf, Ihp, Iic, Inbl, Infp, Inp, Int, Ioc, Iohi, Iohn, Ioho, Iohs, Ioht, Iom, Iork, Iorm, Ip, Ip1, Iplt, IpNbm, IpNcl, IpNg, IpNl, IpNt
3	Nb, Nbc, Nbh, Nbl, Nbm, Nc, Ncc, Nhb, Nhsc, Nj, Np, NpNbm, NpNbr, NpNhf, NpNt, Npnt, Nsc, Nt, Ntp, pbr, plc, plc1, plc2, plc3, plch, plci, plj, pl1, plp, plr, pNb, pNbm, pNbr, pNc, pNcc, pNt

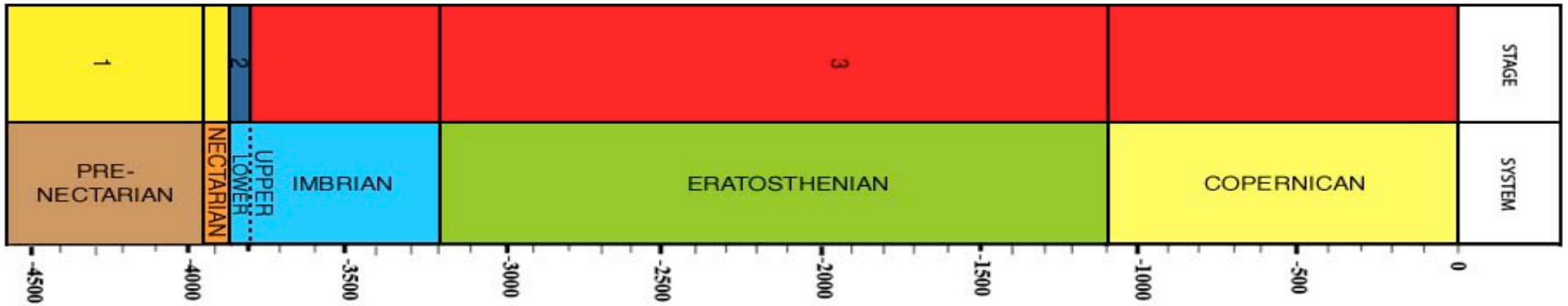
Our approach to investigate surface evolution of the Moon through time

