

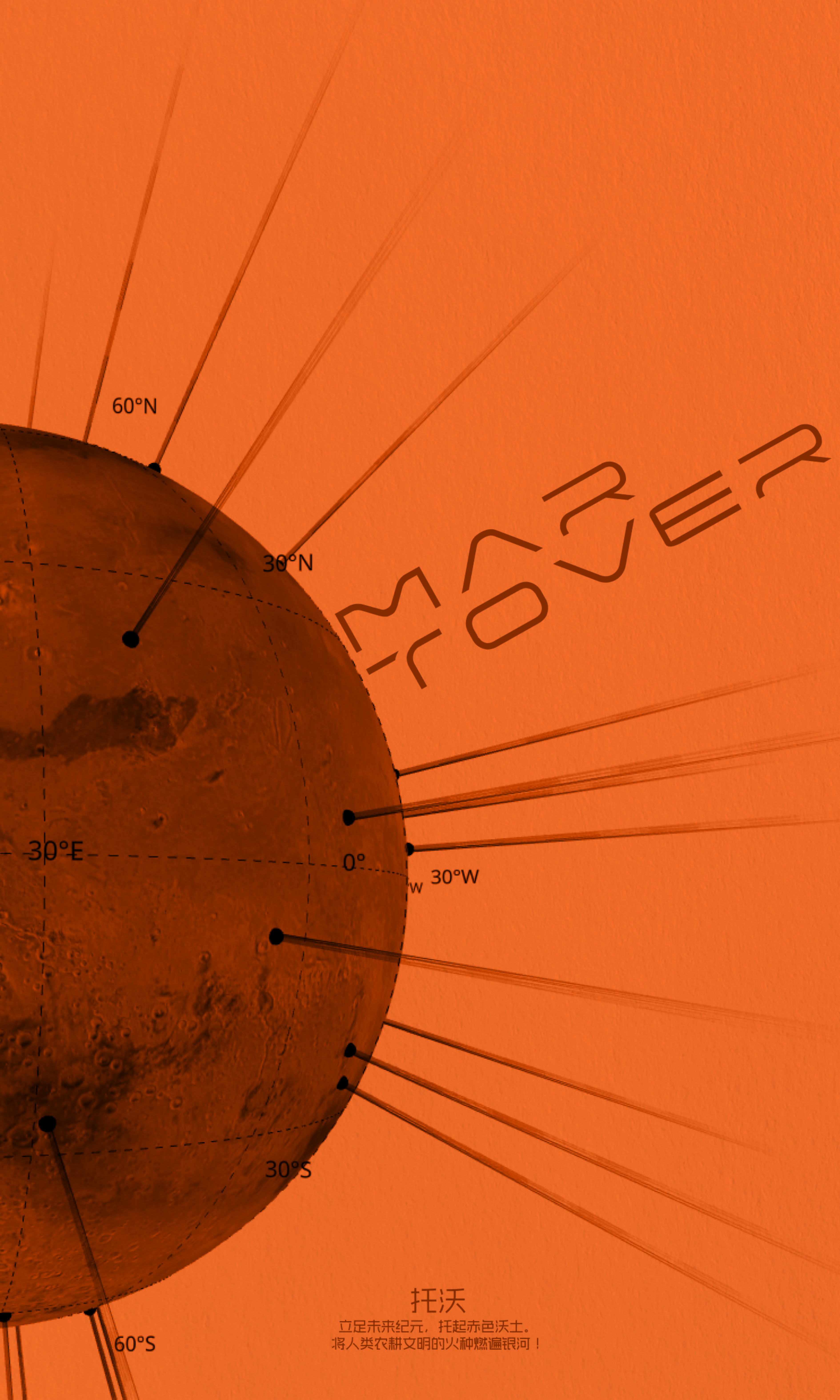
《托沃MARTOVER》

在火星土壤播种明日盛宴
立足未来纪元，托起赤色沃土
将人类农耕文明的火种燃遍银河

一、作品名称



简介：这是一个从未来太空农业出发的当代土豆公益项目。通过未来设计与软件开发，构建科幻叙事场景。详尽分析未来火星土豆农业可行性，通过“农业目标地选择”-“土豆太空育种”-“本土自动化生产”三大步骤书写这篇“科幻小说”。本项目即可作为公益计划发起引子，也可作为营销企划的核心。



托沃

托沃

立足未来纪元，托起赤色沃土。
将人类农耕文明的火种燃遍银河！

Sow the feast of tomorrow in the Martian soil

Rooted in the future epoch, uplifting the red fertile earth
Kindling the flame of human agricultural civilization across the galaxy.

前言

致TOVER联盟第101号成员：

公元2125年，人类首个地外生态系统——火星农业矩阵正式启动。

根据地球联合署第17版《星际生存白皮书》规则，您已通过穹顶生态圈适应性测试，现授权参与火星农业时代核心项目。欢迎加入人类首个跨行星农业工程——"托沃计划"。

你作为TOVER联盟第101号拓荒工程师，即将参与改写文明史的壮举：将地球文明火种，播撒向30万颗火星陨石坑中，你将亲手开启火星土豆文明史诗.....

