# SPACE SUIT IMPACT ON EFFICIENCY AND PERFORMANCE OF FIELD SCIENCE TASKS

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**Introduction:** We conducted field trials at the Mars Desert Research Station (MDRS) near Hanksvill in Utah (USA) focusing on the ability and efficiency of field scientists to: survey endoliths on the ground and in rock walls, collect data in the samples, and core drilling while wearing a pressurized spacesuit. The field trials used the North Dakota Experimental-1 (NDX-1) pressurizable spacesuit system [1].

Off-world field science experience is limited to six Apollo lunar missions where lunar field science practice evolved successively to extensive field surveys in many locations, kilometers from the Lunar Module. Astronaut Schmitt [2] described performing field geology on the moon as: requiring faster mental iterations compared to terrain exploration, is more physically demanding than on Earth inducing fatigue that could be fatal, subject to strict time constraints (due to limited space suit consumables), and dictated by knowledge that returning to the location is unlikely.

The physically and mentally demanding EVAs undertaken by the Apollo astronauts were arguably successful because of years of training focused on a maximum of three Lunar EVAs over 3 day visits. Future off-world missions to Mars or the Moon are likely to be in the paradigm of “go to stay” with astronauts undertaking many EVAs probably with most planned during the mission. Thus understanding the requirements for field science spacesuit performance through simulated field trials is an important step to developing new technologies and skills for future human planetary exploration.

**Objective:** Our objective was to quantify the scientist astronaut performance while wearing a spacesuit during simulated off-world field science doing: data collection, documentation tasks for surveying endoliths and for drilling using a core sample and rotary percussive drill.

**Methodology**: Five subjects, geology and astrobiology post graduate students donned the NDX-1 space suit and undertook:

(1) Endolith surveys on the ground and on a rock wall unit (fig 2) at previously identified locations. The properties documented were: position, strike/dip, rock type, rock color, rock hardness, color, sky angle, endolith presence, endolith color, endolith depth, endolith thickness and a visual survey of associated biology.

(2) Core sample drilling and rotary percussive drilling (fig 1), collecting and storing the core and cutting samples for each drill type.

In addition we measured during all trials, while wearing and not wearing the space suit: bio-medical data including heart-rates, observational accuracy, task duration, and, drill hole depths in the case of drilling. In particular, we compared heart-rates – a measure of human effort, and calculated time metrics, factors that compare task duration while suited to when not suited.

*The University of North Dakota’s NDX–1 space suit.* The North Dakota Experimental-1 (NDX-1) space suit system [1] is a pressurized planetary space suit concept demonstrator for analog Moon and Mars testing, made by the University of North Dakota in 2005. The space suit is part of an iteration of planetary suit concepts designed to be analog test-beds trialling new materials and component assemblies. The space suit systems include a water cooling garment, a wireless communications headset, a biomedical logger monitoring heart ECG (measuring effort), breathing mixture and body temperature, respiration rate, pressure, humidity, $O_2$, $CO_2$ and time. NDX-1 is a separable two- piece suit with lower fabric trousers and upper composite hard torso assemblies.

**Figure 1:** Rotary Percussive drilling while in suit. Note the cuttings around the hole.

**Results:**

*Drilling Results.* Core sample drilling required considerable more effort than rotary percussive drilling (fig 1), due to conserving and documenting the core. Drilling pulse rates, depths drilled in suit and no suit are listed in Table 1. The time metric was calculated as:

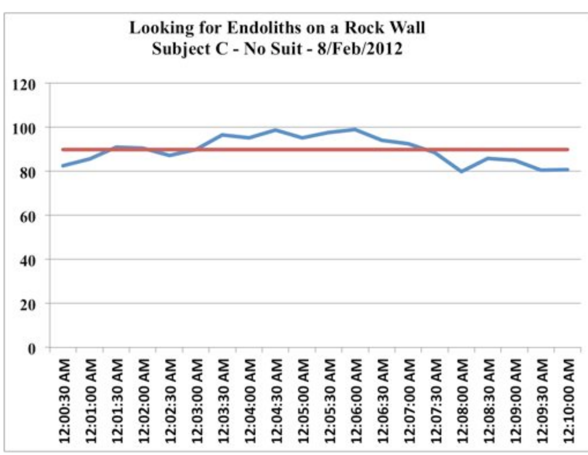
Drilling Time metric = (Duration: in Suit/ No suit) x (Drill depth: no suit/in suit)

| Drill | Average Pulse Rate | | Duration (min) | | Depth Drilled (mm) | | Time Metric |
|---|---|---|---|---|---|---|---|
| | No Suit | Suit | No Suit | Suit | No Suit | Suit | Suit/ No suit |
| Core sample drilling | 97 | 119 | 18:30 | 41 | 185 | 127 | 3.26 |
| Rotary Percussive | 99 | 105 | 33.50 | 34 | 150 | 150 | 1.01 |

**Table 1:** Drilling biomedical data and time metrics for no suit and suit.

*Endolith Surveys Results.* Surveying and sample collecting on the ground was significantly more difficult and exhausting than surveying the rock wall unit. The observational accuracy was consistant at 90%. Heart-rates were on average 33 pulses per minute higher while surveying on the ground (graph 1) and an average of 21 pulses per minute higher while surveying on a rock wall.

**Figure 2:** Surveying endoliths on the ground (left); Surveying endoliths on a rock wall (right).



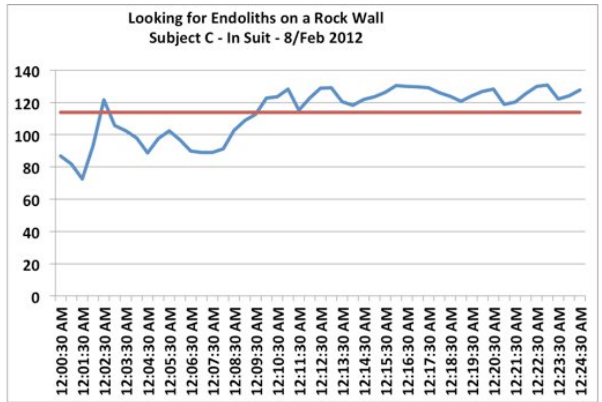




**Figure 3:** Heart rate of a subject while surveying and sample collecting endoliths on the ground with no suit (top) and in suit (bottom) where x axis is time, y axis is heart-rate, red line is average heart-rate. Note the higher average heart-rate while in a suit compared to no suit.

**Conclusion:** We find that while undertaking 'endolith type' surveys while suited, a time metric of at least 1.6 be multiplied to the equivalent survey with no suit (baseline) and, scientist astronauts could, on average, have 33 pulses/minute higher heart rate doing this activity in suit compared to baseline to achieve 90% observational accuracy.

Likewise for core drilling the time metric is 3.3 and the average heart rate could be 23 pulses/minute higher compared to baseline where sample handling cores was a major part of the effort. However the rotary percussive drilling was done in similar time and effort due to a second person capturing the cuttings.

Thus we argue technological solutions for sample handling cores from the drill string will reduce effort for core drilling.

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**References**

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