Space Suit Impact on Performance of Field Science Tasks: Results from Field Trials

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(1) Introduction

Schmitt (2010) 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.

Summary of issues: Off-world field science is physically demanding, has high induced fatigue, time limitations and dangerous.

Question: How does wearing a space suit affect field science performance?

(2) Our Objective

Our objective was to quantify the scientist astronaut performance while wearing a spacesuit during simulated off-world field science doing:

- Data collection; and,
- Documentation tasks.

(3) Our Methodology

Five subjects, (our scientist astronauts) donned the NDX-1 space suit and undertook:

- Endolith surveys on the ground and a rock wall unit (figure 2); and,
- Core sample drilling and rotary percussive drilling (figure 1)

We measured, 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 effort, and calculated time metrics, factors that compare task duration while suited to when not suited.

Table 1: Drilling Data

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

The University of North Dakota's NDX–1 space suit

The North Dakota Experimental-1 (NDX-1) space suit system (De Leon 2006) 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 trialing new materials and component assemblies.

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

(4) Results

(4.1) 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 without a suit are listed in Table 1. The time metric was calculated as:

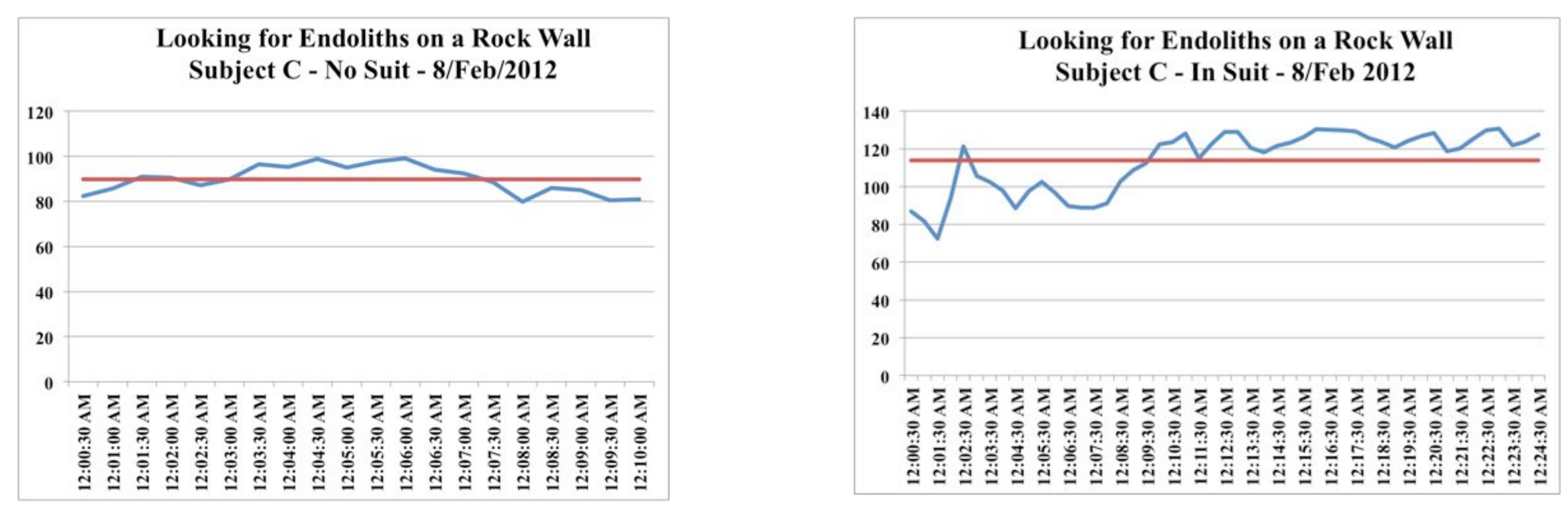
Drilling Time metric = (Duration: in Suit/ No suit) x (Drill depth: no suit/in suit)

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

(4.2) 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 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.



Graph 1: Heart rate of a subject while surveying and sample collecting endoliths on the ground with no suit (left) and in suit (right) 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.

(5) 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 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 will reduce drilling effort.

References

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