请领取你的世界任务 ▶

在火星土壤播种明日盛宴

立足未来纪元，托起赤色沃土
将人类农耕文明的火种燃遍银河

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MAR TROVER

火星农业目标地选址

2012年研究表明人类观察到的
火星陨石撞击坑(直径 $\geq 500\text{m}$)数量是63.5万个。

任务进度

阶段I: 陨石坑驯服计划

- 坑的可视化介绍
- 火星农业选坑法则
- 在101个优质坑里作出你的最终选择

<div>DLERS, HuSL CpxCPt</div> <div>2</div> <div> </div> <div> ID: 07-0-002505 Location: -28.58°N, 333.80°E Diameter: 16.49 km </div>	<div>SLERS, SmBL Smp</div> <div>1</div> <div> </div> <div> ID: 03-1-004826 Location: -12.06°N, 203.57°E Diameter: 3.66 km </div>	<div>DLEPS, SmSL Smp</div> <div>2</div> <div> </div> <div> ID: 08-1-003264 Location: -49.20°N, 285.60°E Diameter: 3.61 km </div>	<div>SLEPS, HuBL CpxCPt</div> <div>1</div> <div> </div> <div> ID: 10-0-004140 Location: 11.44°N, 59.20°E Diameter: 12.35 km </div>	<div>DLERS, HuBL, Butterfly CpxUnc</div> <div>2</div> <div> </div> <div> ID: 06-1-011174 Location: 13.20°N, 289.56°E Diameter: 9.64 km </div>	<div>SLEPS, SmAm Smp</div> <div>1</div> <div> </div> <div> ID: 06-1-016036 Location: 5.04°N, 277.63°E Diameter: 3.12 km </div>
<div>SLEPS, HuSL</div> <div>1</div> <div> </div> <div> ID: 09-1-002499 Location: 49.23°N, 9.09°E Diameter: 4.97 km </div>	<div>SLERS, HuSL</div> <div>1</div> <div> </div> <div> ID: 10-1-001212 Location: 39.93°N, 13.84°E Diameter: 6.59 km </div>	<div>SLERS, HuSL CpxFF</div> <div>1</div> <div> </div> <div> ID: 07-1-019789 Location: -29.20°N, 299.58°E Diameter: 7.70 km </div>	<div>SLERS, HuAm Smp</div> <div>1</div> <div> </div> <div> ID: 05-1-000977 Location: 61.23°N, 286.61°E Diameter: 4.69 km </div>	<div>SLERS, HuBL CpxUnc</div> <div>1</div> <div> </div> <div> ID: 06-0-001781 Location: 17.23°N, 335.10°E Diameter: 9.19 km </div>	<div>SLERS, HuSL Smp</div> <div>1</div> <div> </div> <div> ID: 14-1-009114 Location: 12.03°N, 133.51°E Diameter: 5.95 km </div>
<div>SLEPS, SmSL Smp</div> <div>1</div> <div> </div> <div> ID: 04-1-011523 Location: -74.00°N, 210.97°E Diameter: 7.74 km </div>	<div>Rd/SLERS, HuSL CpxFF</div> <div>1</div> <div> </div> <div> ID: 11-0-003963 Location: -20.08°N, 21.65°E Diameter: 8.61 km </div>	<div>DLERC/DLEPS, Sm/SmSp, Outer is Splash Smp</div> <div>2</div> <div> </div> <div> ID: 16-1-008105 Location: -59.21°N, 168.16°E Diameter: 3.08 km </div>	<div>Rd/SLERS, HuSL CpxCPk</div> <div>1</div> <div> </div> <div> ID: 15-1-033071 Location: -30.77°N, 157.33°E Diameter: 7.58 km </div>	<div>SLEPS, HuSL Smp</div> <div>1</div> <div> </div> <div> ID: 06-1-002421 Location: 38.60°N, 276.07°E Diameter: 4.88 km </div>	<div>Rd/DLERS, HuBL CpxFF</div> <div>2</div> <div> </div> <div> ID: 03-1-020628 Location: -32.60°N, 211.36°E Diameter: 7.95 km </div>
<div>SLEPS, HuAm CpxCPk</div> <div>1</div> <div> </div> <div> ID: 10-1-008317 Location: 15.08°N, 71.99°E Diameter: 10.13 km </div>	<div>DLERS, HuSL CpxFF</div> <div>2</div> <div> </div> <div> ID: 15-1-036211 Location: -32.64°N, 114.45°E Diameter: 20.08 km </div>	<div>MLERS, SmBL CpxCPt</div> <div>4</div> <div> </div> <div> ID: 01-1-001923 Location: 51.40°N, 234.40°E Diameter: 13.72 km </div>	<div>SLEPC, HuSL Smp</div> <div>1</div> <div> </div> <div> ID: 16-1-006573 Location: -56.88°N, 109.52°E Diameter: 4.84 km </div>	<div>SLERS, HuSL Smp</div> <div>1</div> <div> </div> <div> ID: 10-0-000452 Location: 7.47°N, 5.31°E Diameter: 6.16 km </div>	<div>Rd/MLERS, HuBL CpxUnc</div> <div>3</div> <div> </div> <div> ID: 06-0-003218 Location: 6.51°N, 346.79°E Diameter: 51.82 km </div>
<div>SLERC, HuSL Smp</div> <div>1</div> <div> </div> <div> ID: 02-1-006483 Location: 6.93°N, 193.03°E Diameter: 4.72 km </div>	<div>DLEPC, Hu/SmSL</div> <div>2</div> <div> </div> <div> ID: 05-1-003490 Location: 44.69°N, 341.43°E Diameter: 4.35 km </div>	<div>SLERS, SmBL, Pseudo-Small-Crown CpxFF</div> <div>1</div> <div> </div> <div> ID: 02-1-004991 Location: 17.82°N, 238.97°E Diameter: 13.71 km </div>	<div>SLEPS, HuSL Smp</div> <div>1</div> <div> </div> <div> ID: 15-1-029955 Location: -27.53°N, 173.60°E Diameter: 4.82 km </div>	<div>SLERC, HuSL Smp</div> <div>1</div> <div> </div> <div> ID: 10-0-011575 Location: 35.31°N, 44.53°E Diameter: 4.99 km </div>	<div>SLEPS, SmAm Smp</div> <div>1</div> <div> </div> <div> ID: 03-1-028405 Location: -40.96°N, 257.13°E Diameter: 5.04 km </div>
<div>MLERC/MLERS/MLERS, Hu/HuBL/HuBL CpxSuPt</div> <div>3</div> <div> </div> <div> ID: 15-1-003819 Location: -5.23°N, 162.16°E Diameter: 17.29 km </div>	<div>SLERS, HuSL CpxFF</div> <div>1</div> <div> </div> <div> ID: 07-0-000281 Location: -4.58°N, 352.55°E Diameter: 21.11 km </div>	<div>SLERS, HuBL CpxCPk</div> <div>1</div> <div> </div> <div> ID: 06-0-002259 Location: 15.15°N, 339.40°E Diameter: 8.19 km </div>	<div>Rd/SLEPS, HuSL CpxFF</div> <div>1</div> <div> </div> <div> ID: 10-0-011286 Location: 34.84°N, 3.70°E Diameter: 9.22 km </div>	<div>SLEPC, HuSL Smp</div> <div>1</div> <div> </div> <div> ID: 15-1-026396 Location: -23.72°N, 147.56°E Diameter: 3.09 km </div>	<div>Rd/SLERS, HuBL CpxCPt</div> <div>1</div> <div> </div> <div> ID: 10-0-002933 Location: -40.96°N, 18.03°E Diameter: 36.75 km </div>
<div>DLERS, HuBL CpxCPt</div> <div>2</div> <div> </div> <div> ID: 06-0-002680 Location: 11.84°N, 356.97°E Diameter: 17.34 km </div>	<div>SLERS, HuBL Smp</div> <div>1</div> <div> </div> <div> ID: 11-1-008864 Location: -21.18°N, 62.49°E Diameter: 9.79 km </div>	<div>Rd/MLERS, HuBL CpxCPk</div> <div>3</div> <div> </div> <div> ID: 06-1-001156 Location: 40.77°N, 315.65°E Diameter: 30.82 km </div>	<div>SLEPS, HuAm</div> <div>1</div> <div> </div> <div> ID: 14-1-010745 Location: 7.68°N, 103.20°E Diameter: 6.08 km </div>	<div>DLEPS, HuSL/SmSL Smp</div> <div>2</div> <div> </div> <div> ID: 05-1-001890 Location: 51.50°N, 359.95°E Diameter: 3.43 km </div>	<div>DLERS, HuBL CpxCPt</div> <div>2</div> <div> </div> <div> ID: 02-1-000804 Location: 38.05°N, 213.68°E Diameter: 13.61 km </div>
<div>Rd/DLERS, HuSL CpxCPk</div> <div>2</div> <div> </div> <div> ID: 07-1-018576 Location: -27.05°N, 309.83°E Diameter: 6.78 km </div>	<div>DLERS, SmSL Smp</div> <div>2</div> <div> </div> <div> ID: 09-1-000875 Location: 63.54°N, 76.63°E Diameter: 4.23 km </div>	<div>SLERS, SmSL Smp</div> <div>1</div> <div> </div> <div> ID: 13-1-000214 Location: 68.99°N, 98.10°E Diameter: 4.04 km </div>	<div>SLERS, SmAm Smp</div> <div>1</div> <div> </div> <div> ID: 15-1-003501 Location: -4.28°N, 174.68°E Diameter: 4.27 km </div>	<div>SLEPS, HuBL</div> <div>1</div> <div> </div> <div> ID: 14-1-010031 Location: 8.94°N, 114.21°E Diameter: 6.75 km </div>	<div>SLEPS, SmBL CpxFF</div> <div>1</div> <div> </div> <div> ID: 15-1-034443 Location: -31.59°N, 126.73°E Diameter: 9.25 km </div>
<div>SLERS, SmBL Smp</div> <div>1</div> <div> </div> <div> ID: 14-1-008765 Location: 13.02°N, 102.20°E Diameter: 4.47 km </div>	<div>MLERS, HuBL CpxSuPt</div> <div>3</div> <div> </div> <div> ID: 02-1-006741 Location: 5.67°N, 193.50°E Diameter: 13.14 km </div>	<div>SLERC, HuSL Smp</div> <div>1</div> <div> </div> <div> ID: 05-1-001980 Location: 50.87°N, 316.29°E Diameter: 4.19 km </div>	<div>MLERS, HuBL CpxCPk</div> <div>3</div> <div> </div> <div> ID: 10-1-010081 Location: 5.27°N, 81.25°E Diameter: 45.12 km </div>	<div>SLERS, SmBL Smp</div> <div>1</div> <div> </div> <div> ID: 11-0-003852 Location: -18.99°N, 1.61°E Diameter: 4.06 km </div>	<div>DLERS, HuBL</div> <div>2</div> <div> </div> <div> ID: 10-0-009660 Location: 28.46°N, 30.20°E Diameter: 7.22 km </div>
<div>SLEPC, SmSL Smp</div> <div>1</div> <div> </div> <div> ID: 16-1-042015 Location: 36.58°N, 147.32°E Diameter: 9.43 km </div>	<div>Rd/DLERS, HuSL CpxFF</div> <div>2</div> <div> </div> <div> ID: 16-1-000338 Location: -45.87°N, 120.63°E Diameter: 7.00 km </div>	<div>SLEPS, HuBL</div> <div>1</div> <div> </div> <div> ID: 14-1-000029 Location: 14.55°N, 102.00°E Diameter: 7.00 km </div>	<div>SLERS, SmSL Smp</div> <div>1</div> <div> </div> <div> ID: 05-1-000022 Location: 14.55°N, 102.00°E Diameter: 7.00 km </div>	<div>DLERC, SmSL Smp</div> <div>2</div> <div> </div> <div> ID: 01-0-000025 Location: 14.55°N, 102.00°E Diameter: 7.00 km </div>	<div>SLEPS, HuAm</div> <div>1</div> <div> </div> <div> ID: 06-1-000028 Location: 14.55°N, 102.00°E Diameter: 7.00 km </div>

Total: 384,829

凝聚溅射层形状
Cohesive Ejecta Layer Morphology

凝聚溅射层通常是由喷射物与基础材料或环境条件的相互作用造成的，保持一定程度的结构完整性的材料[5]。

坑内形状
Interior Morphology

坑内形状分为简单坑Smp、复杂坑Cpx、盆地坑Bsn三类，其中复杂坑Cpx因更多元的特征可进一步分类（见下页）。

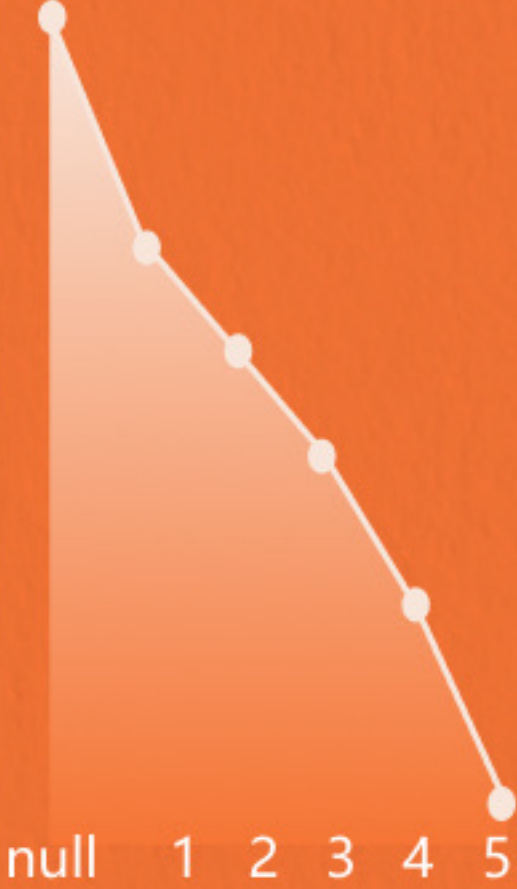
径向溅射层形状
Radical Ejecta Layer Morphology

径向径向溅射层通常与冲击有关，冲击会产生一种物质以径向方式向外喷射的模式，通常受冲击事件动态的影响[4]。

若有「RD」纹理，则代表该坑具有Rd层。

溅射层层数
The Number of Ejecta Layers

溅射层层数反应了溅射层的数量，层数越多，资源丰富程度越高。



DLEPS, SmArp
Smp

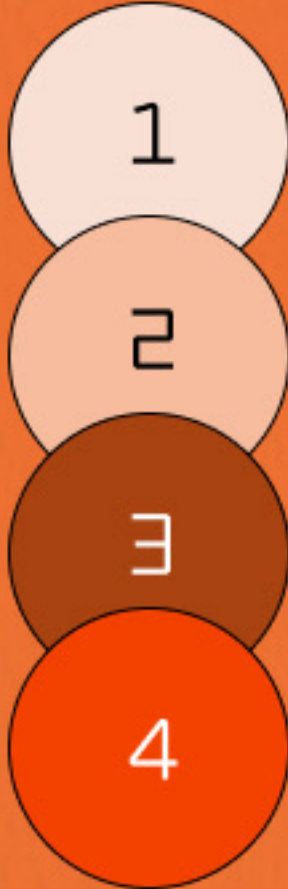
2

ID: 09-1-001237
Location: 59.84°N, 70.23°E
Diameter: 4.00 km

撞击坑可视化形象
Visual image

退化性·色彩

形态学·三大结构



退化性可以分析撞击坑的年龄、撞击后的环境状况以及从撞击相关沉积物中产生资源的可能性，对寻找资源意义重大[2]。

坑内

溅射层

坑底

编号
ID

格式为##-#####。
前两位数字表示火星子区域，
后六位是该子区域内坑直径从大到小排序的陨石坑编号。

经纬度
Longitude and Latitude

通过非线性最小二乘法圆形拟合手动选择的陨石坑边缘顶点得到的中心纬度。单位为十进制度数。

直径
Diameter

通过非线性最小二乘法圆形拟合手动选择的陨石坑边缘顶点得到的直径。单位公里。

[1] ROBBINS S J, HYNEK B M. A new global database of Mars impact craters ≥ 1 km: 1. Database creation, properties, and parameters[J/OL]. Journal of Geophysical Research: Planets, 2012, 117(E5). [2025-03-06]. DOI:10.1029/2011JE003966.