– Apollo-based stratigraphy (3 stages) vs KGRS

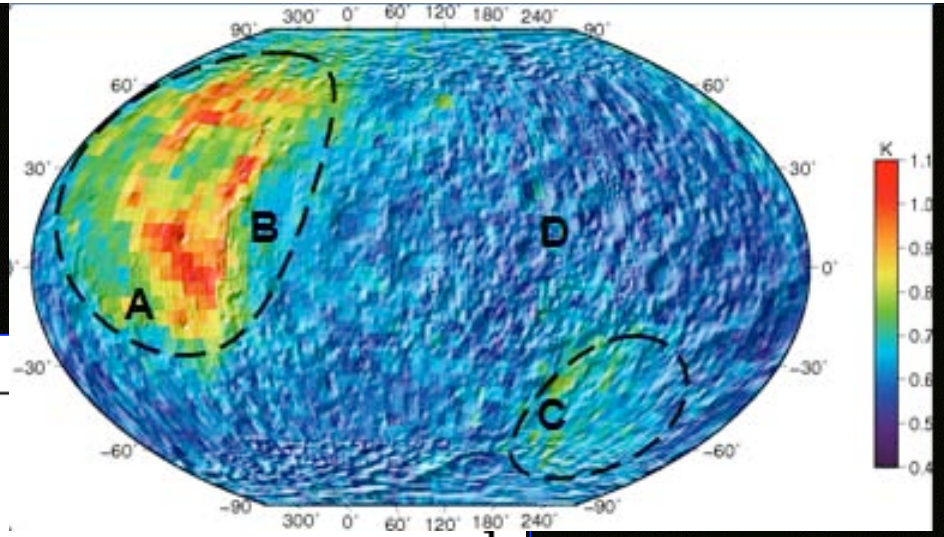


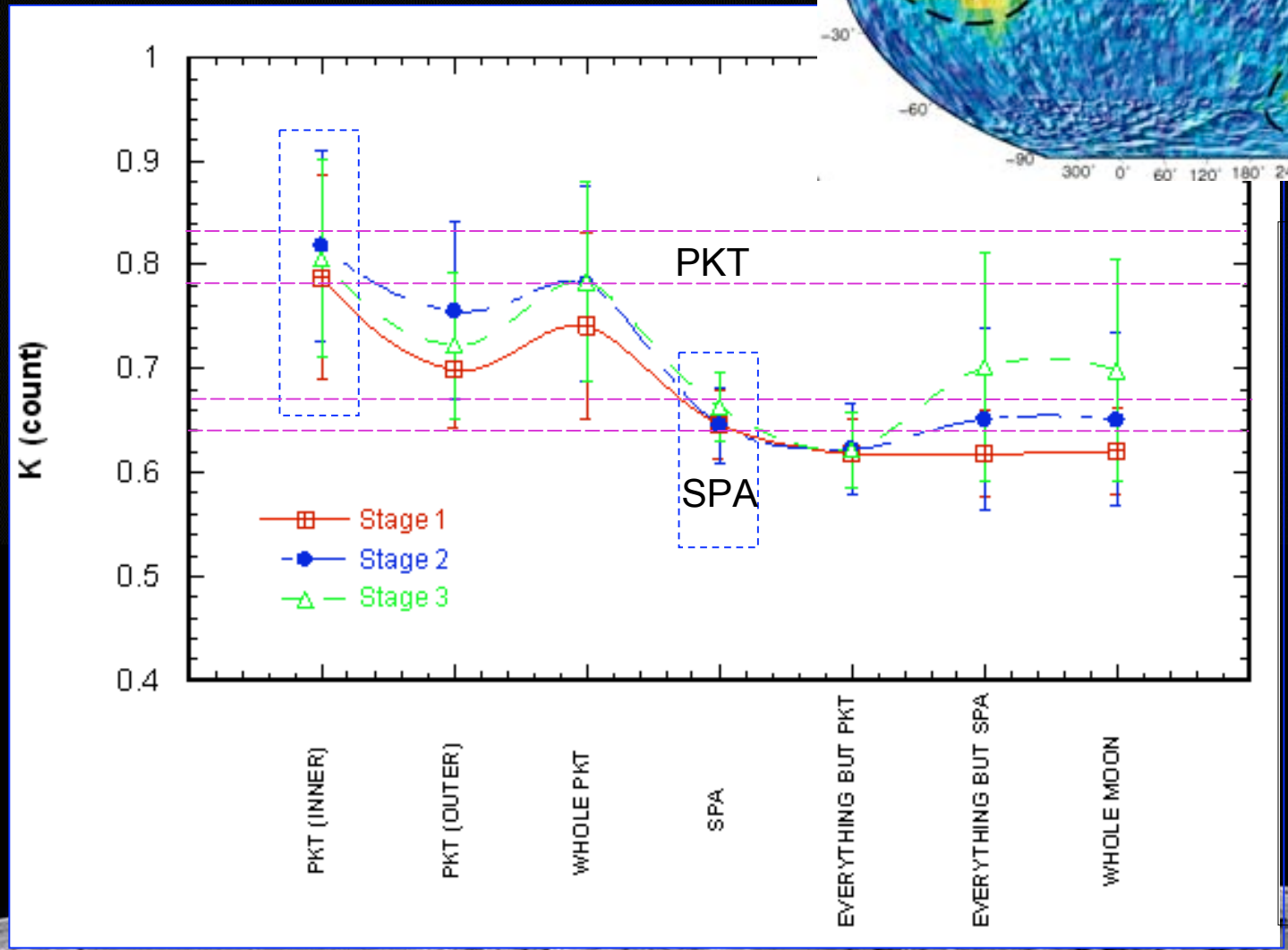


K. J. Kim et al. 2010 (LPSC) and prep.



Comparison of K

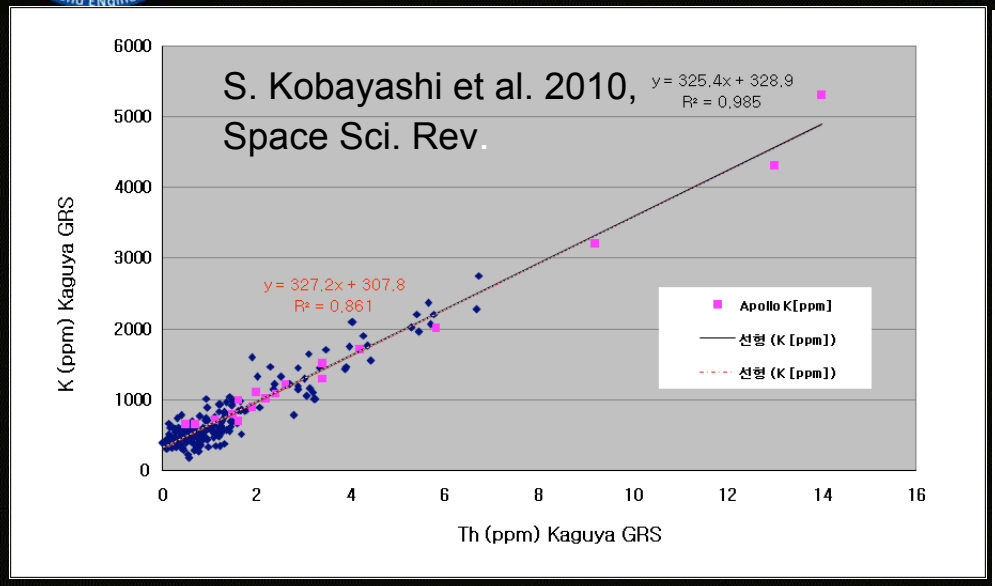


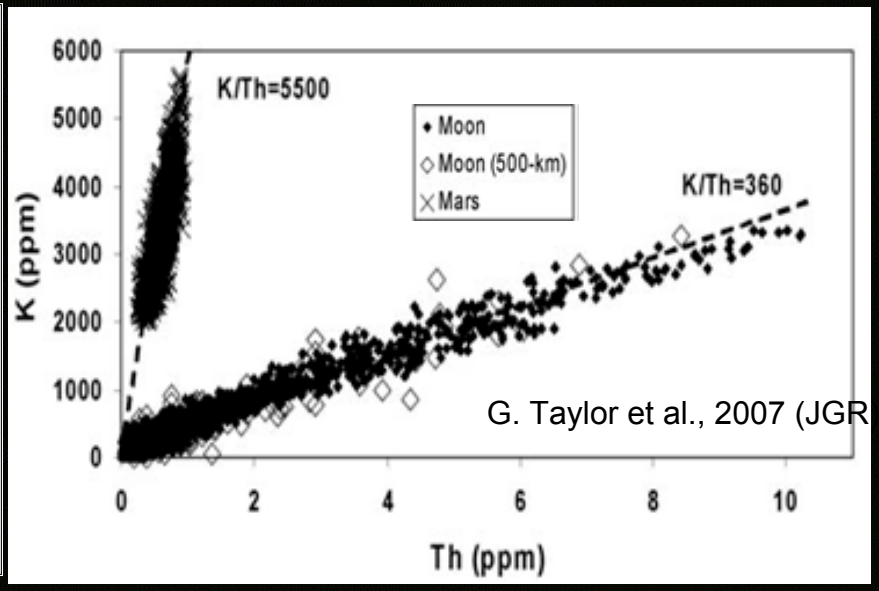


- SPA – K abundance is varied less over time than PKT.
