ODIN - A PROTOTYPE MARS IN-SITU LUMINESCENCE READER FOR GEOCHRONOLOGY AND RADIATION MEASUREMENTS. R. DeWitt[1], S.W.S McKeever[2], [1]Department of Physics, East Carolina University, Howell Science Complex C-209, 1000 E. 5th Street, Greenville, NC, 27858, USA, dewittr@ecu.edu, [2]Oklahoma State University, Stillwater, OK 74078, USA.

Summary: We describe ODIN, a prototype Mars in-situ luminescence instrument for geochronology and radiation measurements. The instrument is intended to be mounted on a static lander or rover and be suitable for detailed in-situ investigation as well as pre-screening of samples for sample return missions. ODIN is designed to allow in-situ dating of Martian regolith deposited during the last ~ 1Ma and allow measurement of the radiation dose on the surface of Mars.

The instrument combines optically stimulated luminescence (OSL) and thermoluminescence (TL). The prototype instrument has been developed with NASA PIDDP funds. The instrument addresses several goals formulated by MEPAG [1], MEPAG E2E-iSAG [2], and P-SAG [3]:

- B2 [2], Goals II-B2 and B3 [1]: geochronology of aeolian, periglacial, and fluvial deposits to understand Mars recent climate history and surface processes.
- SKG B3-4 [3], Goal IV-A-2B [1]: measurement of radiation on the surface of Mars in preparation for human exploration.

OSL and TL: In the applications considered here, luminescence is the light emitted by mineral samples under stimulation with light or heat. The luminescence is proportional to the radiation dose absorbed by the mineral. OSL is therefore a method for radiation dosimetry. A detailed description of the technique and its applications can be found in recent books [4, 5]. TL works on the same premise as OSL. Instead of exposing the sample to light, with TL the sample is heated. For terrestrial aeolian, periglacial, and fluvial deposits, OSL is an established dating technique and routine age determinations within 5% are routinely possible. The technique has been proposed to be suitable for in-situ dating of Martian regolith [6-10]. DeWitt and McKeever [11] estimate an accessible age range of up to 1 Ma. Therefore, OSL would be particularly suited for younger samples and could be used as a method to monitor obliquity changes and landscape modification by aeolian processes.

Highly sensitive OSL dosimeters such as Al_2O_3:C allow measurement of doses in the range from µGy to Gy and have been applied for measurements of particle radiation doses in medical and space applications [5]. Exposing Al_2O_3:C dosimeters on the surface, or at prescribed depths, and subsequently reading the signals using OSL will reveal the natural exposure on the surface and, furthermore, give indication of the radiation shielding provided by the Martian surface.

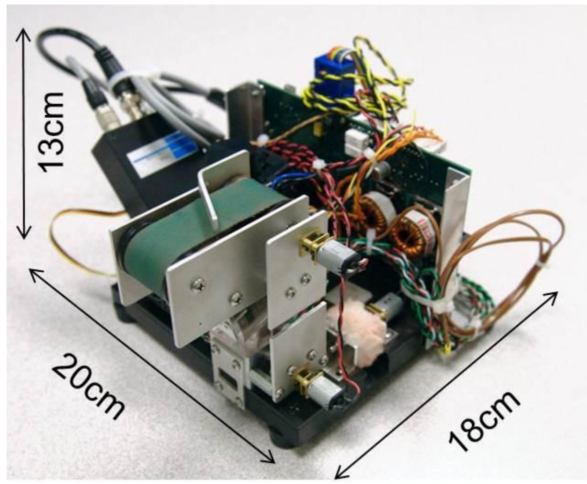

Figure 1: Isometric view of ODIN

Instrumentation: A photo and a schematic drawing of ODIN are shown in figures 1 and 2. The instrument is intended to be mounted on a rover with particulate samples introduced via a robotic arm. ODIN is equipped for basic regolith preparation procedures and luminescence measurements. A sample preparation system allows separation of non-magnetic particles smaller than 250 µm and dispensing of 2mg aliquots. Measurements require light sources and a heater for sample stimulation, a photodetector for sensing the luminescence signal, and radiation sources to calibrate samples. The instrument can also be equipped with Al_2O_3:C dosimeters for dose measurements. A rotating disk with 20 sample positions serves as a sample transport system.