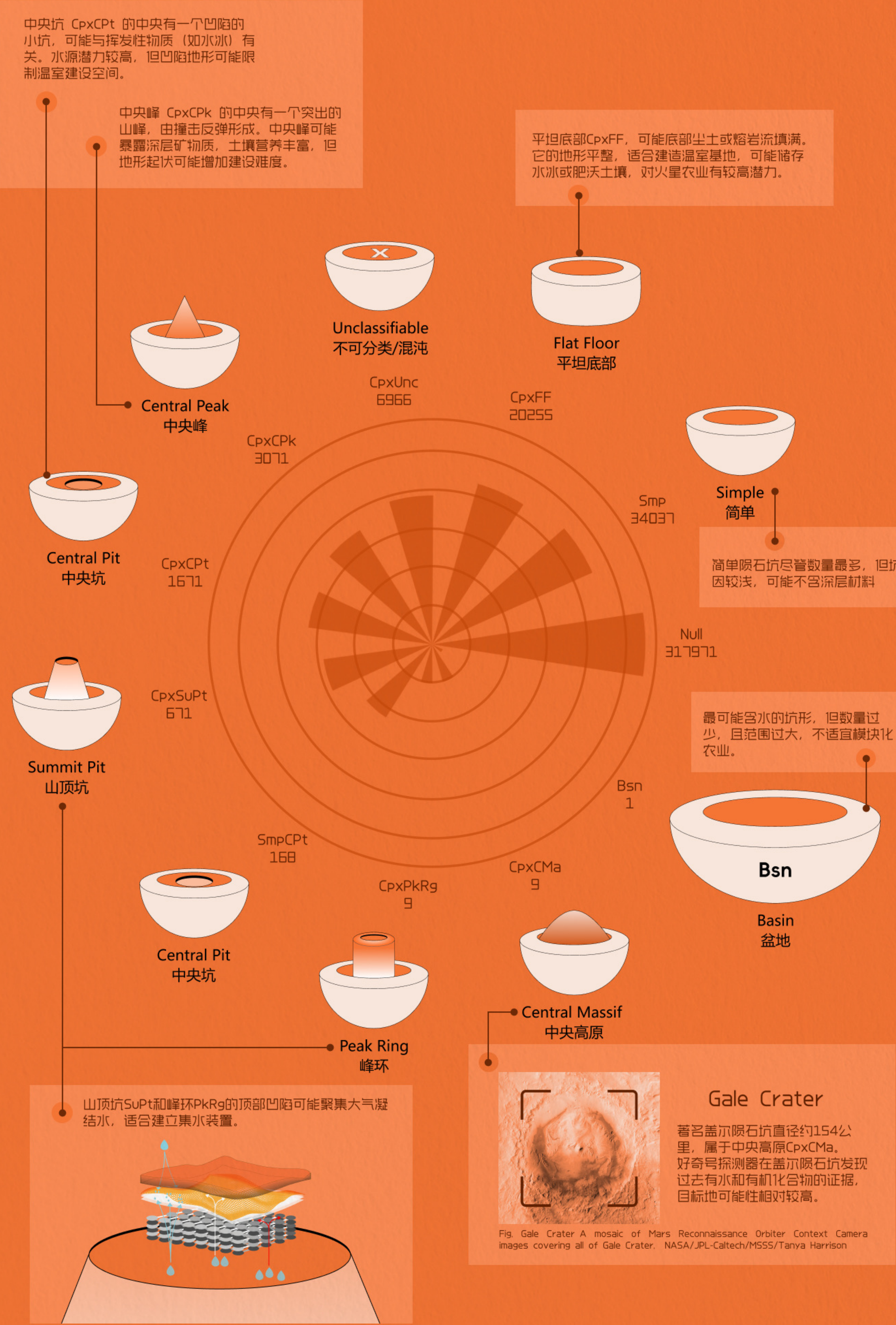
[2] BRAIN D A, JAKOSKY B M. Atmospheric loss since the onset of the Martian geologic record: Combined role of impact erosion and sputtering[J/OL]. [2025][2025-04-06]. DOI:10.1029/98JE02074.

[3] OSINSKI G R, PIERAZZO E. Impact cratering: Processes and products[J]. Impact Cratering, 2013: 1-20.

[4] HARGITAI H. Radially Striated Ejecta (Mars)[M/OL]//HARGITAI H, KERESZTURI Á. Encyclopedia of Planetary Landforms. New York, NY: Springer, 2021: 1-2[2025-04-06]. DOI:10.1007/978-1-4614-9213-9_641-1.

[5] KENKMANN T, WULF G, STURM S, 等. Double-layered ejecta craters on Mars: morphology, formation, and a comparison with the Ries ejecta blanket[J]. 2015: 4266.

* 圆形柱状图以不同坑内形状的幂为刻度单位



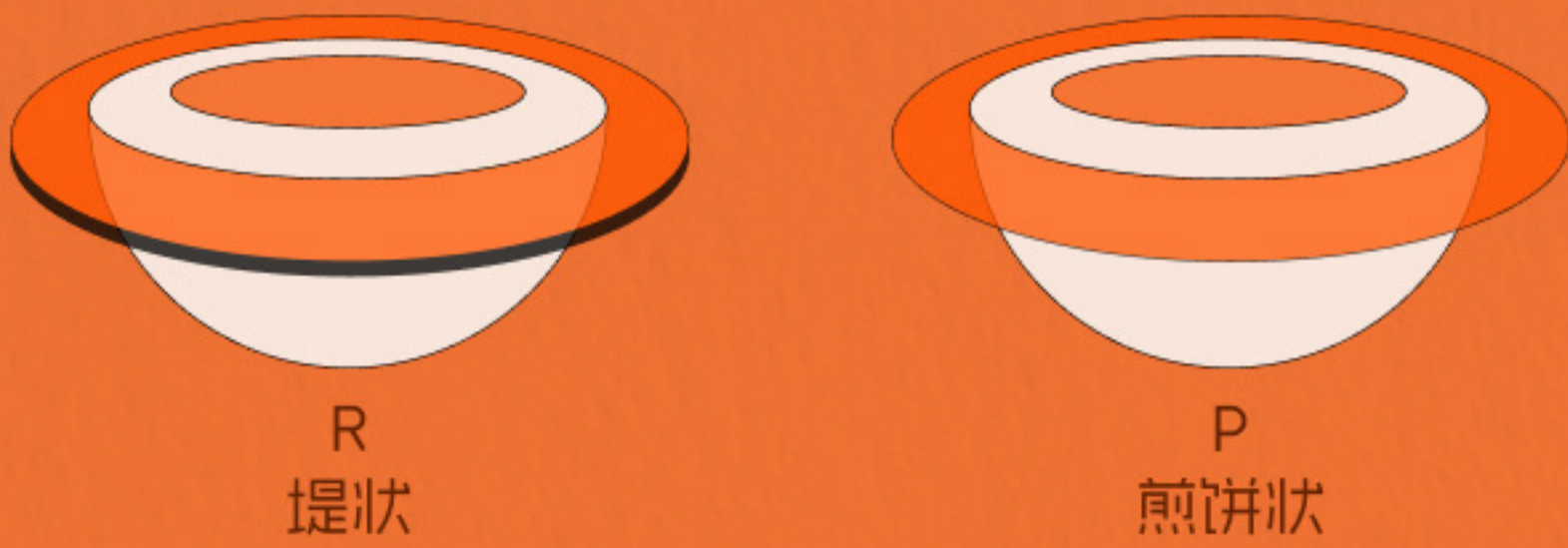
LE覆盖层基本参数
LAY_MORPH1

S/D/M + LE
层数



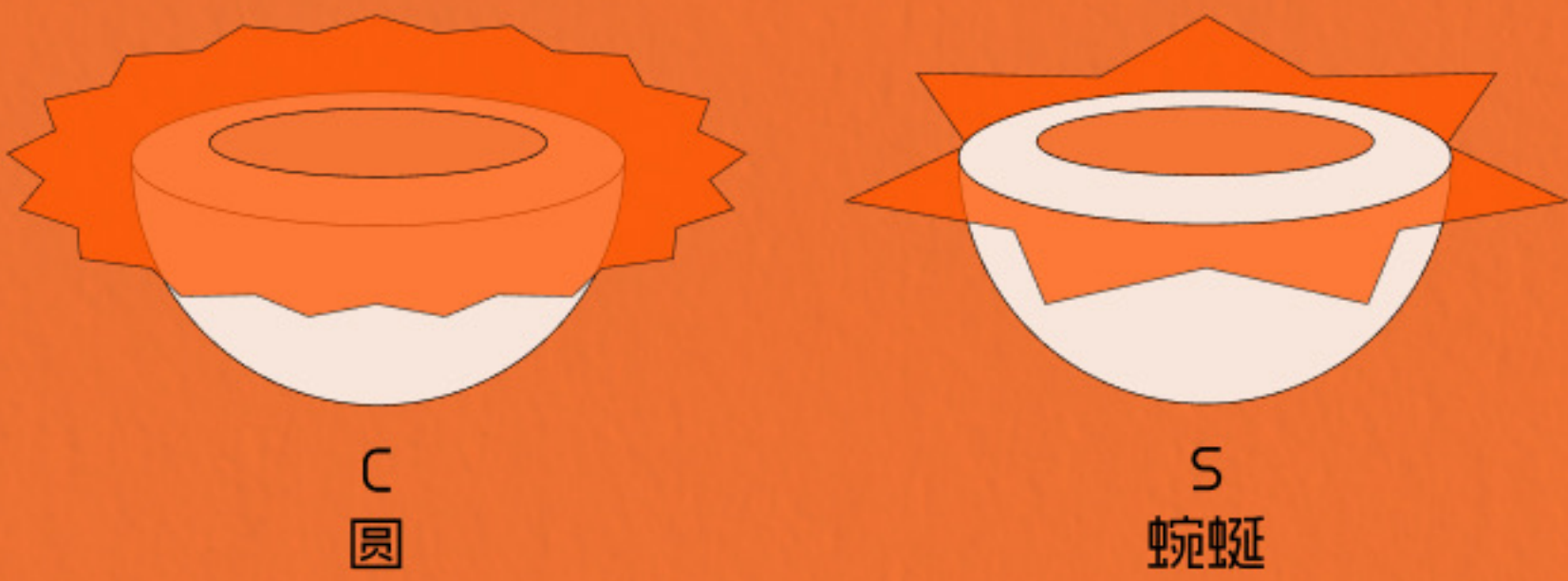
R / P
堤状 / 基底

溅射物边缘是否形成堤岸： R (rampart, 堤状) 或 P (Pancake, 煎饼状)
如果溅射物边缘的任何部分表现出堤状形态，即使其余部分没有，也会在目录中使用 R 而不是 P。