- PKT – Large variation with K over time → Continuous activities

Comparison of K and Th

Similar ratio to those in lunar samples and meteorites.

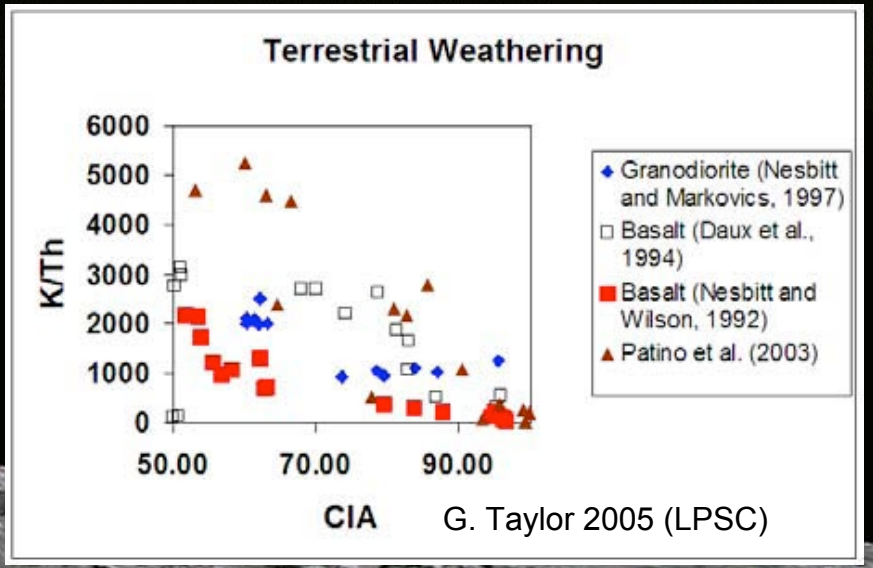




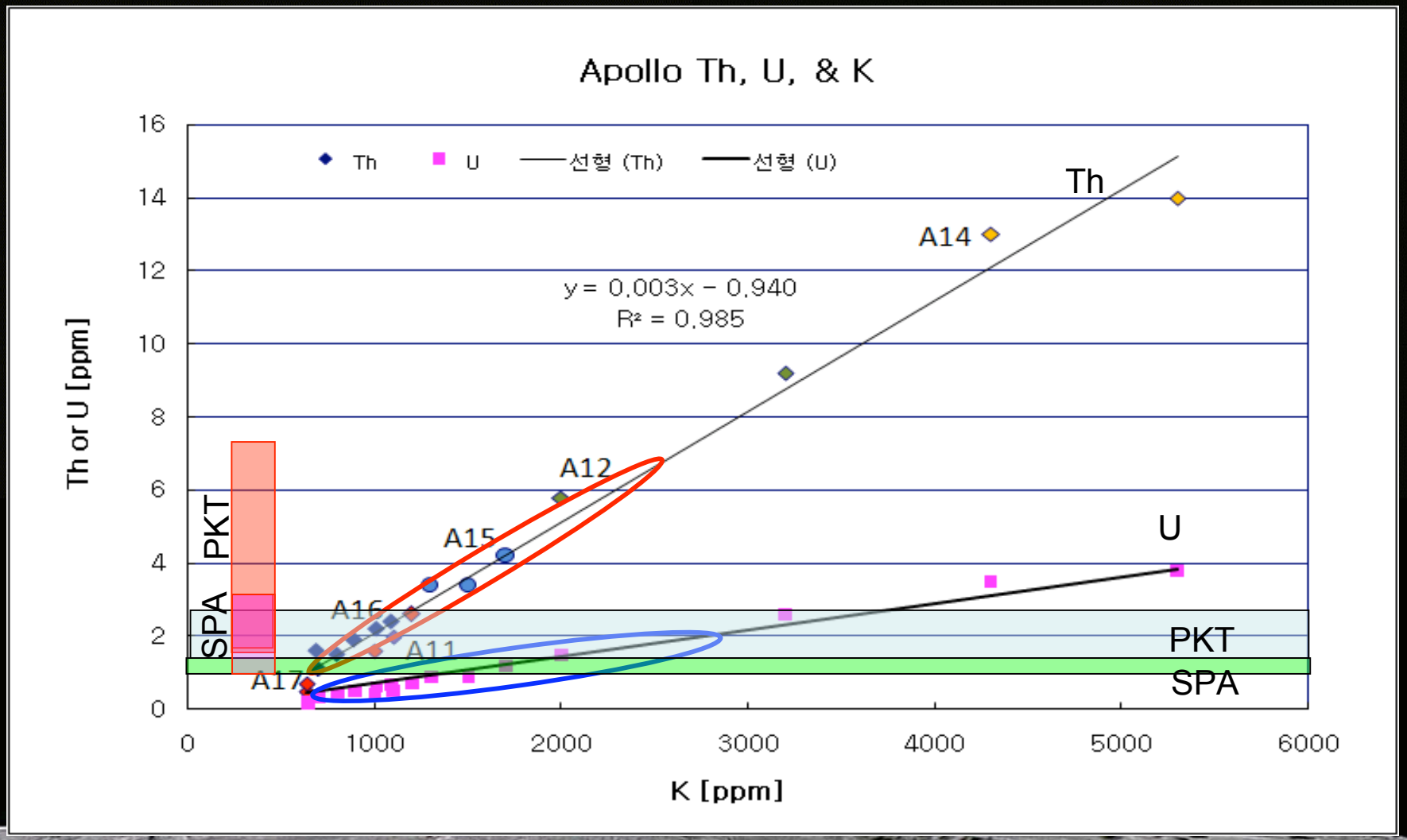
Good correlation among K, Th and U concentrations in the lunar surface :

