THE HYPER SPECTRAL IMAGER INSTRUMENT ON CHANDRAYAAN-1. A. S. Kiran Kumar, A. Roy Chowdhury, K. R. Murali, S. S. Sarkar, S.R. Joshi, S. Mehta, A.B. Dave, K.J. Shah, A. Banerjee, K. Mathew and B.N. Sharma. Sensors Development Area , Space Applications Centre (ISRO), Ahmedabad – 380058 (India), kiran@sac.isro.gov.in, arc@sac.isro.gov.in.

Introduction: The Hyper Spectral Imager (HySI) [1,2], operating in visible and near infrared spectral region, is one of the three spectral imager onboard Chandrayaan-1 for mineralological study of the lunar surface. It complements the Moon Mineralogical Mapper (M-cube) and Near-IR spectrometer (SIR-2) by extending the spectral coverage in the lower range upto 400nm. The total spectral range of 421nm to 964nm is resolved in 64 contiguous bands with spectral sampling better than 20nm. The spatial sampling for all bands is 80m and the pixel value is 12 bit quantized. The instrument maps the lunar surface in push broom mode with a swath of 20km from the polar orbit of 100km altitude. The spatial and spectral data from the instrument will improve the knowledge of the mineral composition of the lunar surface. These data combined with the study of deep craters like South Pole-Aitken basin, which contains surface expression of lower crustal or upper mantle material, as well as central hills of targeted lunar craters will further our understanding of the mineralogical composition of crust and its formation and evolution.

Operating principle: The HySI instrument measures the reflected solar radiation from the Moon's surface. The spectral separation is done using a wedge filter in front of an area detector. The wedge filter is an interference filter with varying coating thickness along one dimension so that the wavelength of the transmitted radiation varies in that direction. The frame size is 40km along track and 20km across track (swath). The detector has 512 pixels in along track and 256 pixels in across track direction. In a given frame, 512 lines of lunar surface are mapped onto 512 rows of detector elements. Each row gets different spectral information and the pixels within a row get different spatial information corresponding to that swath coverage. The spacecraft's movement builds the full spectrum of a target. The frame data at detector output corresponds to 512 spectral bands. The 512 bands are processed on-board to generate the required 64 bands, thereby reducing the transmitted data volume.

Hardware description: The HySI instrument comprises focusing optics, a wedge filter for spectral separation, an area detector, camera and power electronics and the mechanical housing. The schematic of the instrument is shown in Fig. 1.

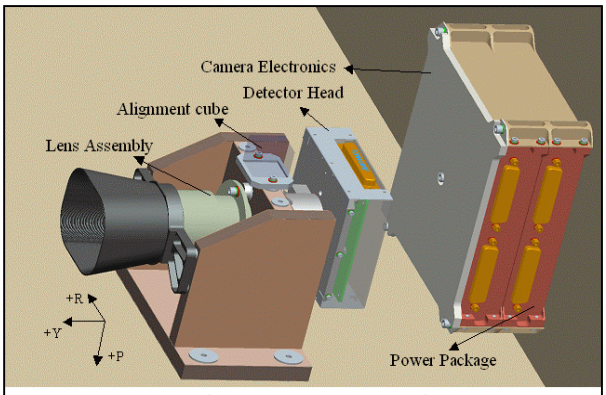

Fig. 1. HySI schematic

The focusing optics is a multi-element lens assembly with a thermal filter at the front covering a circular field of view of ±13°. The wedge filter placed in front of the detector carries out the spectral separation. The detector is an Active Pixel Sensor with integrated timing circuitry, video processing and digitizer. The electronics provides the electrical stimulus to the detector for its operation and processes the spectrally oversampled digitized output from the detector to generate the 64-band data. Programmable gain and exposure level settings are available, this can be exercised based on the intensity of scene illumination. The power electronics generates the required regulated supplies from the spacecraft raw bus. The instrument structure is designed to maintain the relative positions of the optical elements and detector over the mission life. It is of a sandwich construction with face skins of high modulus carbon fiber material and core of aluminum alloy honeycomb. Thermal control in the instrument ensures all sensitive elements remain within the specified temperature limits. The thermal control is achieved by passive thermal control techniques augmented with auto/command-able heaters. The instrument is compact, low weight and low power dissipating. It weighs 2.5kg and the regulated power requirement is 800mW. Table-1 summarises the key features of HySI.