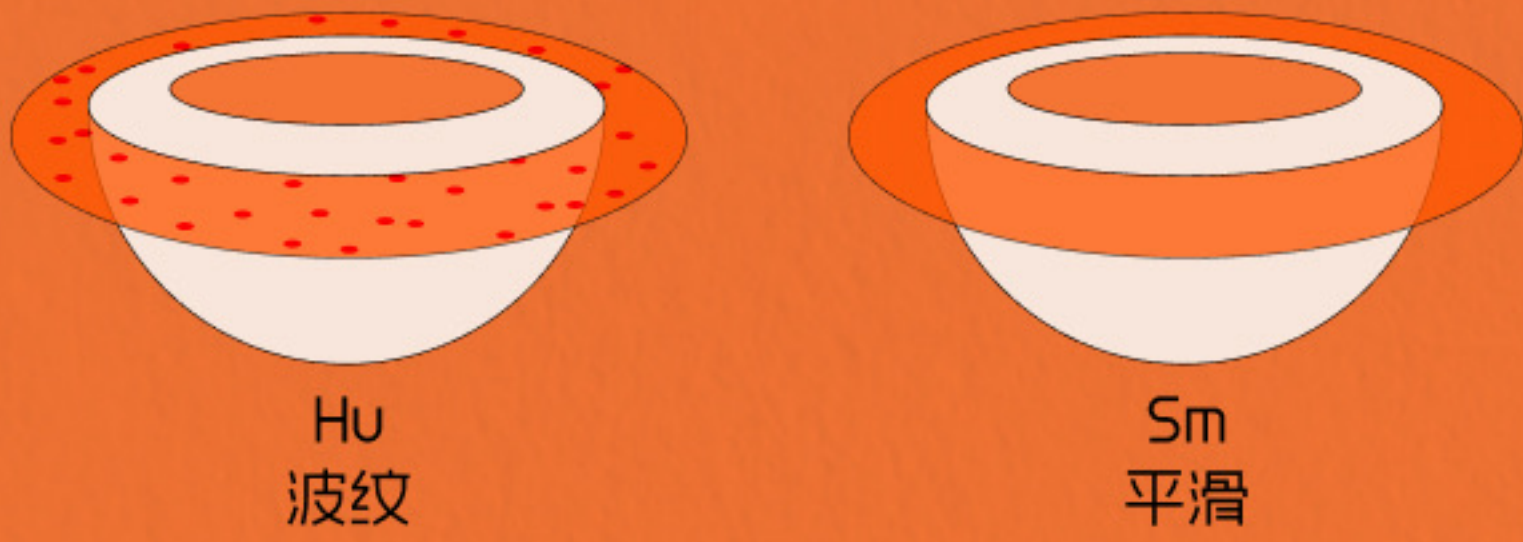
C/S
圆/蜿蜒

溅射物边缘形态是否接近圆形。
根据溅射物的扁平度决定（无量纲）
低于扁平度阈值，则喷出物是圆的 -> C, Circle（例如，SLEPC）
高于扁平度阈值，喷出物是蜿蜒的 -> S, sinuous（例如，SLERS）

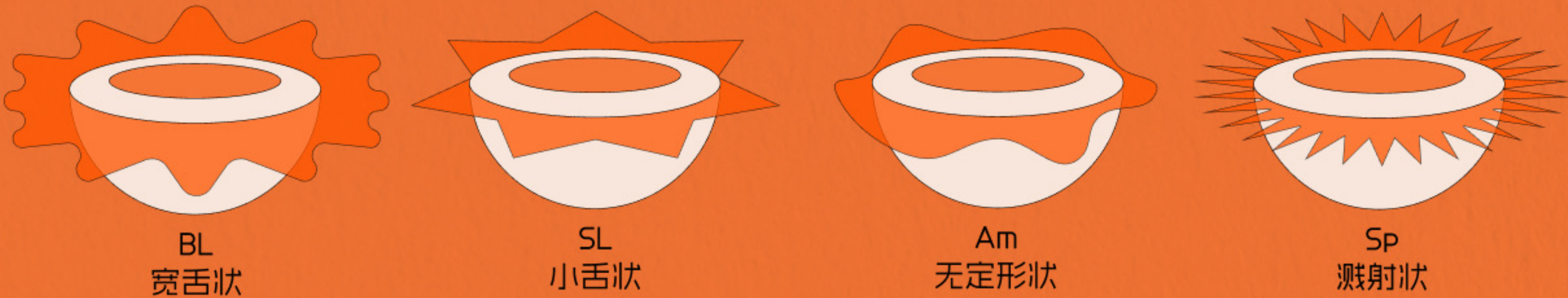


LE覆盖层整体纹理参数
LAY_MORPH2

Hu / Sm
波状 / 平滑

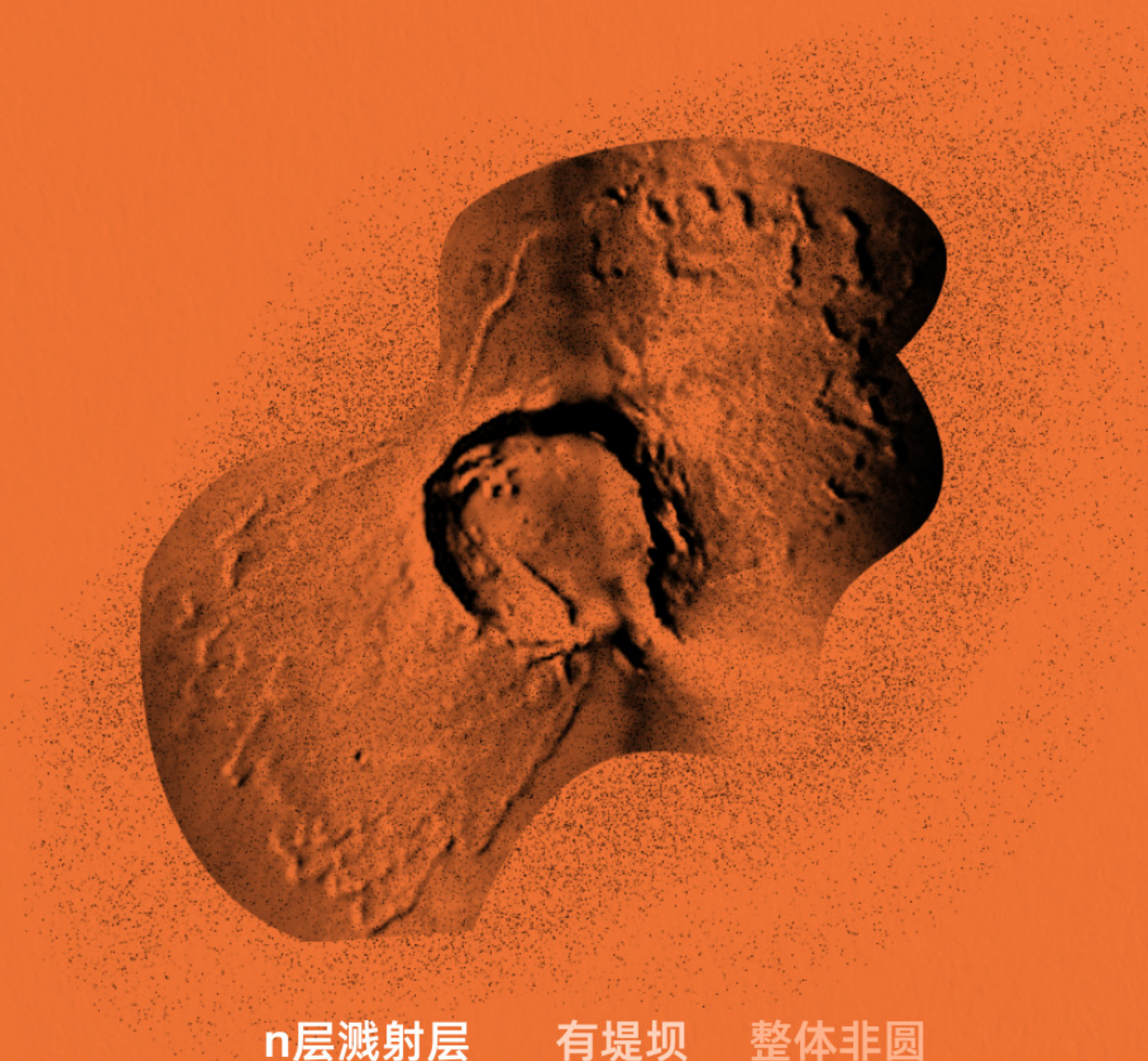


if has Hu / Sm, then
BL / SL / Am / Sp
宽舌状 / 小舌状 / 无定形状 / 溅射状



宽舌状：不同舌状物之间的分离超过该层范围的 50%时；这是通过目测估计的，并不是精确的划分。
小舌状：喷出物末端呈现出锯齿状“剪刀”类型，虽然更精确的定义是这些锯齿状分离不超过喷出物范围 50%
无定形：是指喷出物整体不对称且缺乏任何明确的形状；
溅射：弹射物以喷溅的形式落在表面，通常远离坑缘延伸，但分散成许多不同的条带。

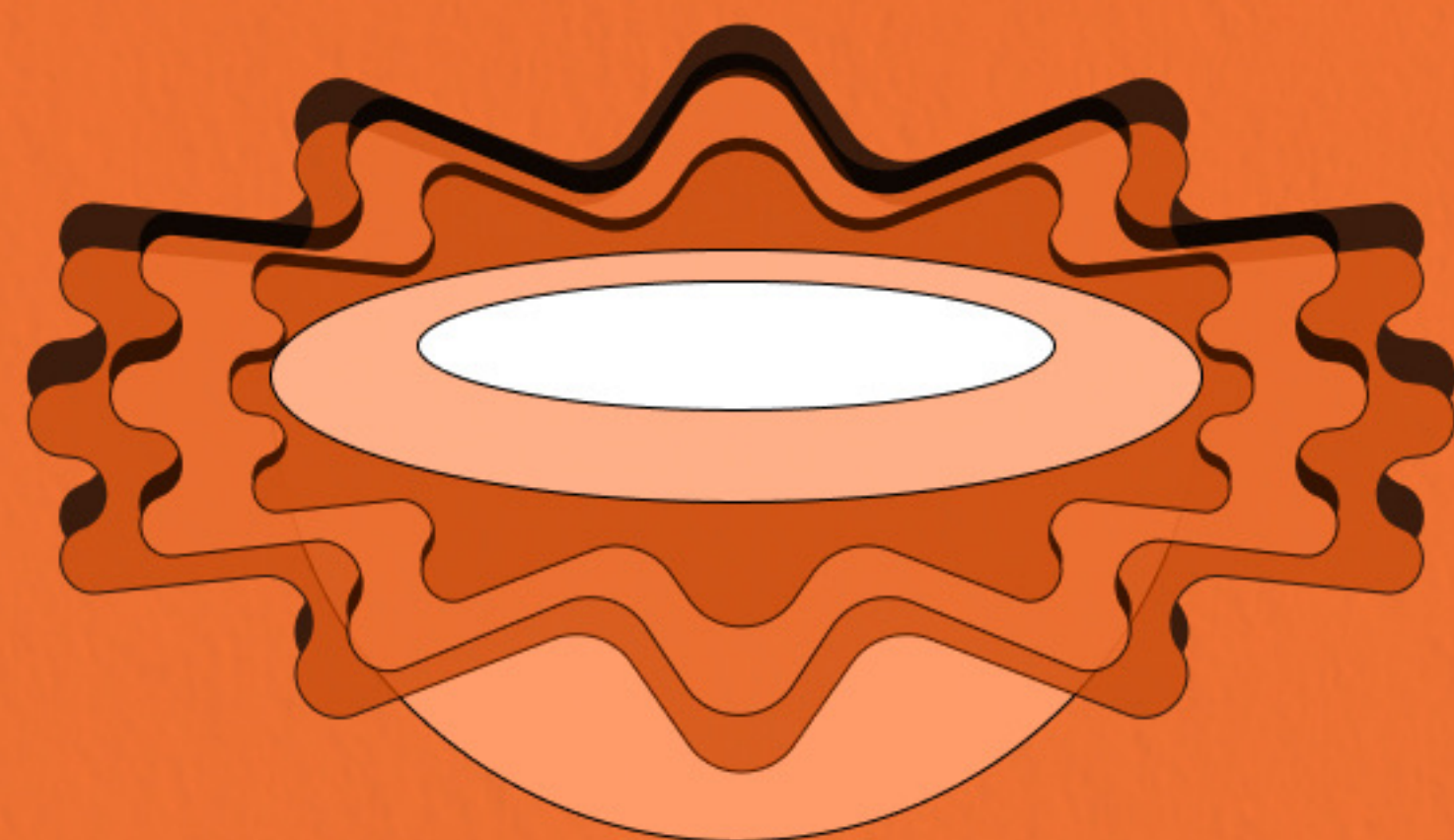
特定特征的撞击坑 是 火星农业目标地
溅射层特征暗示水源
内部形状....