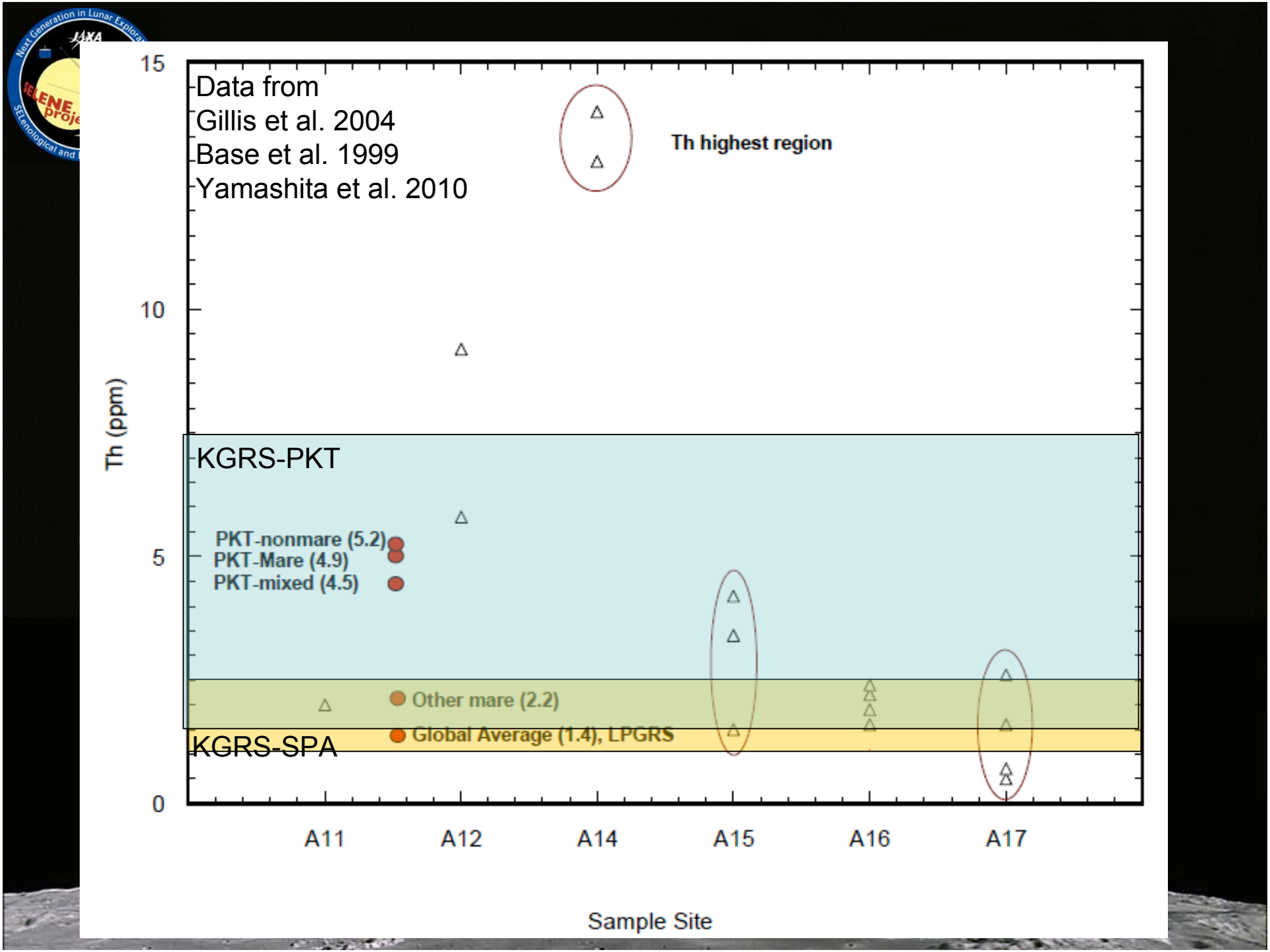
These show global values for K/Th and U/Th. These three elements behave similarly during melting and crystallization in magma. It shows that the Moon is clearly depleted in volatile elements such as K.

The K/Th ratio is about 360 in the Moon compared to 2900 in Earth and 5300 in Mars.

