1
00:00:00,433 --> 00:00:01,334
>> I'M DR. ERIC FOX,

2
00:00:01,334 --> 00:00:02,602
THE IONIC LIQUID SCIENCE LEAD

3
00:00:02,602 --> 00:00:03,370
AT NASA'S

4
00:00:03,370 --> 00:00:05,071
MARSHALL SPACE FLIGHT CENTER.

5
00:00:05,071 --> 00:00:06,906
>> I'M DR. JENNIFER EDMUNSON,

6
00:00:06,906 --> 00:00:08,341
A PLANETARY SCIENTIST

7
00:00:08,341 --> 00:00:10,510
AND IN-SITU RESOURCE UTILIZATION

8
00:00:10,510 --> 00:00:11,945
INTEGRATION LEAD FOR

9
00:00:11,945 --> 00:00:14,581
IN-SPACE MANUFACTURING.

10
00:00:14,581 --> 00:00:15,548
HERE AT NASA'S MARSHALL

11
00:00:15,548 --> 00:00:16,683
SPACE FLIGHT CENTER, WE ARE

12
00:00:16,683 --> 00:00:18,351
WORKING WITH MATERIAL THAT,

13
00:00:18,351 --> 00:00:19,753

WHEN MIXED WITH MARTIAN SOIL

14
00:00:19,753 --> 00:00:21,321
AND CURED BY A DEHYDRATION

15
00:00:21,321 --> 00:00:22,789
PROCESS, WILL FORM

16
00:00:22,789 --> 00:00:23,857
A BUILDING MATERIAL THAT

17
00:00:23,857 --> 00:00:25,158
POTENTIALLY COULD BE USED

18
00:00:25,158 --> 00:00:27,594
TO 3D PRINT HABITATS, ROADS,

19
00:00:27,594 --> 00:00:29,195
OR OTHER STRUCTURES.

20
00:00:29,195 --> 00:00:30,296
ADDITIVE CONSTRUCTION IS

21
00:00:30,296 --> 00:00:31,831
THE PROCESS OF 3D PRINTING

22
00:00:31,831 --> 00:00:32,832
STRUCTURES.

23
00:00:32,832 --> 00:00:33,800
IT IS EXACTLY LIKE

24
00:00:33,800 --> 00:00:35,402
ADDITIVE MANUFACTURING,

25
00:00:35,402 --> 00:00:36,903
BUT ON A LARGER SCALE.

26
00:00:36,903 --> 00:00:37,971
NASA IS INTERESTED IN

27
00:00:37,971 --> 00:00:39,672
3D PRINTING HABITATS BECAUSE

28
00:00:39,672 --> 00:00:40,774
IT REDUCES THE AMOUNT OF

29
00:00:40,774 --> 00:00:42,575
BUILDING MATERIAL NEEDED, AND

30
00:00:42,575 --> 00:00:44,611
SUBSEQUENTLY, WASTE MATERIAL

31
00:00:44,611 --> 00:00:46,045
WHEN COMPARED TO TRADITIONAL

32
00:00:46,045 --> 00:00:47,547
CONSTRUCTION TECHNIQUES,

33
00:00:47,547 --> 00:00:49,215
AND IT ALLOWS FLEXIBILITY

34
00:00:49,215 --> 00:00:50,417
IN THE TYPE OF STRUCTURES

35
00:00:50,417 --> 00:00:52,652
PRINTED WITH THE SAME DEVICE.

36
00:00:52,652 --> 00:00:54,187
NASA IS ALSO INTERESTED IN

37
00:00:54,187 --> 00:00:55,555
TAKING THE SMALLEST AMOUNT

38
00:00:55,555 --> 00:00:57,223

OF MATERIAL NECESSARY

39
00:00:57,223 --> 00:00:58,858
TO BUILD STRUCTURES FROM EARTH,

40
00:00:58,858 --> 00:01:00,093
BECAUSE IT TAKES A LARGE AMOUNT

41
00:01:00,093 --> 00:01:01,694
OF MONEY AND RESOURCES TO LAUNCH

42
00:01:01,694 --> 00:01:03,229
AND TRANSPORT HEAVY ITEMS

43
00:01:03,229 --> 00:01:05,265
LIKE CONSTRUCTION MATERIALS.