n层溅射层 有堤坝 整体非圆

? LERS
SmBL

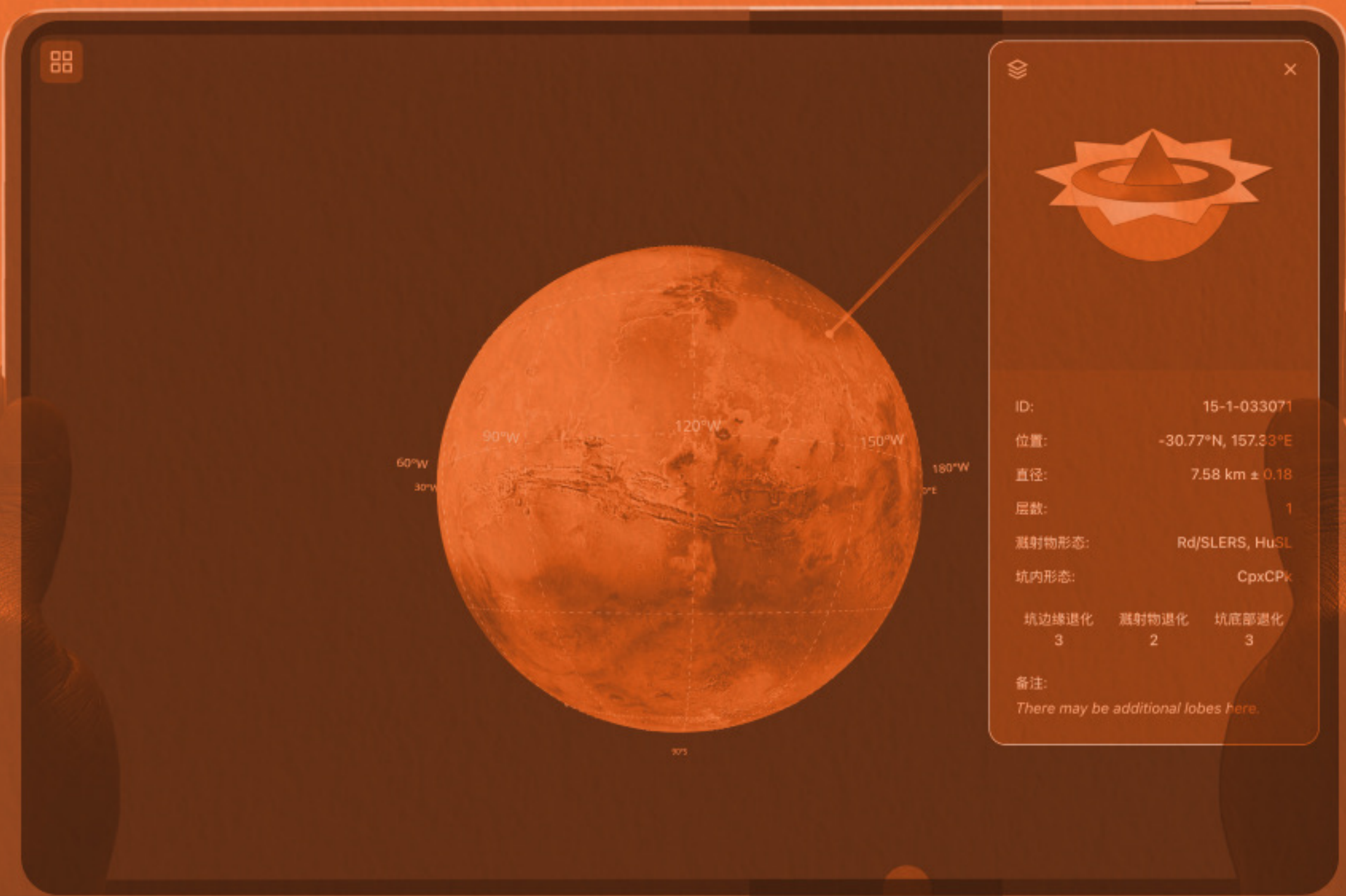
平滑 宽舌状



挑选农业目标地法则

- 1. 形状层次丰富 - 溅射层变化大
- 2. 颜色较浅 - 退化性更低，可能蕴含更多有益矿物质和气体；
- 3. 坑底纹丰富 - 具有Rd溅射层；
- 4. 坑底是方形 - CpxFF比Smp具有水资源概率更高；
- 5. 坑内具有中央高原CpxCMa - 平坦区域便于建造温室，抵抗温度波动；
- 6. 高纬度陨石坑更可能有水冰；
- 7. 不选择简单陨石坑，空间有限，不适合大规模农业。

