The 162 Sailing Stones of Death Valley

ROCK	UTM EASTING (ZONE 11)	UTM NORTHING (ZONE 11)	TOTAL TRAIL LENGTH (M)
1	449509.12	4060184.16	12.67
6	449339.40	4058186.82	84.38
7	449347.16	4058192.54	59.67
8	449391.24	4058146.32	78.54
9	449430.40	4058113.84	13.38
14	449628.32	4058256.42	94.07
15	449463.86	4058178.75	153.33
16	449430.04	4058044.77	82.81
17	449487.27	4058034.00	20.41
18	449592.01	4058286.45	33.19
19	449639.51	4058250.26	47.29
21	450032.67	4057960.25	49.28
22	450018.86	4057953.51	274.54
23	449999.71	4058033.76	123.32
24	449999.79	4058033.64	80.60
25	450041.82	4058173.23	230.61
26	450057.38	4058147.71	315.91
27	450057.32	4058187.71	256.69
28	450130.57	4058293.04	339.56
29	450169.70	4058348.67	67.00
30	450186.93	4058329.43	365.14
31	450255.07	4058309.14	593.17
32	450272.45	4058226.97	574.47
33	450275.09	4058237.33	379.01
34	450236.39	4058240.90	441.05
35	450185.59	4058168.15	148.46
36	450183.32	4058143.31	118.38
37	450160.52	4058138.16	201.34
40	450073.97	4058110.79	143.82
41	450082.13	4058099.54	110.07
42	450101.88	4058095.19	240.96
43	450086.49	4058242.97	163.22
44	450039.46	4058451.76	131.54
45	450021.54	4058657.78	18.93
46	449871.52	4058685.14	71.57
47	449909.62	4058571.88	66.22
48	450077.46	4058553.19	1.56
49	450073.19	4058547.84	3.85
50	450296.29	4058426.70	242.78
51	450279.99	4058423.01	142.46
52	450296.01	4058409.94	107.79
53	450312.77	4058374.94	650.17
54	450295.98	4058368.47	147.97
55	450248.62	4058304.11	507.50
56	450254.71	4058297.39	2.93
57	450175.07	4057868.74	252.49
58	450210.49	4057954.01	82.40
59	450314.15	4058288.61	385.60
60	450317.07	4058481.47	612.66
61	450343.97	4058504.37	640.37
62	450328.75	4058387.03	563.37
63	450223.54	4057777.29	69.04
64	450198.38	4057882.60	8.81
68	450166.43	4057876.43	20.99
69	450132.84	4057842.07	248.68
70	450136.38	4057897.68	412.18
72	450111.04	4057912.46	140.21
73	450121.77	4057991.38	272.08
74	450131.37	4057975.96	12.90
75	450134.39	4057986.94	11.08
77	450246.82	4057960.97	186.40
78	450225.71	4058037.91	54.71
79	450225.99	4058037.04	102.13
80	450174.09	4058004.63	26.29
81	450258.96	4057865.53	92.65
82	450262.68	4057858.98	1.58
83	450273.16	4057808.97	46.14
84	450271.86	4057860.28	83.94
85	450273.21	4057854.70	90.16
86	450267.17	4057979.21	227.18
87	450267.71	4058070.64	92.97
88	450244.64	4058116.86	121.00
89	450278.72	4058120.84	280.64
90	450220.69	4058174.11	423.56
91	450337.03	4058102.21	333.86
92	450345.58	4058096.43	10.04
93	450342.00	4058100.92	77.79
94	450372.56	4058124.76	158.63
95	450354.66	4058153.01	218.46
96	450317.03	4058058.87	291.08
97	450315.74	4058058.72	363.41
99	450310.99	4057981.91	93.13
100	450314.09	4057970.34	62.71
101	450308.06	4057961.35	20.44
102	450296.48	4057953.75	182.51
103	450323.53	4057939.99	95.16
104	450325.64	4057929.51	187.97
105	450318.66	4057914.09	167.00
106	450306.19	4057917.71	177.08
107	450317.91	4057861.07	96.46
108	450337.25	4057846.98	88.34
109	450345.64	4057844.85	143.76
110	450316.32	4057828.11	102.53
111	450302.65	4057790.60	51.58
112	450308.59	4057781.67	47.79
113	450413.24	4057826.64	116.08
114	450357.00	4057968.55	239.93
115	450353.61	4057953.05	222.23
116	450391.47	4057982.29	237.02
117	450369.77	4057955.54	150.32
118	450417.35	4057960.23	318.62
119	450417.35	4057972.70	276.61
120	450444.60	4057987.15	274.42
121	450443.76	4057971.79	120.09
122	450451.21	4057991.36	78.83
123	450476.82	4058047.24	326.88
124	450584.34	4057859.04	16.47
125	450584.02	4057859.64	15.04
126	450581.96	4057852.29	204.13
127	450575.69	4057842.28	19.96
128	450572.85	4057934.84	61.08
129	450595.46	4057960.90	53.10
130	450625.52	4057982.18	248.02
131	450626.79	4057961.85	150.65
132	450645.65	4057966.74	126.32
133	450651.44	4057964.96	29.60
134	450675.91	4058022.92	63.06
135	450666.57	4058020.62	118.01
137	450640.25	4058063.17	247.77
138	450638.13	4058055.34	216.67
139	450606.39	4058071.53	6.01
140	450589.68	4058176.32	305.44
141	450985.16	4058984.26	131.50
142	450822.23	4058865.14	61.16
143	450756.05	4058817.18	789.52
144	450783.33	4058881.62	661.88
145	450693.65	4058762.46	880.73
146	450664.06	4058684.71	414.33
147	450678.45	4058654.99	656.48
148	450651.34	4058607.48	183.80
150	450695.99	4058556.55	208.46
151	450606.58	4058574.35	343.41
152	450571.65	4058523.83	342.24
153	450517.08	4058558.96	252.52
154	450501.58	4058525.03	386.06
155	450531.37	4058436.70	476.77
156	450571.13	4058420.12	438.26
157	450571.07	4058362.86	286.92
158	450606.65	4058351.06	454.78
159	450567.81	4058303.08	204.43
160	450520.47	4058279.22	150.49
161	450516.22	4058145.63	220.95
162	450510.91	4058140.15	405.68