The instrument (Fig. 2) was extensively tested before mating with the spacecraft. The focusing was ascer-

tained at various stages by measuring the Square Wave Response (SWR) as a function of defocus in the image plane. The spectral stability was confirmed in thermo-vacuum condition at four wavelenghts. The worst case variation seen was 0.1 spatial pixel and 0.05 spectral pixel. The Signal to Noise Ratio (SNR) over the dynamic range is compatible with the specification. Radiometric, Spatial and Spectral calibrations of the instrument have also been performed. These will be complemented by on-board calibration by viewing known features on Moon. The dark calibration will be done by looking at the lunar dark side or deep space.

Table-1 HySI key features

Spatial sampling	80 x 80 m^2
Swath	20 km
Spectral range	421-964 nm
No. of spectral bands	64 continuous
Spectral bandwidth	< 20 nm
Gain / Exposure settings	2 / 4
Quantization	12 bits
SNR	> 100
SWR	> 40
Operating temperature	20 ± 10 °C
Regulated power	800 mW
Weight	2.5 kg

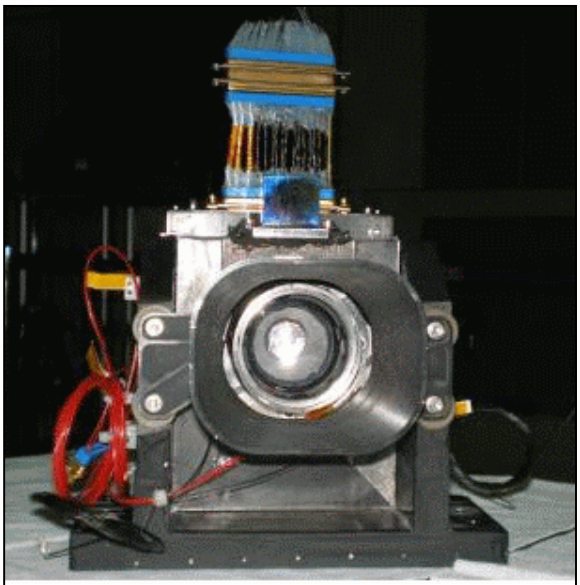

Fig. 2. HySI flight model

Discussion: The ground test results of the instrument indicates satisfactory performance [3]. The HySI instrument being operated regularly after reaching the lunar orbit. HySI was switched ON on 15 November 2008. Fig. 3 shows the 64 band image of Barrow-H craterlet taken during the initial phase. HySI, along with M-cube and SIR-2, will provide mineral map of the entire lunar surface during the two year mission period and will pave the way for a better understanding of the composition and evolution of the lunar crust. Details of on-orbit performance will be presented.

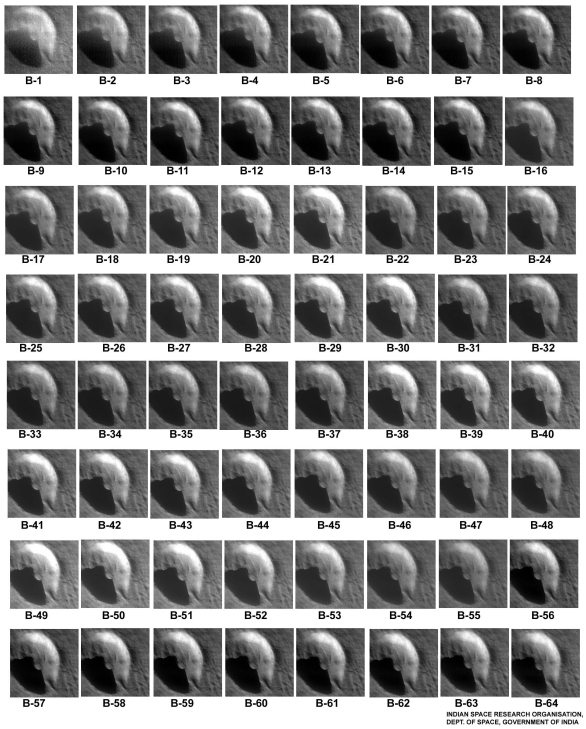

Fig. 3. 64 bands image by HySI

Acknowledgements: The authors acknowledge with thanks the contribution of all colleagues. We also gratefully acknowledge the constant encouragement and guidance received from Dr. RamRattan, Associate Director and Dr. R.R Navalgund, Director Space Applications Centre.

References: [1] Kiran Kumar A. S. and Roy Chowdhury A. (2005) *J. Earth Syst. Sci. 114*, 721-724. [2] Roy Chowdhury A. et.al. (2007) *Proc. 9th Int. Conference on Exploration & Utilization of the Moon,* 35-36. [3] Kiran Kumar A. S. et.al. (2009) *Curr. Sci.*, in press.