欢迎前往网页体验
<https://kdocs.cn/l/chebun6ebTz7>



MAR
TROVER

101

终 选 火 星 陨 石 撞 击 坑

Rd/DLEPC, SmSL
Smp

2



ID: 16-1-001894
Location: -46.56°N, 145.73°E
Diameter: 4.31 km

MLERS, HuBL
CpxFF


3



ID: 07-1-011336
Location: -17.65°N, 331.10°E
Diameter: 20.23 km

SLEPS, HuSL
Smp

1



ID: 15-1-026068
Location: -24.29°N, 125.66°E
Diameter: 3.20 km

SLEPS, SmSL
CpxFF

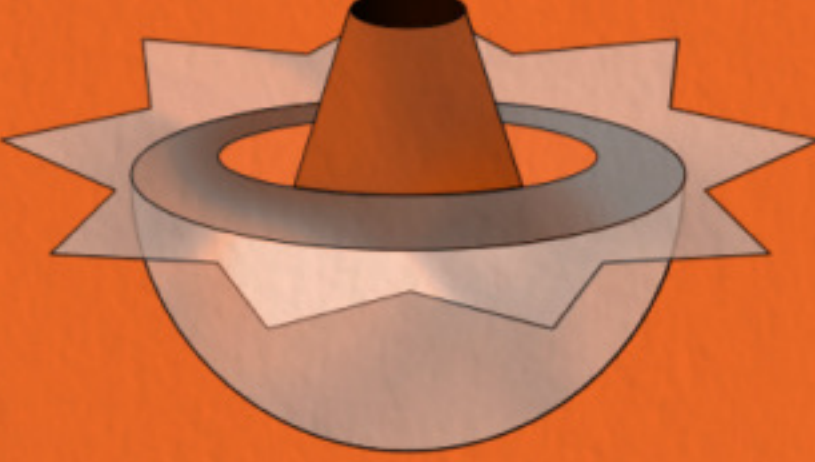
1



ID: 04-1-010503
Location: -70.22°N, 240.71°E
Diameter: 9.14 km

SLERS, HuSL
CpxSuPt

1



ID: 14-1-012604
Location: 2.87°N, 118.65°E
Diameter: 12.59 km

SLEPS, HuSL

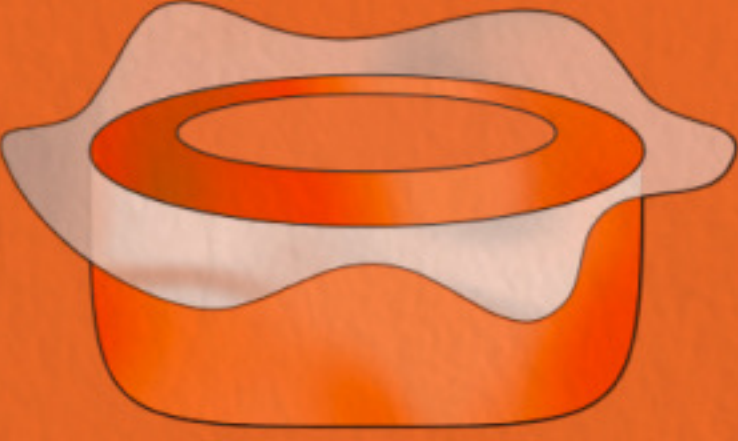
1



ID: 07-1-026212
Location: -41.00°N, 341.68°E
Diameter: 6.78 km

SLERS, HuAm
CpxFF

1



ID: 10-0-000299
Location: 4.69°N, 3.08°E
Diameter: 9.90 km

SLERS, HuBL
CpxFF


1



ID: 14-1-013294
Location: 0.97°N, 132.85°E
Diameter: 11.15 km

SLERS, SmBL
Smp

1



ID: 10-0-000183
Location: 3.32°N, 12.82°E
Diameter: 4.93 km

SLEPS, HuSL
Smp

1



ID: 03-1-017127
Location: -28.49°N, 194.92°E
Diameter: 5.34 km

MLERS, HuSL
CpxCPk


3



ID: 15-1-020059
Location: -19.96°N, 126.13°E
Diameter: 18.81 km

SLERS, HuSL
CpxUnc

1



ID: 10-0-004585
Location: 13.82°N, 35.02°E
Diameter: 10.75 km

SLERC, SmSL
Smp

1



ID: 03-1-013090
Location: -23.45°N, 219.05°E
Diameter: 4.45 km

SLERS, HuBL
Smp


1



ID: 10-1-000925
Location: 40.39°N, 89.12°E
Diameter: 4.93 km

SLERS, HuBL, Pseudo-Small-Crown

1



ID: 02-1-004311
Location: 19.74°N, 185.36°E
Diameter: 6.96 km

DLERS, HuSL
CpxCpt

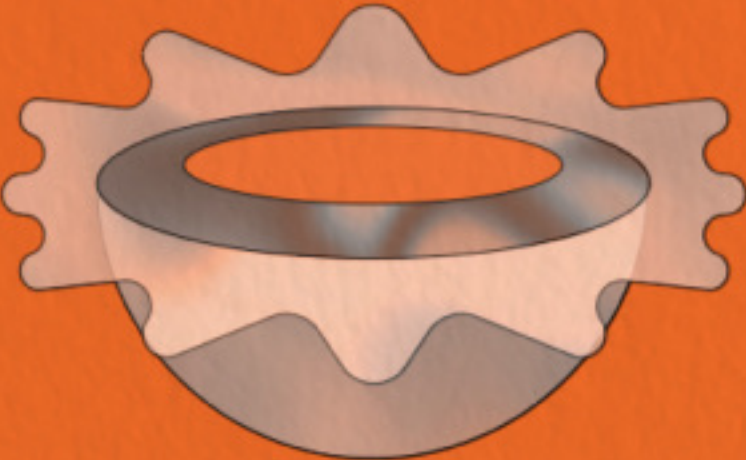
2



ID: 07-0-002505
Location: -28.58°N, 333.80°E
Diameter: 16.49 km

SLERS, SmBL
Smp

1



ID: 03-1-004826
Location: -12.06°N, 203.57°E
Diameter: 3.66 km

DLEPS, SmSL
Smp


2



ID: 08-1-003264
Location: -49.20°N, 285.60°E
Diameter: 3.61 km

SLEPS, HuSL

1



ID: 09-1-002499
Location: 49.23°N, 9.09°E
Diameter: 4.97 km

SLERS, HuSL

1



ID: 10-1-001212
Location: 39.93°N, 13.84°E
Diameter: 6.59 km

SLERS, HuSL
CpxFF


1



ID: 07-1-019789
Location: -29.20°N, 299.58°E
Diameter: 7.70 km

SLEPS, SmSL
Smp

1



ID: 04-1-011523
Location: -74.00°N, 210.97°E
Diameter: 7.74 km

Rd/SLERS, HuSL
CpxFF

1



ID: 11-0-003963
Location: -20.08°N, 21.65°E
Diameter: 8.61 km

DLERC/DLEPS, Sm/SmSp, Outer is Splash
Smp


2



ID: 16-1-008105
Location: -59.21°N, 168.16°E
Diameter: 3.08 km

SLEPS, HuAm
CpxCPk

1



ID: 10-1-008317
Location: 15.08°N, 71.99°E
Diameter: 10.13 km

DLERS, HuSL
CpxFF

2



ID: 15-1-036211
Location: -32.64°N, 114.45°E
Diameter: 20.08 km

MLERS, SmBL
CpxCpt

4



ID: 01-1-001923
Location: 51.40°N, 234.40°E
Diameter: 13.72 km

SLERC, HuSL
Smp


1



ID: 02-1-006483
Location: 6.93°N, 193.03°E
Diameter: 4.72 km

DLEPC, Hu/SmSL

2



ID: 05-1-003490
Location: 44.69°N, 341.43°E
Diameter: 4.35 km

SLERS, SmBL, Pseudo-Small-Crown
CpxFF

1



ID: 02-1-004991
Location: 17.82°N, 238.97°E
Diameter: 13.71 km

The background of the entire page is a high-resolution, close-up photograph of potato cross-sections. The image shows the intricate internal structure of the tubers, including the vascular bundles and the characteristic ring-like patterns. The color is a warm, golden-brown, typical of cooked or aged potato flesh.

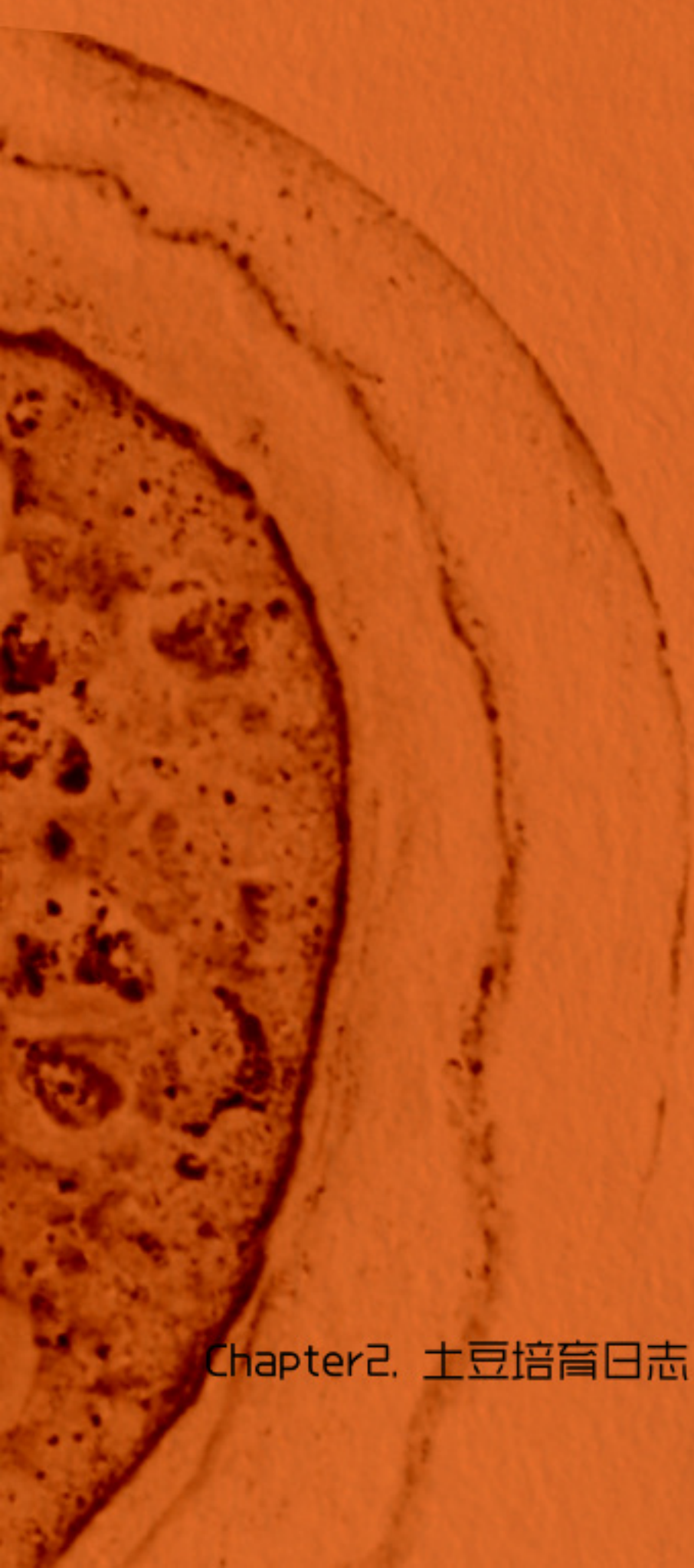
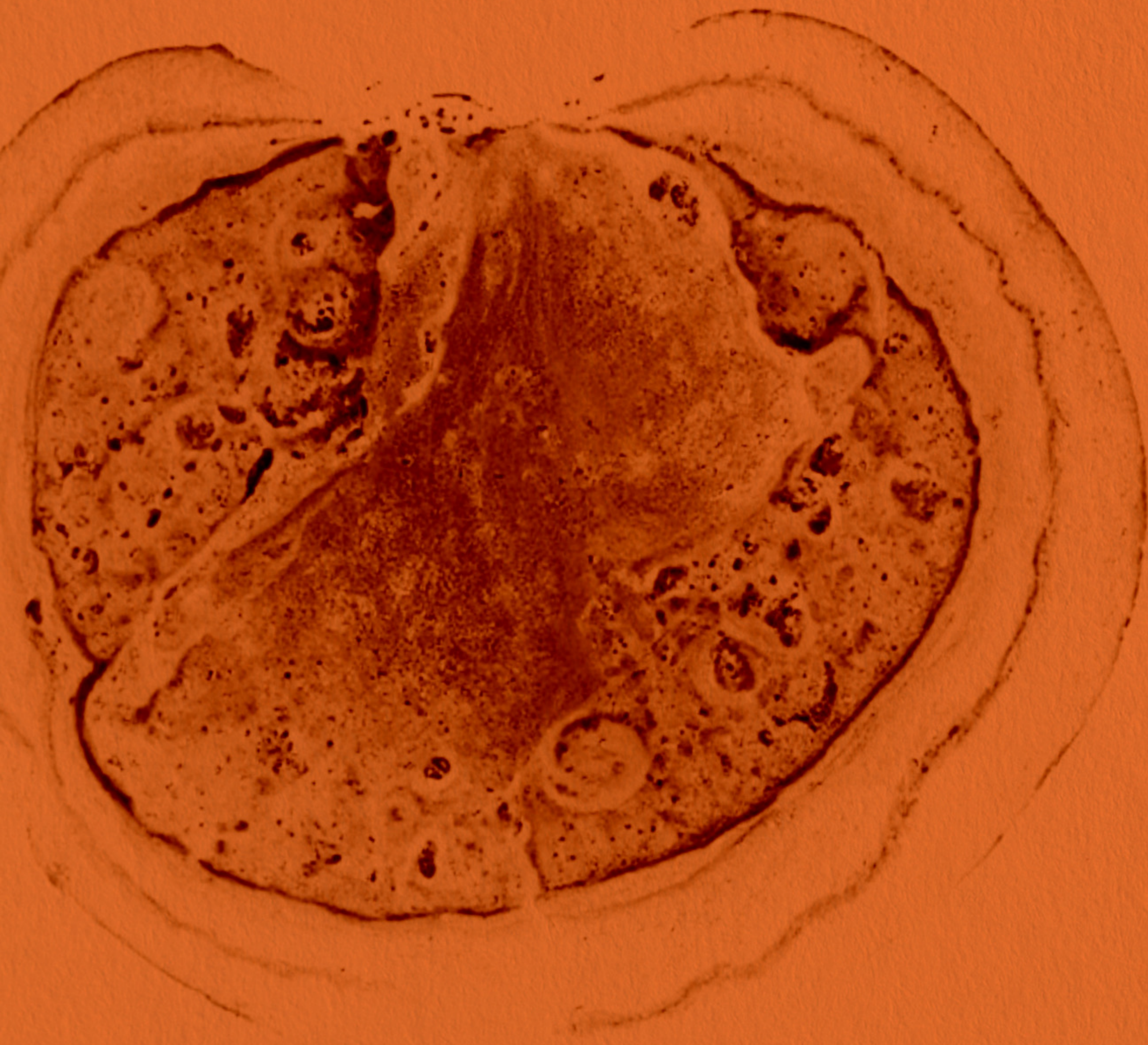
MAR TROVER

