SUITABILITY OF AN MSL-GENERATION APXS IN A LUNAR SETTING AND FUTURE IMPROVEMENTS. R. Gellert[1], S. J. VanBommel[2], E. Cloutis[3], and L. Kerber[4], [1]University of Guelph, Guelph, ON, Canada; [2]Washington University in St. Louis, St. Louis, MO, USA; [3]University of Winnipeg, Winnipeg, MB, Canada; [4]Caltech/JPL, Pasadena, CA, USA.

APXS Method: Chemistry from X-ray spectroscopy has been a staple of scientific payloads of mobile robotic platforms on Mars. Mars Pathfinder [1], the twin Mars Exploration Rovers (MER) *Spirit* and *Opportunity* [2, 3] and the Mars Science Laboratory (MSL) rover *Curiosity* were all equipped with an Alpha Particle X-ray Spectrometer (APXS) [4]. With each generation, the experience gained from the predecessor mission and available new technology helped improving the capability significantly over time, allowing faster data acquisition, new trace elements and lower detection limits. The APXS uses complementary particle-induced X-ray emission (PIXE) and X-ray fluorescence (XRF) induced by radiogenic ^{244}Cm sources. It measures the elemental composition of rocks and soils, including major, minor, and some trace elements (depending on the their abundances) [5].

Recent investments made by the Canadian Space Agency (CSA) through their Lunar Exploration Accelerator Program (LEAP) [6] have permitted investigations aimed at modernizing the APXS design, with new electronics and detector technologies to optimize the instrument for the lunar surface. Preliminary results indicate a well understood pathway to further improve the capabilities compared to its MSL predecessor. CSA has recently announced their intention to support up to two Canadian instruments (such as an APXS) as contribution to payloads submitted through NASA's Commercial Lunar Payload Services (CLPS) 2021 PRISM call [7].

Expected Lunar Performance: The scientific suitability of an APXS is unquestioned for missions to Mars and other rocky bodies such as martian moons or asteroids. The ability to reliably determine the bulk composition of rocks and soils along the traverse and to indicate aqueous alteration through the abundance of salt forming elements like S, Cl or Br, or trace elements like Ni, Zn, Ge was a key part of recent Mars mission results. We posed the question, what science questions could an APXS with MSL-like performance on lunar materials address? We used the ACES (APXS Characterization by Empirical Simulation) software package [5, 8], which simulates an APXS spectrum for a user-defined composition and experimental conditions (e.g., duration, sample proximity and resolution). This alleviates the need for extensive and time-consuming laboratory experiments. The basis of the ACES simulation is the MSL sample calibration suite of ~100 igneous and sedimentary powdered rocks and the empirical analysis model used for MER and MSL [3]. With this it was possible to show that lunar samples can be well analyzed within one hour [5]. Accuracy can be significantly improved when going from the wide ranging Mars calibration to a more appropriate igneous suite for lunar materials. The ability to imply mineralogy from bulk chemistry of likely igneous martian samples has been demonstrated for many samples using Mössbauer spectroscopy [9].

Expected Science to be achieved:. For a sample like Apollo 12009 (an Apollo 12 olivine basalt), ACES determined that an MSL-era APXS could precisely quantify (within $\leq$10% error) major oxides such as SiO_2, TiO_2, Al_2O_3, Cr_2O_3, FeO, MgO, CaO, K_2O, P_2O_5, and SO_3 within an hour. Na_2O, MnO, Ni, Cu, Y can be detected as well but with higher uncertainties for that specific composition. Using three lunar materials (mare basalt, highland anorthosite, and KREEP) as possible endmembers of expected samples, it was found that element groups can be identified that would allow tracking their mixing ratios.

We conclude that an MSL-like APXS would be able to determine the bulk composition of samples along any traverse on the Moon within an hour. The mature method would reliably cope with any unexpected sample composition and provide ground-truth for remote observations and support the mission objectives. Further instrument improvements can be implemented by using updated components. In addition, various other approaches like complementary X-ray sources or self-positioning mechanisms are under investigations that would expand the scientific capabilities even more.

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