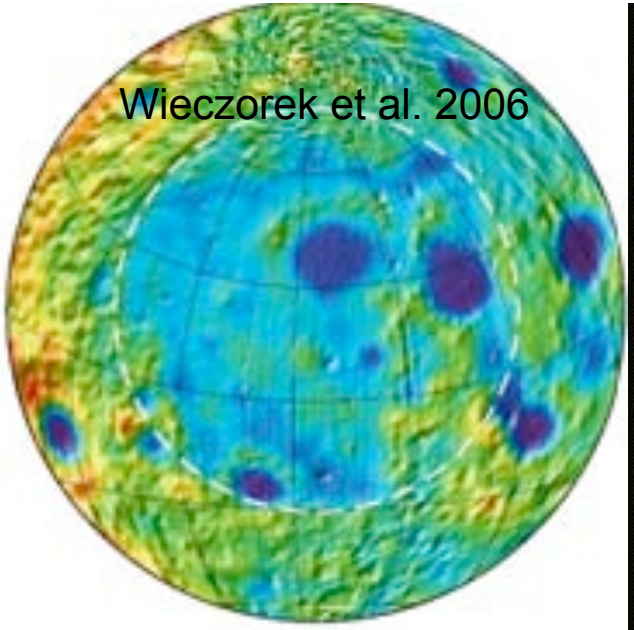


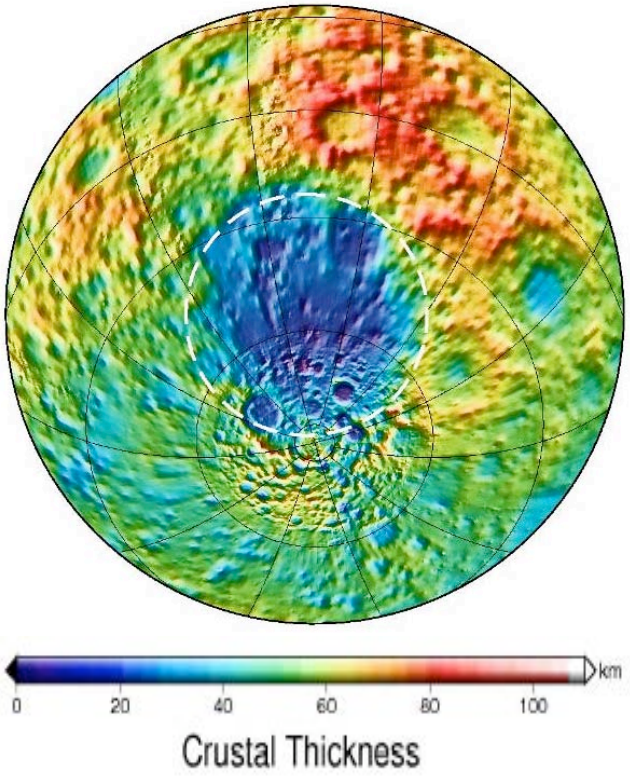
Comparison of K, Th, and U between KGRS and Apollo samples

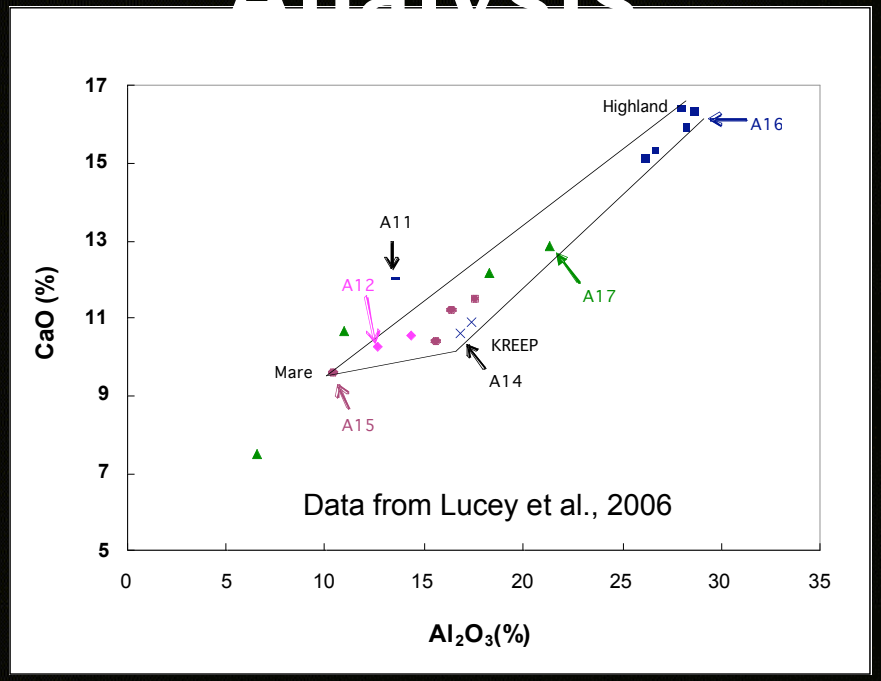


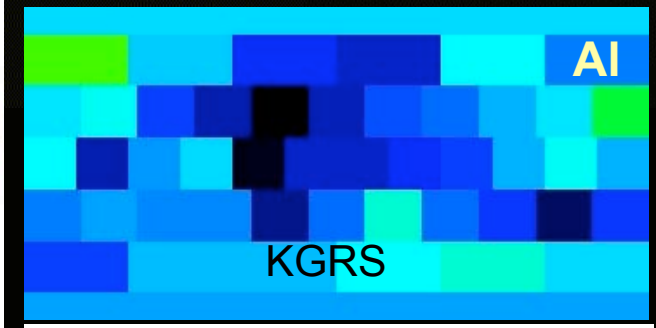

Data from
Gillis et al. 2004
Base et al. 1999
Yamashita et al. 2010
Th highest region
KGRS-PKT
PKT-nonmare (5.2)
PKT-Mare (4.9)
PKT-mixed (4.5)
Other mare (2.2)
Global Average (1.4), LPGRS
KGRS-SPA
Th (ppm)
15
10
5
0
A11
A12
A14
A15
A16
A17
Sample Site