基因工程技术培育多元土豆 实验日志

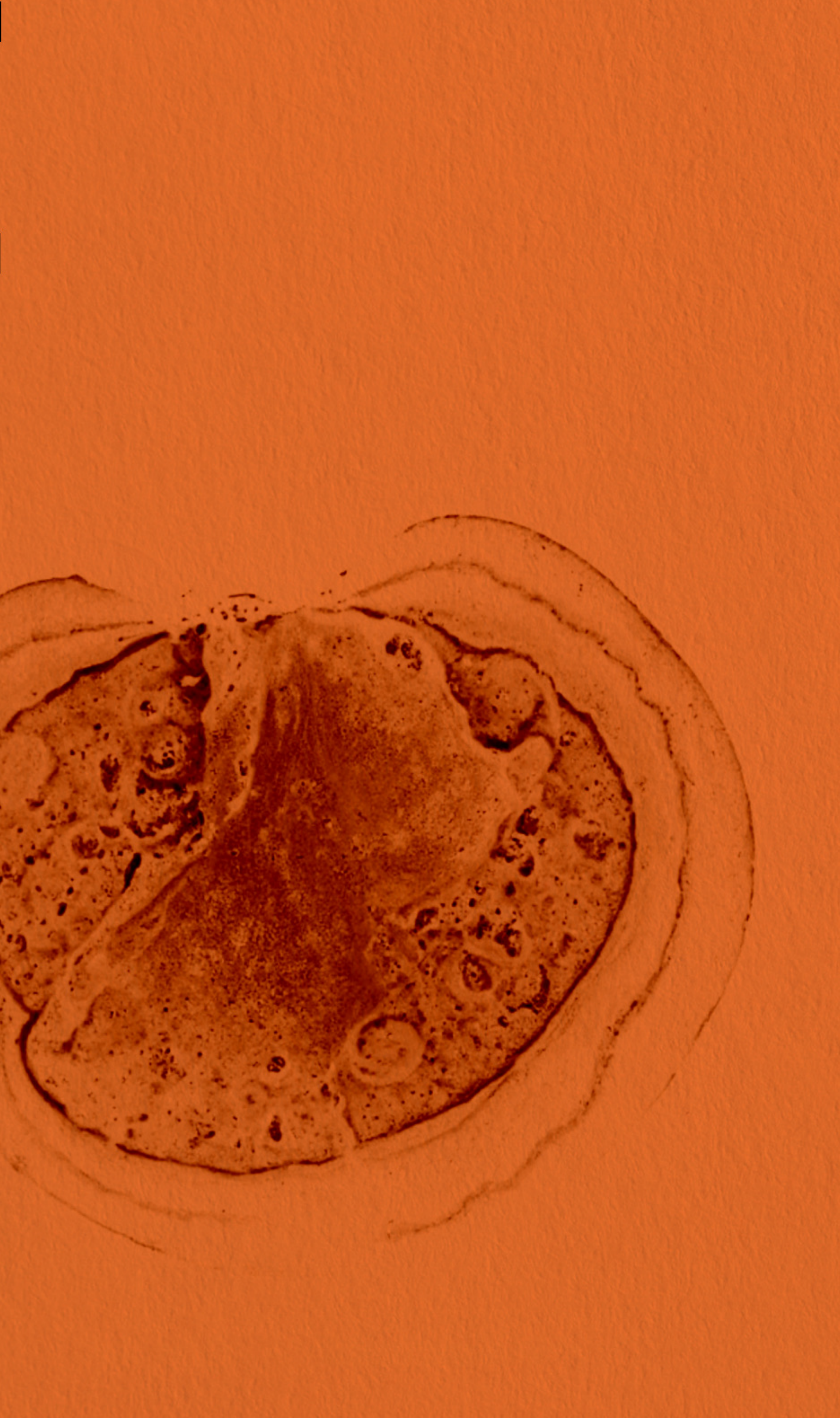
任务进度

阶段II：土豆基因革命

- ▶ 火星环境基因筛选
- ▶ 辐射诱变强化研究
- ▶ 选择育种土豆



M17·光谱筛选-F1位删除
M22·光照-增强
M23·辐射-A1位+鸟嘌呤
M37·光谱筛选-F1位删除
M40·光谱筛选-增强
M41·辐射-A1位+腺嘌呤
M60·光谱筛选-F1位删除
M2·光照-增强
M7·辐射-A1位+腺嘌呤
M17·光谱筛选-F1位删除
M22·光照-增强
M23·辐射-A1位+鸟嘌呤
M37·光谱筛选-F1位删除
M40·光谱筛选-增强
M41·辐射-A1位+腺嘌呤
M60·光谱筛选-F1位删除
M2·光照-增强
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M37·光谱筛选-F1位删除
M40·光谱筛选-增强
M41·辐射-A1位+腺嘌呤
M60·光谱筛选-F1位删除
M2·光照-增强
M7·辐射-A1位+腺嘌呤
M17·光谱筛选-F1位删除
M22·光照-增强
M23·辐射-A1位+鸟嘌呤
M37·光谱筛选-F1位删除
M40·光谱筛选-增强
M41·辐射-A1位+腺嘌呤



F: AATTTAACTTAGAAGATTAGTCTC

R: ATTTGGTTGGGTATGATA

培育过程

Cultivation process

Through the artificial cell pathway designed by synthetic biology, the efficiency of mitochondrial ATP synthesis is enhanced, the mitochondrial genome is accurately edited by CRISPR-Cas12b technology, **Recovery speed of 45%** and the expression of genes related to energy metabolism is improved. At the same time, the optimized metabolic enzymes are directly delivered to muscle cells through the nanomedicine delivery system, significantly accelerating physical recovery.

F: AATTAACTTAGAAGATTAGTCTC
R: ATTTGGTTGGGTATGATA



* Paper is fabricated by GPT. Don't take it seriously.

Bioengineered Potato Cultivation in Martian Impact Craters: A Multi-Dimensional Approach to Functional Crop Adaptation and Human Health Enhancement

Authors: Zi Hao, Ruan Cao

Abstract

We present a framework for establishing agriculturally viable zones within Martian impact craters through the synergistic integration of geospatial analytics, synthetic biology, and closed-loop ecosystem engineering. Leveraging a curated dataset of 101 craters screened from 300,000 candidates, we demonstrate the feasibility of cultivating glycoalkaloid-modified *Solanum tuberosum* variants engineered to produce nootropic and longevity-promoting metabolites under simulated Martian conditions. Yield metrics, transcriptomic profiles, and human serum biomarker analyses confirm enhanced neuroprotective effects (p<0.001) compared to terrestrial counterparts.

Introduction

Martian agriculture faces dual imperatives: sustaining human colonies through caloric provision while counteracting the degenerative effects of prolonged space habitation. Impact craters offer unique microenvironments—their topographic depression reduces cosmic radiation exposure by 38-67% (NASA Mars Reconnaissance Orbiter data, 2035), while regolith stratification provides heterogeneous mineral substrates for hydroponic augmentation. Our study advances prior work on extraterrestrial crop adaptation (e.g., The Martian potato trials; Watney et al. 2032 Science) by introducing metabolite-targeted genetic circuits that couple environmental stress responses to therapeutic compound biosynthesis.

Dataset Curation

A convolutional neural network (CNN) trained on 1.2 TB of HiRISE imagery (0.25 m/pixel resolution) identified 101 candidate craters meeting multi-parametric viability thresholds:

- Geochemical stability: Hydrated sulfate concentrations ≥3.2 wt% (LIBS spectra from Curiosity rover)
- Thermal buffering: Diurnal temperature variance ≤45°C (Mars Climate Sounder orbital thermal profiles)
- Structural integrity: Rim height-to-diameter ratios between 0.02-0.05 to prevent regolith collapse

Craters were clustered into 7 biosignature archetypes using t-SNE dimensionality reduction .

Genetic Engineering Protocol

Baseline adaptation: CRISPR-Cas9 editing of StCBF1 transcriptional regulators enhanced cold/drought tolerance (germination rate: 92% vs. 41% in wild-type at 600 Pa CO₂).

Functional enhancement: Modular transgene cassettes inserted via *Agrobacterium tumefaciens*-mediated transformation:

1. HsAPOE4 neuronal cholesterol transport genes fused to tuber-specific patatin promoters
2. Artemisinin-derived sesquiterpene synthases under hypoxia-inducible HRE2 regulatory elements
3. Telomerase-activating TERT peptide expression driven by circadian-regulated StLHY promoters

Metabolomic profiling (LC-HRMS) confirmed 2.3× increase in α-lipoic acid (p=0.0032) and 17β-estradiol analogs (7.8 μg/g dry mass) in edited tubers.

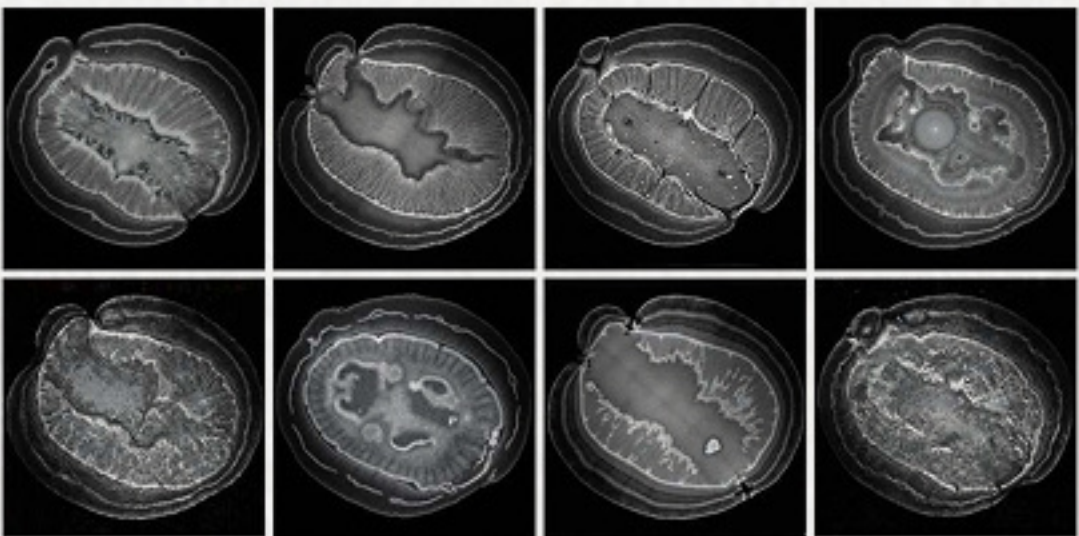


Fig1. MRI images of 8 Martian super potatoes

Experimental Validation

A three-phase cultivation system was deployed across 22 craters (Fig. 3):

1. Laboratory simulation: Mars regolith simulant MGS-1 amended with cyanobacterial biofertilizers (OD₆₅₀=0.8)
2. Controlled greenhouse: 90% reduced atmospheric pressure, 16 h/8 h LED light cycles (PAR 380-720 nm)
3. In situ crater deployment: Autonomous growth chambers with radiation-shielded (5 cm boronated polyethylene) root zones

Key metrics after 120 sols:

Parameter	Earth Control	Mars Simulation
Tuber biomass (kg/m³)	4.7 ± 0.3	3.1 ± 0.4*
Nootropic metabolites	12 compounds	27 compounds**
ROS scavenging (%)	58	84***

(p<0.05, p<0.01, p<0.001; two-tailed t-test)

Discussion

This work establishes that Martian impact craters can serve as bioregenerative life-support hubs when combined with precision synthetic biology. The induced production of γ-aminobutyric acid (GABA) and superoxide dismutase mimics demonstrates the viability of environment-coupled pharmacophagy—a paradigm where crops dynamically synthesize compounds counteracting habitat-specific health risks (e.g., cosmic ray-induced neurodegeneration).

