IN-SITU LIFE DETECTION & DATING: A MSR PRECURSOR MISSION CONCEPT.

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Introduction: We propose a Mars in-situ life detection/characterization and geochronology mission concept that will triage and validate samples as a precursor to MSR. During the 2008 Decadal Survey community outreach effort, the required technology for such a mission had not yet been demonstrated; however, today, this technology is moving from lab prototype to field deployable instrument.

We believe that technological advances enable a mission concept that addresses four of the five competing scientific, political, and fiscal requirements for flight in this decade. Specifically, the mission must:

1) be responsive to the astrobiological and chronological science goals of the MEPAG [1], Decadal Survey (DS) [2], and E2E-iSAG [3];
2) address the physical/chemical/biochemical surface materials "Strategic Knowledge Gaps" (SKGs) for human exploration of Mars [4];
3) focus on the challenge areas identified in the "Concepts and Approaches for Mars Exploration" call;
4) avoid the MSR *appearance* of long term political commitment and cost;
5) cost less than $700M, or risk being competed via the New Frontiers call;

The majority of these requirements (req. 1-4) would be accomplished by a minimum of a lander, and more optimally, a rover.

Mission Concept: As a precursor to MSR, we propose a MER- to mid-sized rover to carry out life detection, organic characterization, geochronology, and mineralogy measurements (**Fig. 1, Table 1**) to establish the validity of a potential future MSR landing site. The rover requires an arm and drill with coring and abrading bits [5-7]. The instruments are an integrated package sharing a high-resolution mass spectrometer (HRMS) capable of extensive analysis of biotic and abiotic chemistry, as well as Rb-Sr geochronology. The system leverages a μRaman/LIBS required for mineral characterization, in combination with the HRMS, to additionally measure K-Ar [8]. **The proposed mission is consistent with payload capability of newly designed MER variants [9].**

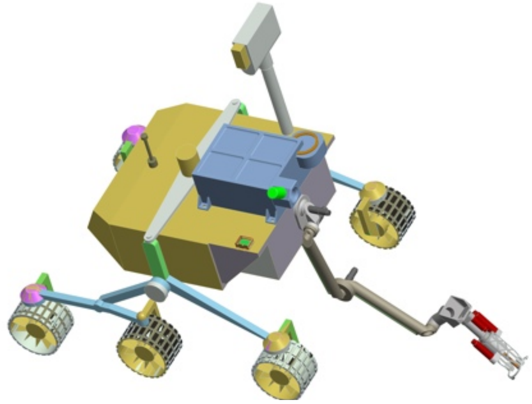


Figure 1: Notional MER sized rover with proposed mission payload shown in blue.

Table 1: Concept details

Payload Component (including power supplies, support electronics, & structure)	Potential Supplier	TRL	Mass (kg)	Power (W)	Total Power (W-hrs)/ Isochron	Total Power (W-hrs)/ Bioassay
Shared ZZTOF	SwRI	5	5.5	3	18.8	2
FPGA	SwRI	5	0.1	2	25.0	1
3 Pumps	Creare	9	1	3	25.0	48
Astrobiology Source	SwRI	4	0.3	0.5	-	0.25
Cryotrap	SwRI	6	2.5	6	-	36
GCxGC	SwRI	3	2.5	5	-	30
Pyrolysis	SwRI	4	0.5	0.3	-	2
TDC (2 GS/s)	SwRI	5	0.1	1	-	0.5
Sample Handling	SwRI	3	2	1	-	1
Dating Source	SwRI	4	0.3	0.5	6.3	-
Ablation Laser	JPI	4	1	11	138	-
Sr Laser	JPI	4	2.5	6	75	-
Rb Laser	JPI	4	2.5	5	63	-
ADC (200 MHz) +	SwRI	4	1	4	50	-
XYZ stages	Micos	4	0.3	5	0.4	-
Sample Handling	SwRI	3	2	1	1	1
μRaman / LIBS	U Hawaii	4	2	5	4	-
Arm	Honeybee	5	4	-	-	-
Drill/Coring/Abrading/scoop	Honeybee	5	3	45	15	15
Cameras x3	JPL	9	0.8	2	12	12
Camera electronics x3	JPL	9				
Totals			33.8		433	147