SAILING STONES are a geological phenomenon where rocks move and inscribe long tracks along a smooth valley floor without human or animal intervention. Instead, rocks move when large ice sheets a few millimeters thick floating in an ephemeral winter pond start to break up during sunny days. These thin floating ice panels, frozen during cold winter nights, are driven by wind and shove the rocks dubbed "sailing stones" at up to 5 m/min.

MECHANICS OF MOVEMENT: The rocks move across the playa when the surface is wet, creating the appearance of a "wake" trail of mud in the playa surface. Racetrack Playa is surprisingly flat - so gravity is not a factor. In fact, the northeast corner of the playa is 5-10cm higher than the southwest, which means that most rocks are moving uphill.

In order for the rocks to "sail", the playa must fill with water, deep enough to form floating ice, but shallow enough so the rocks are still exposed. The water freezes during the cold winter nights, and when the sun rises and warms the ice, it begins to melt and break up into large floating panels. Wind then moves the ice panels, and if the force is stronger than the friction holding the rock in place, it will move the rock. Movement can either be due to the ice pushing against the rock, or the ice "floats" the rock by making it buoyant. The rock then follows the path of the ice sheet.

These rocks can be found in various locations, however the rock paths and distances referenced here were studied and recorded from Racetrack Playa, Death Valley, California by Dr. Paula Messina, a professor of Geology in San Jose State University.

The illustration below shows the direction and relative distance of 162 of these sailing stones.

OPTIMAL CONDITIONS:

1. a flooded surface
2. a thin layer of clay
3. light wind
4. ice floes (floating ice)
5. warming temperatures

SAILING STATISTICS:
typical wind velocity = 4-5 m/s
average meters moved = 200 m
typical rock speed = 2-5 m/min