44
00:01:05,265 --> 00:01:06,833
THAT IS WHY NASA WANTS TO USE

45
00:01:06,833 --> 00:01:08,034
MATERIALS WE CAN FIND

46
00:01:08,034 --> 00:01:10,270
ON PLANETARY SURFACES, SUCH AS

47
00:01:10,270 --> 00:01:11,371
THE MINERALS THAT MAKE UP

48
00:01:11,371 --> 00:01:12,772
THE MARTIAN SOIL.

49
00:01:12,772 --> 00:01:13,740
QUITE A FEW MINERALS CONTAIN

50
00:01:13,740 --> 00:01:15,975
SODIUM AND SILICON DIOXIDE.

51
00:01:15,975 --> 00:01:17,010
TWO SUCH MINERALS ARE

52
00:01:17,010 --> 00:01:19,245
ALIBITE AND SODIUM BENTONITE.

53
00:01:19,245 --> 00:01:20,113
BOTH OF THESE MINERALS

54
00:01:20,113 --> 00:01:21,714
EXIST ON MARS.

55
00:01:21,714 --> 00:01:22,749
OUR PROJECT USES

56
00:01:22,749 --> 00:01:24,384
IONIC LIQUIDS TO SEPARATE

57
00:01:24,384 --> 00:01:26,052
THE SODIUM AND SILICON DIOXIDE

58
00:01:26,052 --> 00:01:27,420
IN THE MINERALS, AND THEN

59
00:01:27,420 --> 00:01:29,055
EMPLOYS CHEMICAL PROCESSES

60
00:01:29,055 --> 00:01:30,523
TO TRANSFORM THE MATERIAL

61
00:01:30,523 --> 00:01:32,292
INTO OUR 3D PRINTABLE BINDER

62
00:01:32,292 --> 00:01:34,961
MATERIAL, SODIUM SILICATE.

63
00:01:34,961 --> 00:01:35,762

>> IONIC LIQUIDS ARE

64
00:01:35,762 --> 00:01:37,163
A VERSATILE CLASS OF MATERIALS

65
00:01:37,163 --> 00:01:38,631
THAT ARE POTENTIALLY USEFUL IN

66
00:01:38,631 --> 00:01:41,067
MANY NASA-RELEVANT APPLICATIONS.

67
00:01:41,067 --> 00:01:42,068
OF PARTICULAR INTEREST

68
00:01:42,068 --> 00:01:43,937
TO THIS PROCESS IS THEIR ABILITY

69
00:01:43,937 --> 00:01:45,004
TO CHEMICALLY DISSOLVE

70
00:01:45,004 --> 00:01:46,439
MARTIAN REGOLITH, ALLOWING FOR

71
00:01:46,439 --> 00:01:47,674
THE RECOVERY OF HIGH PURITY

72
00:01:47,674 --> 00:01:48,842
SINGLE ELEMENTS, SUCH AS

73
00:01:48,842 --> 00:01:50,910
SODIUM, FROM THE SOIL.

74
00:01:50,910 --> 00:01:52,545
ADDITIONALLY, AS THIS PROCESS

75
00:01:52,545 --> 00:01:54,347
CONSUMES NO IONIC LIQUID,

76
00:01:54,347 --> 00:01:55,682
NO CHEMICAL RESUPPLY OTHER THAN

77
00:01:55,682 --> 00:01:57,283
THE INITIAL IONIC LIQUID MASS

78
00:01:57,283 --> 00:01:58,852
WILL BE REQUIRED TO ALLOW FOR

79
00:01:58,852 --> 00:01:59,619
THE PROCESSING OF

80
00:01:59,619 --> 00:02:00,887
A THEORETICALLY INFINITE

81
00:02:00,887 --> 00:02:03,089
AMOUNT OF MARTIAN REGOLITH.