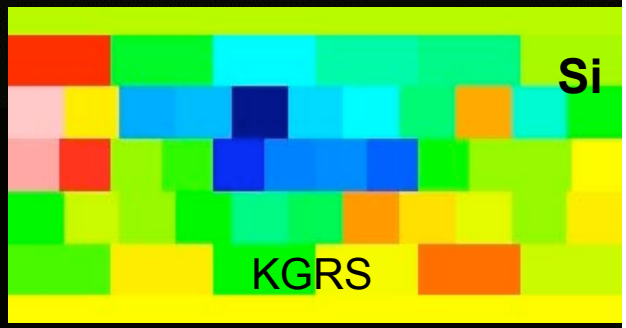
Preliminary Analysis

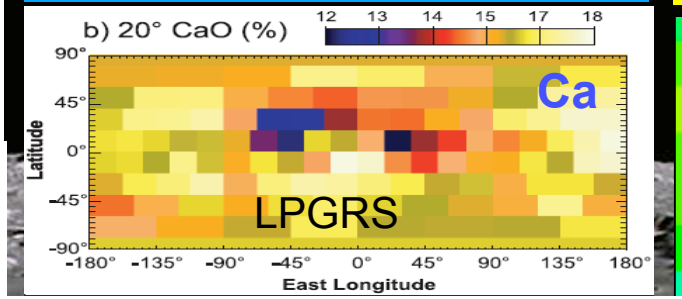


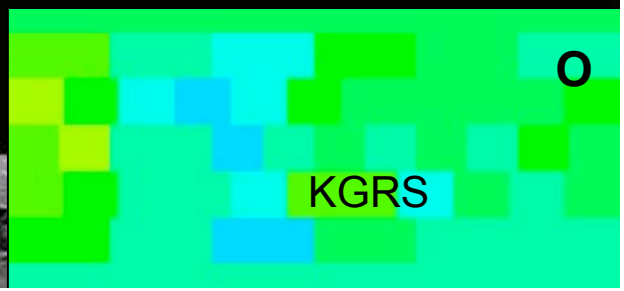




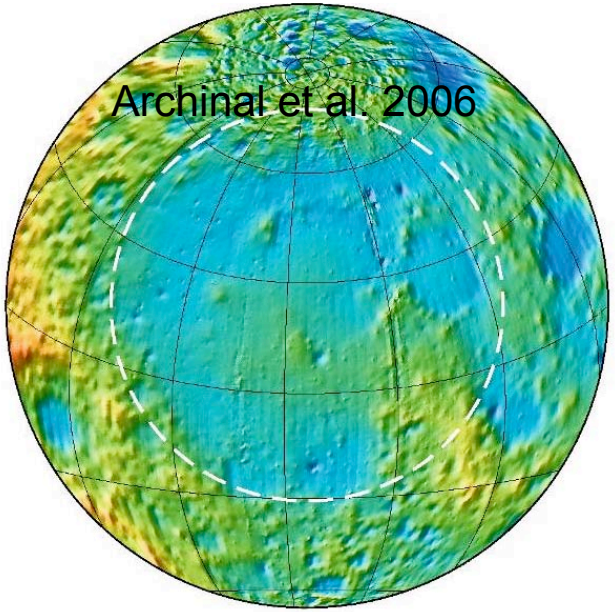


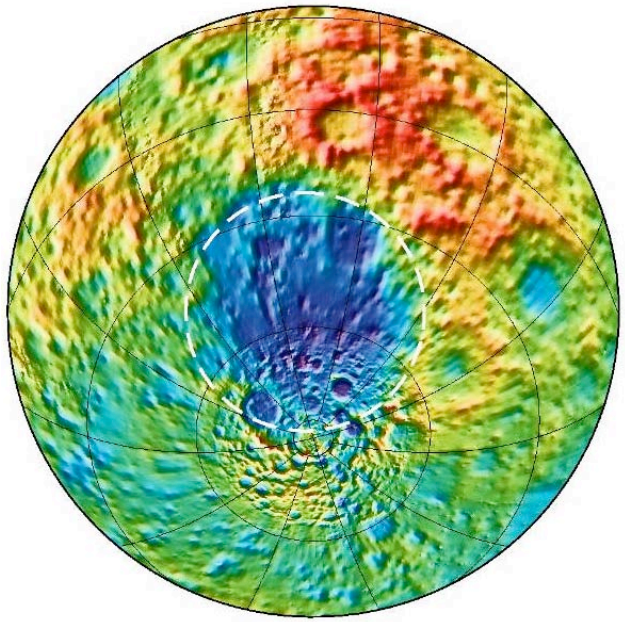


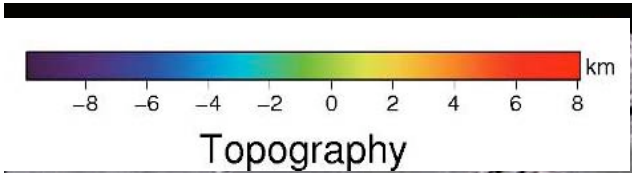


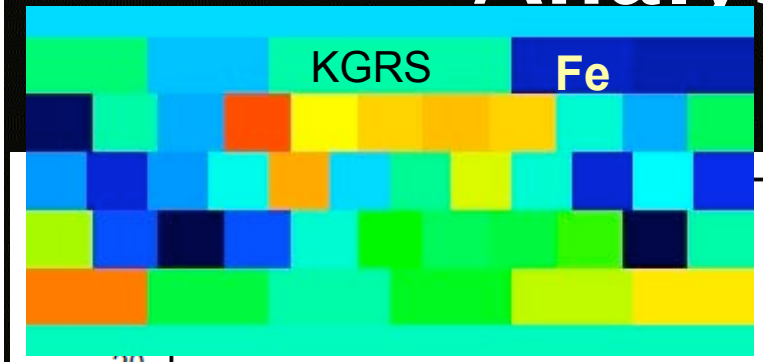


