Important Results: This facility is mainly dedicated for geological and planetary science studies. Some of the recent work is mentioned here. Using the geochemical data, various meteorites are classified on the basis of their Si and Fe, Ni and Co content. Using the chemical

Fig. 4. EPMA facility at PLANEX

composition as well as the X-ray mapping, Al-rich and Fe-rich phases were identified in chondrules from undifferentiated ordinary meteorites for further isotopic study to correlate the different heat sources responsible for early metamorphism of planetesimals (*R.K. Mishra et.al., APJ, (2010) 714:L217-221.*). In another study, Multi-shelled orbicular olivine gabbronorite with anorthositic rims from Leh, J&K, India have been studied for morphological details, preliminary mineralogy and petrology (Prashant Rai et al., Current Science, 97(12), 2009). The comparative geochemical study of samples from local area as well Spherules from target area of Ramgarh have revealed that local samples are mainly shale and sandstone while target sample consists of mostly SiO_2, Al_2O_3, Fe_2O_3 and MnO along with certain trace elements like Ba, Co, Zn, Ni, S, Cu and Cr in significant amount. Thus, on the basis of geochemical and petrological studies, an attempt is being made to show that Ramagarh structure was formed due to a meteoritic impact (Saumitra et al., 39th and 40th LPSC). In addition to these, spherules collected from Indian Ocean have been analysed to characterize the magnetic material and cosmic components (Shyam et al.). Adding to the diversity of studies in the lab , Aerosols collected from Mount Abu and Ahmedabad were analysed to find out variations in their composition and the size distribution during winter night (Das and Dipak).

Acknowledgements: I thank Ms. Yogita for her valuable suggestions that helped in improving this article.

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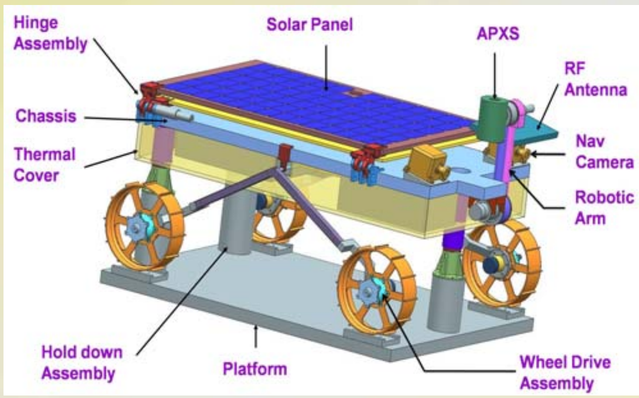
Alpha Particle X-Ray Spectrometer on Chandrayaan-2 Rover for Surface Chemical Composition

Introduction: Moon samples from Apollo and Luna missions have given us the first hand information on the chemical, mineral and chronological information about the Moon and led to the derivation of the average bulk composition and the evolution of the Moon. While Apollo / Luna samples represented samples from only equatorial region of Moon, lunar meteorites, ejected from random locations on Moon offered additional samples for study. Significant compositional differences between lunar meteorites and Apollo/Luna samples highlighted the need for obtaining chemical composition of more samples from other known locations of Moon in general and the polar regions in particular, in view of the importance of the South Pole Aitken (SPA) basin, representing one of the largest craters in the solar system, to better understand the compositional diversity. While orbiters provided a global coverage with a coarse resolution, in situ chemical composition determination along the traverse of a rover will offer the best way to address this aspect, until the resumption of sample return missions to Moon.

Fig. 1. Schematic representation of the rover and various



sub-systems. The position of APXS on the robotic arm is indicated.

Alpha Particle X-ray Spectrometer (APXS) is a well proven instrument for in situ quantitative elemental analysis of planetary surfaces. Mars pathfinder rover Sojourner has first carried an APXS instrument and provided the first in situ composition data on Mars samples. Subsequently, the twin Mars exploration rovers Spirit and Opportunity have carried improved APXS instruments onboard and provided elemental composition for many surface samples. Another mars

