National Aeronautics and Space Administration

Mars Subsurface Exploration Task I: Sounding for Groundwater (TH2OR: Transmissive H2O Reconnaissance)

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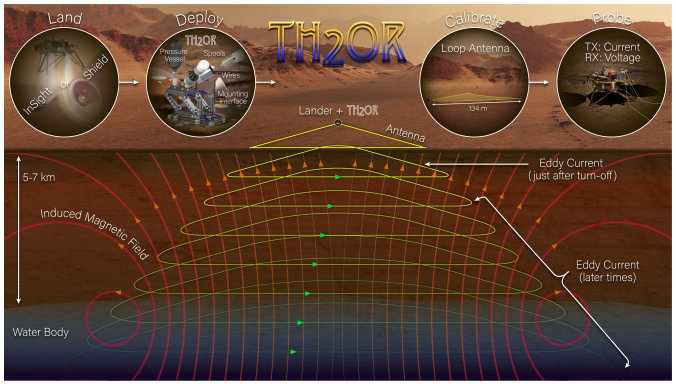
Objectives: Transmissive H2O Reconnaissance (TH2OR) is a transient electromagnetic (TEM) sounding instrument prototype designed to probe the Martian subsurface for the presence of aquifers. The goals of this Strategic RTD are (1) to assess the feasibility of TEM to detect ground water at Mars to depths of several kilometers, (2) build a low-mass, low-power TEM prototype, and (3) test the prototype in a relevant environment and benchmark results to commercially available TEM instruments.

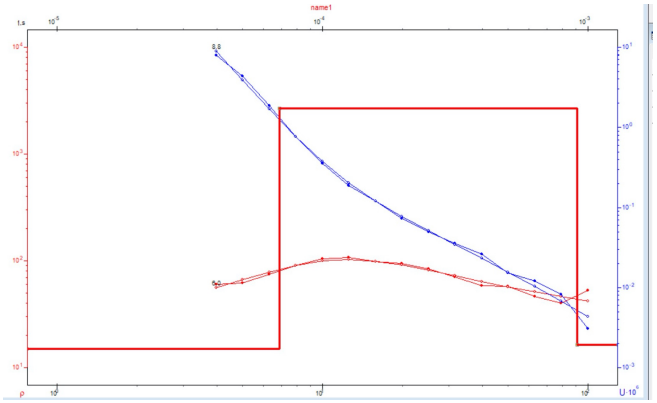
Background: TEM is a common technique employed on Earth to detect and map ground water.TH2OR will be the first planetary TEM and will further cement JPL's position as the leader in planetary subsurface exploration. TEM employs a transmitter (TX), a receiver (RX), and a loop antenna for each. The transmitter imparts pulsed electric current in the TX loop antenna with a given pulse repetition frequency (PRF) to generate a primary magnetic field during "current on" intervals, while the receiver senses induced subsurface secondary magnetic fields during "current off" intervals.



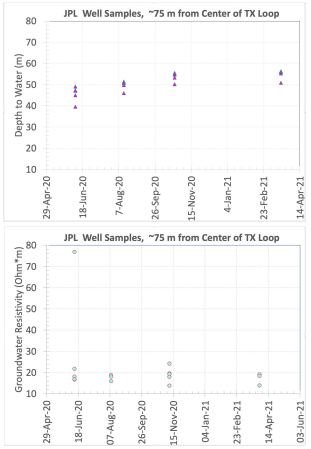
Concept of TH2OR and TEM sounding

TH2OR projectiles loaded with antenna wires spooled and mid-launch

Deployment		Totals / Avgs	D-001	D-002	D-003	D-004	D-005	D-006	D-007	D-008	D-009	D-010	D-011
Parameters	th2or heading (deg from N)	-	90	90	90	90	70	70	70	70	70	70	70
	elevation (deg)	45	45	45	45	45	45	45	45	45	45	45	45
	azimuth (deg)	60	60	50	60	60	60	60	60	60	60	60	60
	tank pressure (psi)	171	200	145	165	150	155	155	155	170	170	200	200
	tube diameter (inch)		2	2	2	2	2	2	2	2	2	2	2
	tube throw dist (cm)	20.4	20	20	20	20	20	20	30	20	30	20	20
Environment	date (D-M-Y)	-	8/8/21	8/9/21	8/10/21	8/11/21	8/31/21	8/31/21	8/31/21	8/31/21	8/31/21	8/31/21	8/31/21
	local time (24hr)	-	11:00	11:30	12:00	12:20	10:55	11:23	11:45	12:10	12:25	12:45	13:15
	air temp (C)	24.9	26	27	27	29	23	23	25	24	24	25	24
	pressure (bar)	1.0	1	1	1	1	1	1	1	1	1	1	1
	humidity (%)		49	42	40	37	63	64	62	60	58	58	61
	wind heading (deg from N)	-	200	180	200	220	120	90	90	210	210	90	90
	wind speed (m/s)	1.0	2.5	1.3	3.8	5.4	0.1	0.3	0.2	0.0	0.0	0.5	0.0
Projectile A	version (curr. 2)	-	*2P*	*2P*	*2P*	*2P*	*3P*	3MS	3ML	3MS	3ML	3MS	3ML
	launch mass (kg)	1.0	1.05	1.05	1.05	1.05	1.00	1.15	1.35	1.15	1.35	1.15	1.35
	exit velocity (grey m/s)	18.6	-	-	-	23	17	16	15	18	18	21	18
	down-wire length (m)	36.5	**25**	**34**	**33**	**36**	**32**	**30**	**46**	**29**	**47**	**29**	**44**
Projectile B	version (curr. 2)	-	2P	2P	2P	2P	3P	3MS	3ML	3MS	3ML	3MS	3ML
	launch mass (kg)	1.0	1.05	1.05	1.05	1.05	1.00	1.15	1.35	1.15	1.35	1.15	1.35
	exit velocity (green m/s)	18.6	-	-	-	23	17	16	15	18	18	21	18
	down-wire length (m)	39.2	**32**	**33**	**22**	**31**	**32**	**29**	**47**	**32**	**45**	**30**	**48**
Earth	average deploy dist (m)		29	34	28	34	32	29	47	30	46	30	46
	estimated area (m^2)		352	486	327	486	444	368	937	400	934	382	914
Mars	Probable Dist (m), Target = 134		75	89	73	89	85	77	123	80	123	79	121
	Probably Area (m^2) Target = 7853		2,456	3,394	2,287	3,394	3,104	2,571	6,546	2,793	6,521	2,669	6,380



Inversion of TH2PR data showing depth to aquifer of 91 m.



TH2OR test site at the Arroyo and sounding locations and well data

Significance/Benefits to JPL and NASA

TEM is the best technique for detecting groundwater on Mars. TH2OR is a functional and viable implementation, and its relatively low-mass, low-power and compact nature may allow it to be added to smaller missions being considered for Mars, such as SHIELD. Determining the presence of aquifers on Mars will answer first-order question about the Red Planet in regards, to the inventory and state of water and the presence of a possible habitat for extant life. Inversion of TH2OR data (O1) will allow us to determine depth and salinity of ground water.

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