Preliminary Analysis



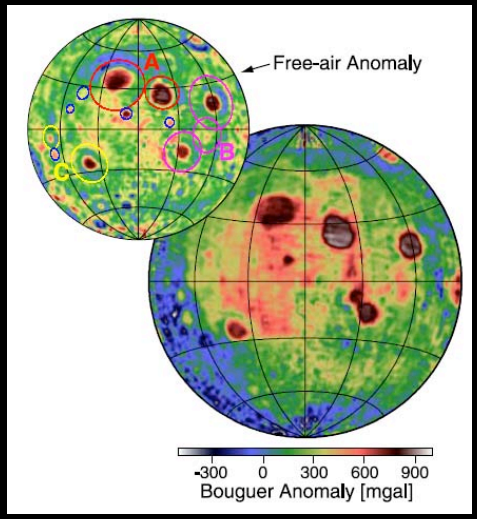




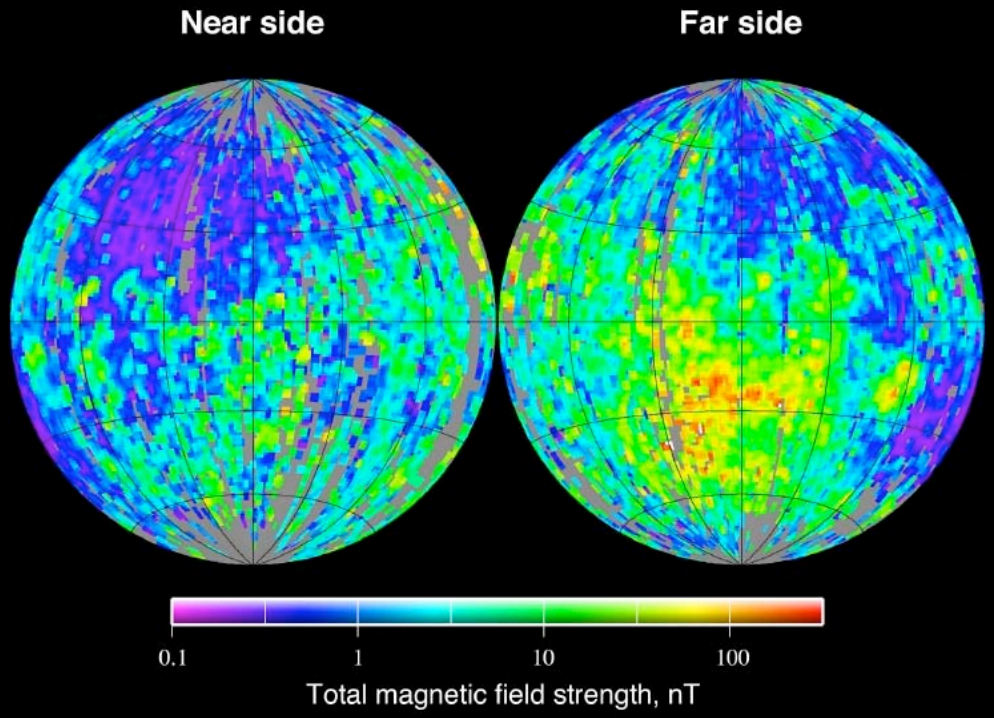


The South Pole Aitken Basin has not changed significantly since the formation.

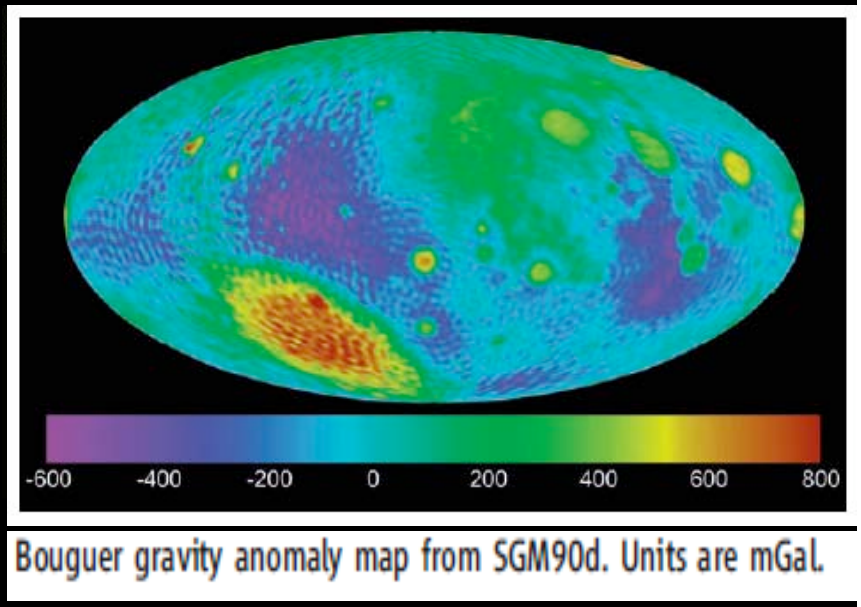
Is the new information of our study important?



