AUTONOMOUS ROVER SCIENCE IN THE FIELD: FIRST RESULTS. E.Z. Noe Dobrea¹, C. Ahrens², M.E. Banks³, A. Breitfeld³, A. Candela³, R.N. Clark¹, M. Hansen⁴, A. Hendrix⁴, G. Holsclaw⁴, G. Kramer³, M.D. Lane⁵, T.H. Prettyman¹, C. Thieberger⁶, S. Vijayarangan³, F. Vilas⁷, D. Wettergreen⁴, S.P. Wright⁴, and the TREX Team
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Introduction: The autonomous science rover project of the Toolbox for Research and Exploration (TREX), a NASA SSERVI node, is investigating tools and techniques designed to improve operational efficiency and science yield of future rover missions.

Central to our investigation is the concept that rover activities should not be prescribed uniquely by a tight operator/robot iterative process that often reflects limited knowledge of the field area; instead, activities should be open-ended and responsive to ongoing observations, even without iterative operator feedback.

We propose that robotic explorers should be able to plan traverses and observations that address driving hypotheses and require little to no input from outside operators. Periodically, or when the robotic explorer encounters circumstances that fall outside the realm of expected observables, the robotic explorer contacts the operator to offer updates or request new directions.

Approach: We are integrating multiple tools onto Carnegie Mellon’s intelligent robotic testbed in order to enable the rover to autonomously plan traverses, acquire measurements, perform analyses, and report higher-level findings. These tools include a new decision-making technique known as the hypothesis map [1,2] and the Tetracorder system [3-5]. The rover’s instrument suite includes spectrometers observing in the 0.2–14 μm range - a spectral region containing a broad range of mineralogically diagnostic features - as well as a gamma ray spectrometer and an X-ray diffractometer. A description of the approach is given in [6, 7]. Here, we describe our field-testing of the autonomous science capabilities of the rover.

Objectives: The overall project objectives of the field experiment were to:
- Compare the operational efficiency and science yield of a semi-autonomous rover and of astronaut/rover collaboration with the standard exploration strategy.
- Test the efficacy of Tetracorder as a spectral analysis tool on an autonomous rover system.
- Test new exploration strategies that take advantage of rover autonomy.

Experiment: Three operational scenarios were executed for comparison purposes [7]: 1) standard rover exploration paradigm, 2) autonomous rover exploration, and 3) autonomous rover with astronaut in the loop.

To this effect, the Carnegie Mellon rover, Zoë, was commanded from a science operations center in Flag-
inferred from the spectra using Tetracorder. Likelihood of a geologic origin was established by the number of minerals found at a location having a common geological origin. Conversely, the number of potential geologic origins attributed to a mineral detection was used to establish uncertainty in geological origin.

The rover then used the hypothesis map and associated uncertainties to plan a traverse that would best reduce uncertainty in geologic origin. As the rover traversed the terrain, it updated the hypothesis and uncertainty maps on the basis of the discovery of additional minerals and also updated its traverse on the basis of changes in the maps (Fig. 1).

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Figure 1. Evolution of Hypothesis map and Entropy maps. Top pair shows the maps as provided by the science team, before the rover traverse. Bottom pair shows the resulting map at the end of the traverse. White markers represent route traversed by the rover.