Life Detection & Organic Characterization. Consensus is rapidly growing that definitive extraterrestrial life detection and organic detection requires "gold-standard" triple coincidence correlation techniques using organic pattern recognition, isotopic fractionation, and determination of chirality of organic molecules [10]. Specifically:

a) Organic pattern recognition: In general, abiotic organic homologous compounds exhibit a decreasing abundance with increasing chain length; deviations from such a distribution is a signpost of pre-biotic chemistry on the road to life [11].
b) Isotopic fractionation: The majority of autotrophic metabolisms on Earth discriminate against the heavy isotopes (C,N) by photolytically driven fractionation, including from the results of photosynthesis, nitrification, denitrification, sulfate reduction, sul-

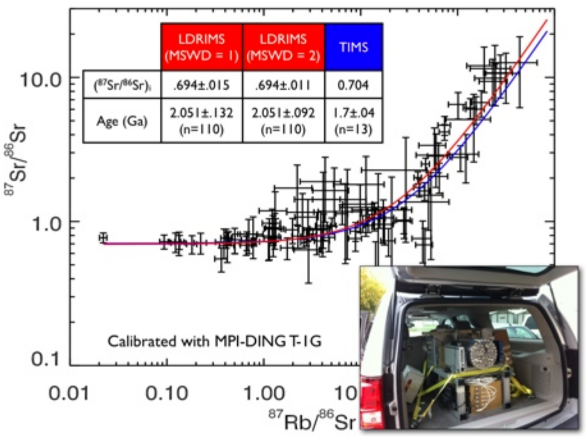
fide oxidation, methane oxidation and methanogenesis [12, 13].

c) Chirality: A preponderance of biologically formed compounds are synthesized exclusively of identical enantiomers, which are believed to be a universal signature of living systems [14].

Hence, determining organic patterns, compound-specific C and N isotopic ratios, and chirality of each compound within the chemical pattern is the most generally applicable and conclusive way to identify extant or fossil life. We have developed an instrument capable of separating organics by chirality, then identifying the organic patterns with GCxGC HRMS, and determining the C and N isotopic ratios of individual compounds through split-flow of the effluent, with an accuracy sufficient to identify biological isotopic fractionation. **This level of analysis is identical to that which would be performed in a terrestrial lab on a returned sample.**

Geo*chronology.* In-situ geochronology measurements better than ±200 Ma, and preferably using more than one isotope system, have long been a key goal for planetary science [15]. We have developed a relatively rapid, portable Rb-Sr dating instrument that avoids the interference and mass resolution issues associated with geochronology measurements [16]. We have succeeded at producing moderate precision dates of ±130 Ma (MSWD=1; **Fig. 2**); near term improvements should result in a final precision of ~±50 Ma. Biased secondary mineralogies are avoided using a µRaman spectrometer sharing the LDRIMS ablation laser, and in combination with the HRMS, enable simultaneous K-Ar measurement [8]. **Simultaneous Rb-Sr and K-Ar dates will significantly improve confidence to the ultimate scientific interpretation.**

Addressing Requirements: The proposed instrument payload addresses req. 1 goals such as assessment "of the past and present habitability of Mars, whether life is or was present on Mars in its geochemical context, and characterize carbon cycling and prebiotic chemistry", as well as, "Determine the nature and evolution of the geologic processes...and characterize the ... composition... and evolution of Mars's interior" [2]. These methods will provide new data on E2E-iSAG priorities 1-3, 5, and 8, and reproduce the desired E2E-iSAG in-situ measurements (1-4, p.8) [3]. The approach provides insight into organic biohazards, addressing req. 2, including SKG B.2, and the chemistry of trace/minor phases that may act as, or inhibit, catalysts for ISRU (SKG B.7) [4]. These new approaches are responsive to req. 3 challenge area 1.2, "...in situ instrumentation to identify and triage high-priority materials for analysis". Finally, while meeting many of the science goals of req.s 1-3, our mission avoids the issues of req 4. The mission may be possible as a static lander and meet req. 5, but would achieve a much higher science return with a modified MER rover. If the budget outlook improves, our payload would be ideally suited to the first MSR caching rover and meets all of the objectives of the MRR-SAG. **Our mission feeds forward into MSR by validating that the collected samples are astrobiologically and geochronologically relevant, and triages those samples by scientific priority for return by MSR.**



	LDRIMS (MSWD = 1)	LDRIMS (MSWD = 2)	TIMS
$(^{87}Sr/^{86}Sr)_i$	.694±.015	.694±.011	0.704
Age (Ga)	2.051±.132 (n=110)	2.051±.092 (n=110)	1.7±.04 (n=13)

Figure 2: Example Rb-Sr isochron and portable system in a SUV.

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