Sugano & Heki, 2004

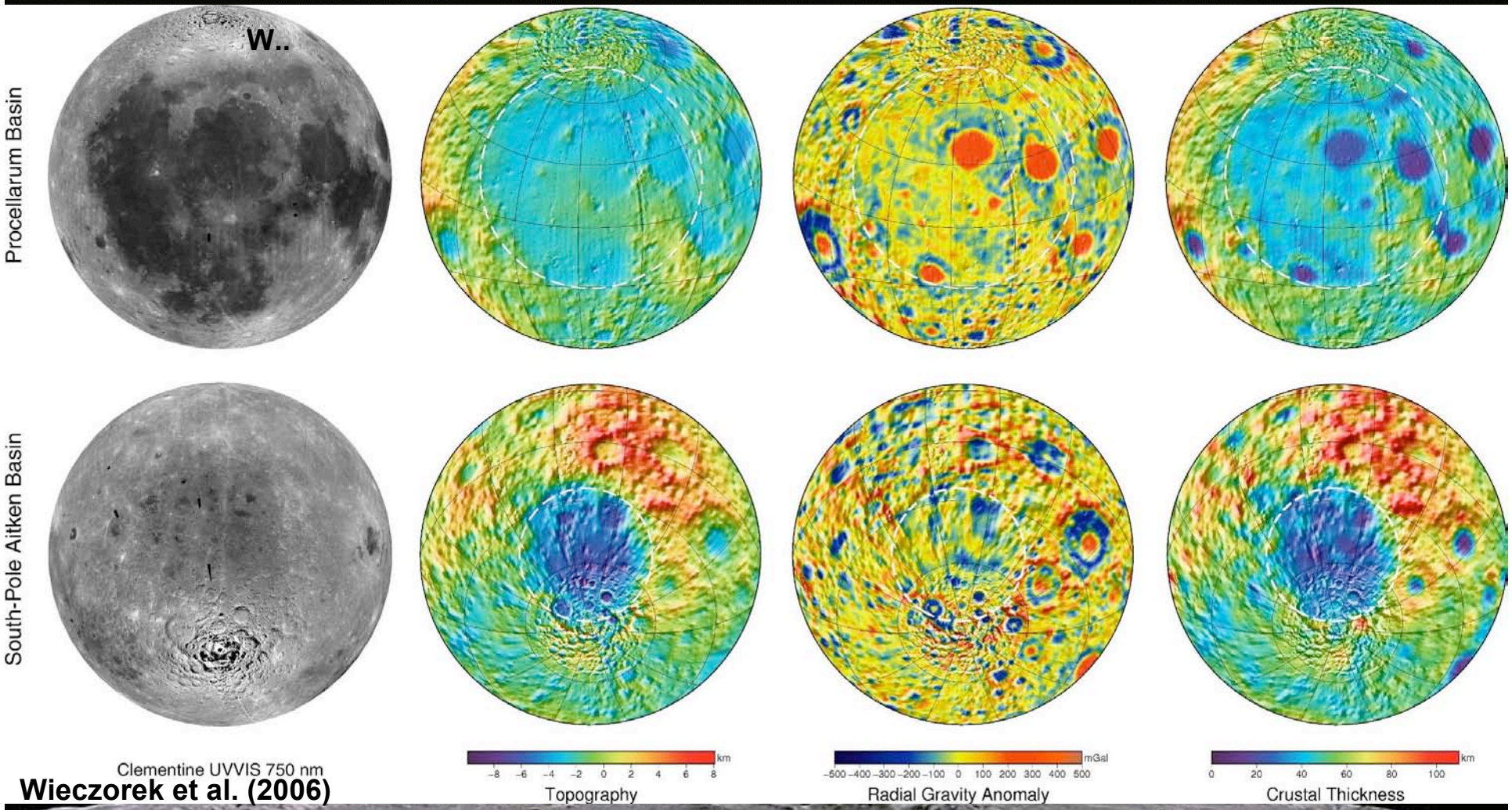


Lunar Prospector: Electron reflectometer



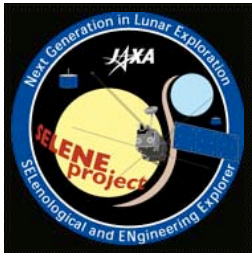
N. Namiki et al., 2010, Science

Is Procellarum an Impact Basin [Cadogon (1974) & (Whitaker (1981)] ?



Summary

- Global maps of U, Th and K show SPA has not changed much since its formation similar to other part of the Moon except Procellarum.
- The Procellarum is distinct from the rest of the Moon because of its geologic history (impact ?).
- Further investigations of the evolution of lunar surface will continue using additional Kaguya data both elemental and geophysical data.
- Multi perspectives from all existing mission data will be beneficial to pin down the surface evolution of the Moon.



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