82
00:02:03,089 --> 00:02:04,023
WHILE THE CHEMICAL PROCESS

83
00:02:04,023 --> 00:02:05,492
TO PRODUCE CEMENT-LIKE MATERIALS

84
00:02:05,492 --> 00:02:07,026
USING A SODIUM SILICATE BINDER

85
00:02:07,026 --> 00:02:09,295
IS QUITE SIMPLE, THE DESIGN

86
00:02:09,295 --> 00:02:10,563
OF A CEMENT THAT IS BOTH

87
00:02:10,563 --> 00:02:11,965
SUITABLE FOR EXTRUSION FROM

88
00:02:11,965 --> 00:02:13,132

A 3D PRINTER, BUT THAT

89
00:02:13,132 --> 00:02:14,667
ALSO PROVIDES THE REQUIRED

90
00:02:14,667 --> 00:02:15,802
MECHANICAL PROPERTIES

91
00:02:15,802 --> 00:02:16,836
TO PRODUCE A STRUCTURE, IS

92
00:02:16,836 --> 00:02:18,505
QUITE COMPLICATED.

93
00:02:18,505 --> 00:02:19,739
THIS STUDY EXAMINED A NUMBER OF

94
00:02:19,739 --> 00:02:21,708
PROPERTIES OF CEMENT, SUCH AS

95
00:02:21,708 --> 00:02:23,510
THE PARTICLE SIZE DISTRIBUTION

96
00:02:23,510 --> 00:02:25,111
OF REGOLITH, THE RATIO

97
00:02:25,111 --> 00:02:26,913
OF BINDER TO AGGREGATE, AND

98
00:02:26,913 --> 00:02:28,181
THE INCLUSION OF ADDITIVES

99
00:02:28,181 --> 00:02:29,315
SUCH AS GLASS FIBER,

100
00:02:29,315 --> 00:02:30,550
AND QUANTIFIED THE EFFECT

101
00:02:30,550 --> 00:02:31,784
THAT THESE PROPERTIES HAD

102
00:02:31,784 --> 00:02:33,486
ON THE SUITABILITY OF USE FOR

103
00:02:33,486 --> 00:02:35,121
PARTICULAR CEMENT COMPOSITIONS

104
00:02:35,121 --> 00:02:37,357
IN 3D PRINTING PROCESSES.

105
00:02:37,357 --> 00:02:38,858
OVERALL, THE OVERLAP OF

106
00:02:38,858 --> 00:02:39,893
CEMENT COMPOSITIONS THAT

107
00:02:39,893 --> 00:02:41,895
PROVIDE BOTH SUITABILITY FOR

108
00:02:41,895 --> 00:02:43,162
PRINTING OR EXTRUSION FROM

109
00:02:43,162 --> 00:02:44,564
A PRINT NOZZLE WHILE ALSO

110
00:02:44,564 --> 00:02:45,865
PROVIDING THE MECHANICAL

111
00:02:45,865 --> 00:02:46,966
PROPERTIES REQUIRED TO PRODUCE

112
00:02:46,966 --> 00:02:49,435
A STRUCTURE IS QUITE LIMITED.

113
00:02:49,435 --> 00:02:50,737

HOWEVER, FURTHER REFINEMENT

114
00:02:50,737 --> 00:02:52,138
OF THE PROCESS-- IN PARTICULAR,

115
00:02:52,138 --> 00:02:54,340
THE DESIGN OF CUSTOM 3D PRINT

116
00:02:54,340 --> 00:02:56,209
HEADS DESIGNED FOR USE WITH

117
00:02:56,209 --> 00:02:57,710
MARTIAN REGOLITH-- SHOULD ALLOW

118
00:02:57,710 --> 00:02:58,811
FOR THIS SET OF STUDIES

119
00:02:58,811 --> 00:02:59,646
TO BE EXPANDED,

120
00:02:59,646 --> 00:03:01,114
AND THE EVENTUAL CONSTRUCTION

121
00:03:01,114 --> 00:03:02,815
OF HABITATS ON MARS USING