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Results of the mole penetration tests in different materials

Roman Wawrzaszek (1), Karol Seweryn (1), Jerzy Grygorczuk (1), Marek Banaszkiewicz (1), Tomasz Rybus (1), Lukasz Wisniewski (1), Clive R. Neal (2), and Shaopeng Huang (3)

(1) Space Research Center PAS, Warsaw, Poland., (2) Dept. Civil Engineering & Geological Sciences, University of Notre Dame, Notre Dame, IN 46556, USA, (3) Department of Geological Sciences, University of Michigan, Ann Arbor, MI 48109-1005, USA

Mole devices are low velocity, medium to high energy, self-driven penetrators, designed as a carrier of different sensors for in situ investigations of subsurface layers of planetary bodies. The maximum insertion depth of such devices is limited by energy of single mole's stroke and soil resistance for the dynamic penetration. A mole penetrator 'KRET' has been designed, developed, and successfully tested at Space Research Centre PAS in Poland. The principle of operation of the mole bases on the interaction between three masses: the cylindrical casing, the hammer, and the rest of the mass, acting as a support mass. This approach takes advantage of the MUPUS penetrator (a payload of Philae lander on Rosetta mission) insertion tests knowledge. Main parameters of the mole KRET are listed below:

- outer diameter: 20.4mm,
- length: 330mm,
- total mass: 488g,
- energy of the driving spring: 2.2J,
- average power consumption: 0.28W,
- average insertion progress/stroke: 8.5mm,

The present works of Space Research Center PAS team are focused on three different activities. First one includes investigations of the mole penetration effectiveness in the lunar analogues (supported by ESA PECS project). Second activity, supported by Polish national fund, is connected with numerical calculation of the heat flow investigations and designing and developing the Heat Flow Probe Hardware Component (HPHC) for L-GIP NASA project. It's worth noting that L-GIP project refers to ILN activity. Last activity focuses on preparing the second version of the mole ready to work in low thermal and pressure conditions.

Progress of a mole penetrator in granular medium depends on the mechanical properties of this medium. The mole penetrator 'KRET' was tested in different materials: dry quartz sand (0.3 – 0.8 grain size), wet quartz sand, wheat flour and lunar regolith mechanical simulant – Chemically Enhanced OB-1 (CHENOBI). Wheat flour was selected due to its high cohesion rate and small grain size. Influence of the material compaction on the mole progress was also investigated. For these tests the small testbed has been used. It allowed us to test our mole penetrator up to the depth of 0.5 meters. Obtained results show that 'KRET' is able to penetrate even compacted lunar regolith simulant CHENOBI with minimum progress rate about 2mm per stroke. Moreover, we have confirmed that the mole works properly in both materials with low and high cohesion.