Back to Contents

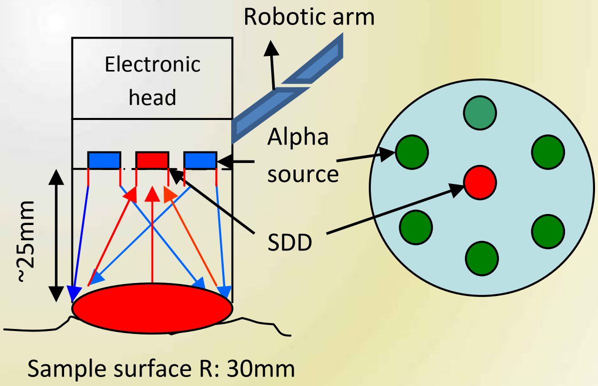


Fig. 2. APXS sensor head

rover (MSL) slated for launch in 2011, also has the most sensitive APXS on board. Though alpha scattering has been employed on the Surveyor missions on Moon during 1960s, APXS has not been attempted so far on the lunar surface. Here we present the objectives and status of APXS, selected for ISRO's Chandrayaan-2 rover, slated for launch in 2013.

Though lack of atmosphere on Moon offers an advantage in terms of the attenuation of Alphas and X-rays, the fluffy regolith and temperature extremes offer new challenges for the operation of APXS on lunar rovers. The landing site of Chandrayaan-2 is likely to be south polar sunlit region, where the temperature excursions are expected to be in the range of -30°C to -190°C (day/night), though the exact location is yet to be finalized. The detector head needs to be kept away from touching the regolith surface to prevent dust contaminating the detector, necessitating a robotic arm to maneuver it. The schematic diagram of the rover, with APXS on the robotic arm is shown in Fig.1.

Working Principle of APXS and objective: APXS involves the measurement of characteristic X-rays emitted from the sample due to α particle induced X-ray emission (PIXE) and X-ray florescence (XRF) processes. The schematic arrangement of the alpha (and X-ray) sources and the X-ray detector is shown in Fig. 2. The ^{244}Cm source, with a half life of 18.1 years emits Alpha particles and two X-rays with energies of 5.8 MeV and 14.1 keV, 18 keV respectively. PIXE is dominant for low Z elements while XRF is more prominent for high Z elements, allowing the determination of elements from Na to Br, spanning the energy range of 0.9 to 16 keV (see Fig. 3). The activity of each alpha source is ~5 ± 25% mCi and the total activity of the six alpha sources is about 30 mCi. Each source is of 8mm circular disc and <1mm thickness, with 6mm active spot at the center. These sources are coated on Si substrate and are sealed with 3 micron thick, light weight Ti foil. The source configuration is similar to flight sources used on Mars Exploration Rover missions.

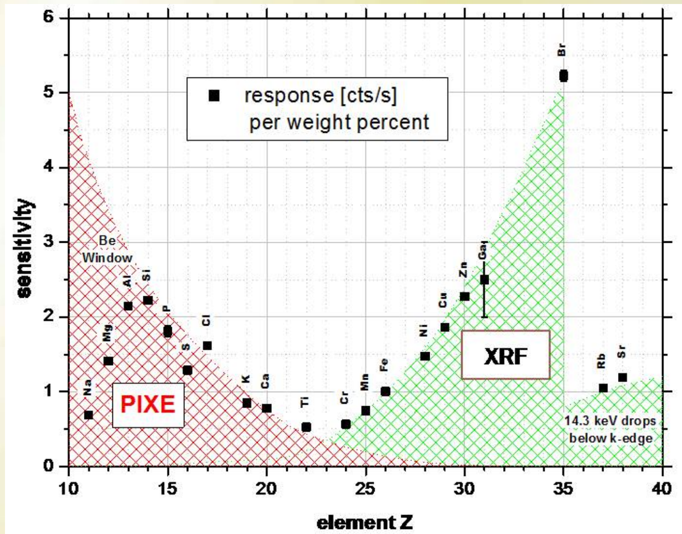


Fig. 3. Sensitivity of X-ray production by PIXE and XRF, as a Function of Z.

X-ray detector: From several possible X-ray detectors, we chose Silicon Drift Detector (SDD), with proven credentials in the APXS on Mars rovers. SDD makes it possible to detect X-ray emissions from planetary surfaces with an energy resolution of ~150 eV at 5.9 keV in the energy region 1 to 16 keV. This will be carried out by placing the sensor head close to the sample, powering on the instrument, and commanding it to acquire the spectra.

