Hindsight 2020: X-ray Spectroscopy on Mars, Challenges, Results and Future.

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Three generations of the Alpha-Particle-X-ray-Spectrometer (APXS) have been part of the science suite on all four landed NASA Mars rovers so far. Using x-ray spectroscopy following excitation with alpha particles and x-rays from $^{244}$Cm radioactive sources, so far about 2000 samples have been investigated along the combined traverse of ~85km on the surface of Mars.

The APXS reports 16 standard elements in all samples and additional trace elements like Ge, Cu, Ga, Rb, Sr, As, Se, Y and Pb if at elevated levels. The sample spot of ~ 20 mm diameter is often large enough to represent bulk content, though small enough to reveal evidence for certain minerals through element correlations when oversampled in rasters. The results from all missions revealed large scale sedimentary formations, like Murray and Burns indicating specific environmental conditions in the past. The soil was found similar at all sites, representing a well mixed global crust component. APXS geochemical data were used for important constraints of complimentary mineralogy results, ground truth for orbiters and comparison to Martian meteorites.

Results from the ongoing Curiosity mission and the long living MER rovers will be discussed. Additionally, some very successful applications and investigations that were serendipitously developed after launch will be reviewed. Part of the presentation will be devoted to the unique challenges, trade-offs during design and lessons learned from the long operation of the instrument. The combination of APXS, XRD and Moesbauer results from MER and MSL with future fine scale XRF results of the soil at the Mars 2020 landing site might shed a light into the enigmatic amorphous phase, which could represent a record of the past alteration processes on Mars.