Sample preparation and transport system. It is expected that a significant percentage by weight of the sample collected will be metallic. Metallic and magnetic materials dilute the OSL effect requiring that they be separated and discarded before measurement. The design for ODIN's magnetic separator assembly comprises a cleated moving belt over a cylindrical rare-earth permanent magnet with a horizontal axis. The magnet retains magnetic materials as an inverted sample passes over the collection port. Magnetic attraction will hold retained material on the belt until it traverses the hopper entrance and past the magnet, after which it drops to the surface and is discarded. Non-magnetic materials drop into the tumbler, which serves as a screen and breaks up conglomerates by the tumbling motion. In reverse motion, soil is dumped from the system in preparation for receiving a new batch of soil. Particles < 250 μm are dispensed from the tumbler by a rotating grooved cylinder, similar to those used in the pharmaceutical industry to dispense measured amounts of powder to pill presses. A predetermined angular rotation dispenses the required mass, about 2 mg. The dispenser drops an aliquot into a reusable copper sample cup on the turntable. Aliquots are transported via a rotating disk from the loading position to the measurement position. After an aliquot has been tested, a rotating brush sweeps it from the sample cup and onto a disposal chute, from which it drops to the Martian surface.

Stimulation. OSL measurement procedures require sources for IR and / or blue stimulation. ODIN uses LEDs in combination with broadband interference filters to narrow the bandwidth of the stimulation light and to prevent an overlap with the detection band. Both LEDs can be pulsed at periods ranging from 55-7074 µs. The duty cycle can be adjusted and is synchronized with the PMT which allows detection of the signal during and after stimulation. This increases the signal to noise ratio and allows measurement of smaller doses. The system also uses a conductive heater for heating of the samples and TL measurements.

Detection. ODIN uses a photomultiplier (Hamamatsu H7828) with UV filter for detection of the OSL signal.

Radiation Sources. A MOXTEK Bullet miniature x-ray source is used for dose calibration. The X-ray source is small and lightweight (~ 1 lb.) and has low power consumption (4 W maximum). It produces up to 50 keV x-rays from a Ag target with 0.1 mA maximum emission current. The dose rate was determined as 30.4 mGy/s ± 2.1 mGy/s

Acknowledgements: The development of ODIN was funded by NASA (PIDDP NNX09AN28G).

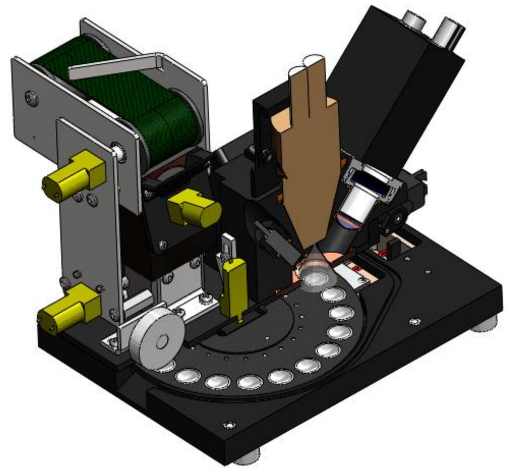

Figure 2. Schematic drawing of ODIN. Some components have been removed to allow viewing the inside of the system. Clearly visible are the conveyor belt of the sample transport system, the brush to remove measured aliquots, the turntable with the sample cups, the X-ray source (brown, cut in half), the PMT (right side, facing the sample at an angle) and the heater below the turntable.

References: [1] MEPAG (2010), http://mepag.jpl.nasa.gov/reports/index.html. [2] MEPAG E2E-iSAG (2011), http://mepag.jpl.nasa.gov/reports/. [3] P-SAG (2012), http://mepag.jpl.nasa.gov/reports/. [4] L. Bøtter-Jensen et al. (2003) Elsevier Press, Amsterdam. [5] E.G. Yukihara and S.W.S. McKeever (2011) Wiley, ISBN 9780470697252. [6] P.T. Doran et al. (2004) *Earth-Science Rev. 67*, 313-333. [7] K. Lepper and S.W.S. McKeever (2000) *Icarus 144*, 295-301. [8] S.W.S. McKeever et al. (2003) *Radiat. Meas. 37*, 527-534. [37] M. Jain et al. (2006) *Radiat. Meas. 41*, 755 – 761. [9] R. Kalchgruber et al. (2007) *Planet. Space Sci.*, *55*, 2203-2217. [10] Gucsik, A. (Ed.) (2009) Springer, Heidelberg. [11] DeWitt R. and McKeever S.W.S. (2011) *IEEE*, Abstract #2.1304.