The APXS Instrument: APXS instrument consists of two packages namely APXS sensor head and APXS backend electronics. APXS sensor head will be mounted on a robotic arm. On command, the robotic arm brings the sensor head close to the lunar surface (without touching it) and after the measurement, the sensor head is taken back to the parking position. APXS sensor head assembly contains SDD, six alpha sources and front end electronic circuits such as charge sensitive preamplifier (CSPA), shaper and filter circuits associated with the detector. Sensor head contains a circular disc which holds 6 alpha sources symmetrically around the disc and the detector at the centre, as shown in Fig. 2. SDD to be used in the experiment will have ~20 mm^2 active area detector module. This detector module contains in-built peltier cooler and heat sink to maintain the detector at ~ -30°C by providing required power and dissipating the heat by means of additional heat dissipation mechanism. The front face of the detector module is covered with 8 micron thick Be window to protect the detector from contamination. The threshold energy of the detector module due to the Be window is about 1keV. APXS sensor head also carries an electro mechanical door to protect the source and detector from lunar dust contamination. APXS backend electronics consists of PCBs for digital, power and rover interface electronics circuits, which are housed inside the Warm Electronics Box (WEB). WEB will be part of the rover where the sub-system temperatures are maintained at certain safe range.

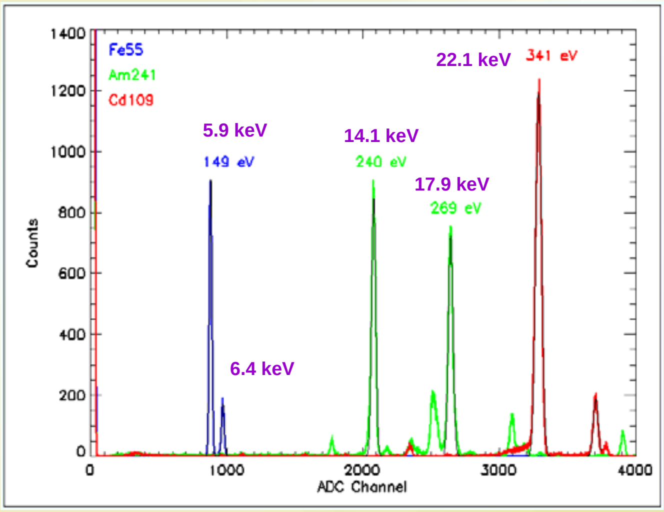


Fig. 4. Spectral response obtained using three X-ray sources (^{55}Fe, ^{241}Am and ^{109}Cd). The peak energy [keV] and the FWHM [eV] are indicated

The CSPA has been designed with "Reset" type and shaper with shaping time constant of 2μs. Peltier controller has been designed with PWM technique and it allows the required current through the peltier to get desirable ΔT. It has been tested with stability of < 1°C, achieved within a minute from power on. The laboratory model of APXS is ready and its working has been demonstrated by assessing the energy resolution of ~150 eV at 5.9 keV (Fig.4) and by qualitative detection of elements in the spectrum obtained from Allende meteorite sample, irradiated by ^{241}Am source (Fig. 5).

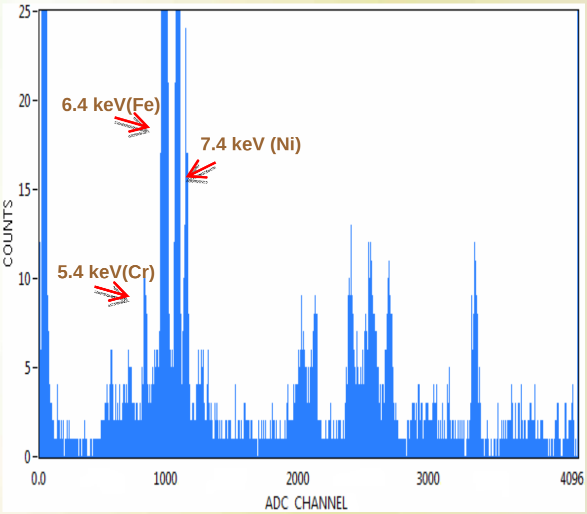


Fig. 5. Spectral response obtained from Allende sample with ^{241}Am source. The peaks and corresponding elements are indicated

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Back to Contents