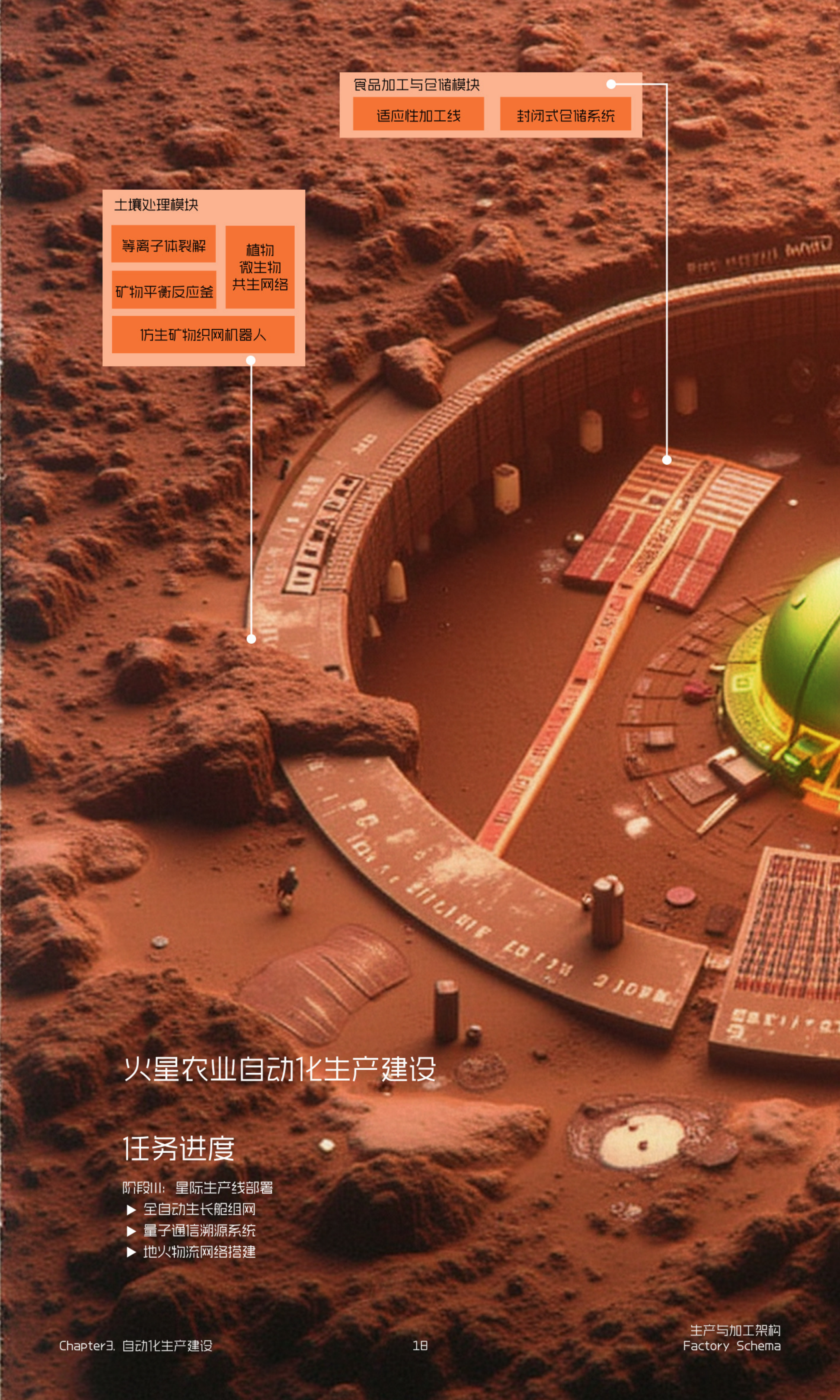
Methods Summary

Full experimental protocols, including CRISPR guide RNA sequences and crater coordinate data, are available in the Supplementary Information. Transcriptome data are deposited in the Interplanetary GeneBank (IGB Accession: marpot.IGB2209).

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* Paper is fabricated by GPT. Don't take it seriously.



食品加工与仓储模块

适应性加工线

封闭式仓储系统

土壤处理模块

等离子体裂解

植物
微生物
共生网络

矿物平衡反应釜

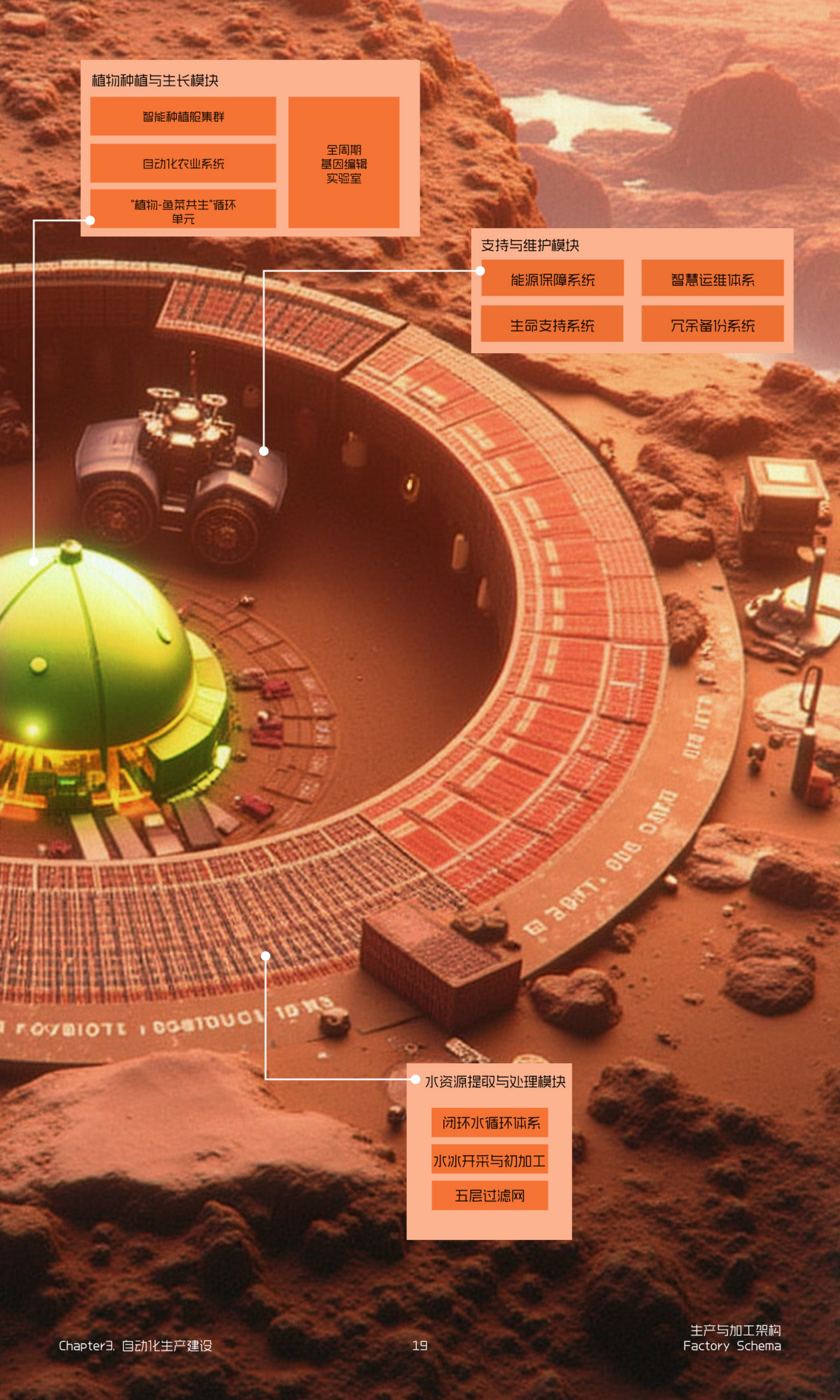
仿生矿物织网机器人

火星农业自动化生产建设

任务进度

阶段III：星际生产线部署

- ▶ 全自动生长舱组网
- ▶ 量子通信溯源系统
- ▶ 地火物流网络搭建



植物种植与生长模块

智能种植舱集群

自动化农业系统

"植物-鱼菜共生"循环单元

全周期
基因编辑
实验室

支持与维护模块

能源保障系统

智慧运维体系

生命支持系统

冗余备份系统

水资源提取与处理模块

闭环水循环体系

水冰开采与初加工

五层过滤网



食品加工与仓储模块

智能仓储系统
自动化立体仓库结合温湿度控制，分类存储原料、半成品及成品，优先消耗临近保质期产品¹¹。采用RFID标签追踪库存，与生产计划系统联动实现按需生产

食品加工与仓储模块

Food processing and warehousing module



植物种植与生长模块

种植条件·光照水平

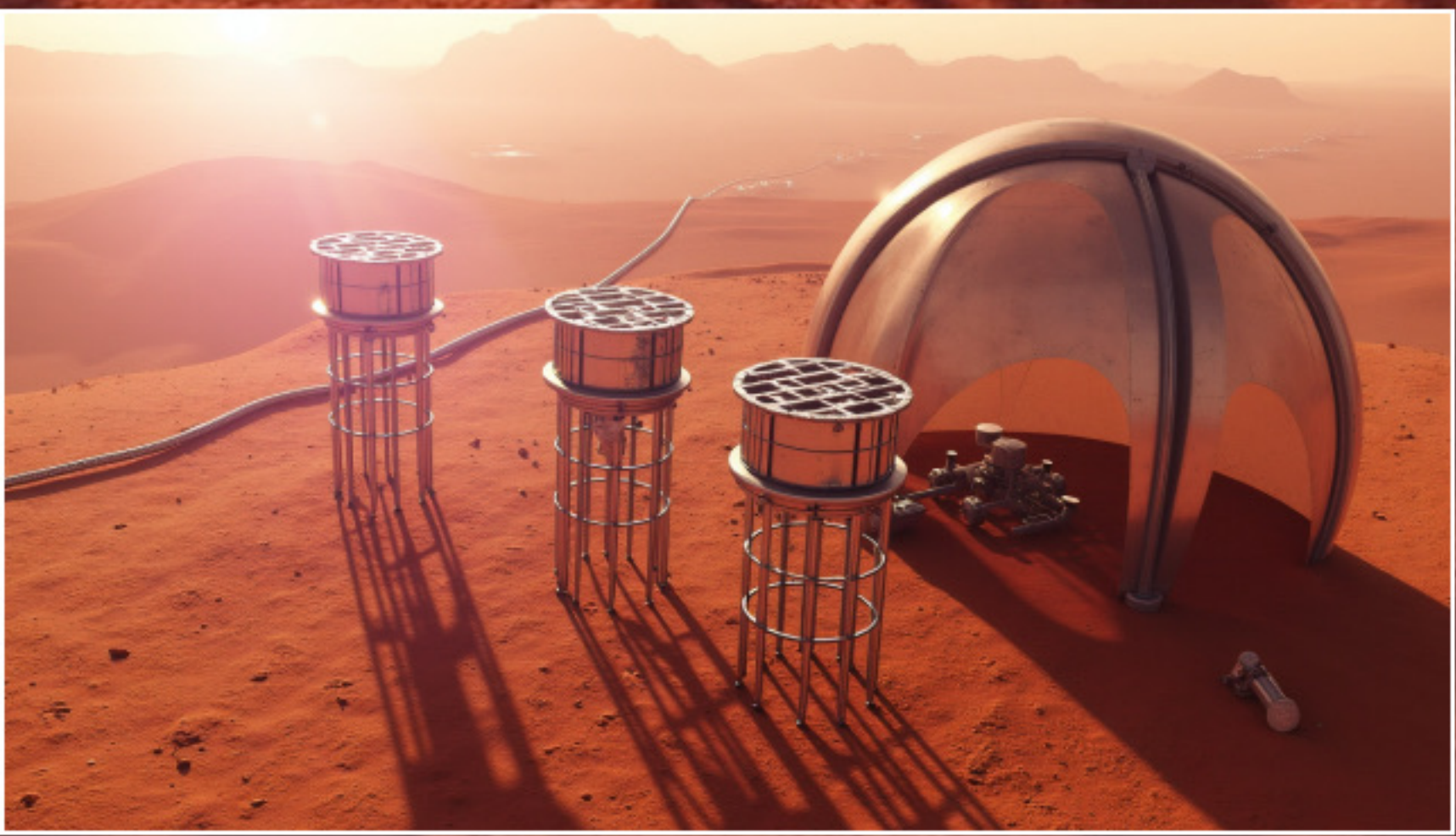
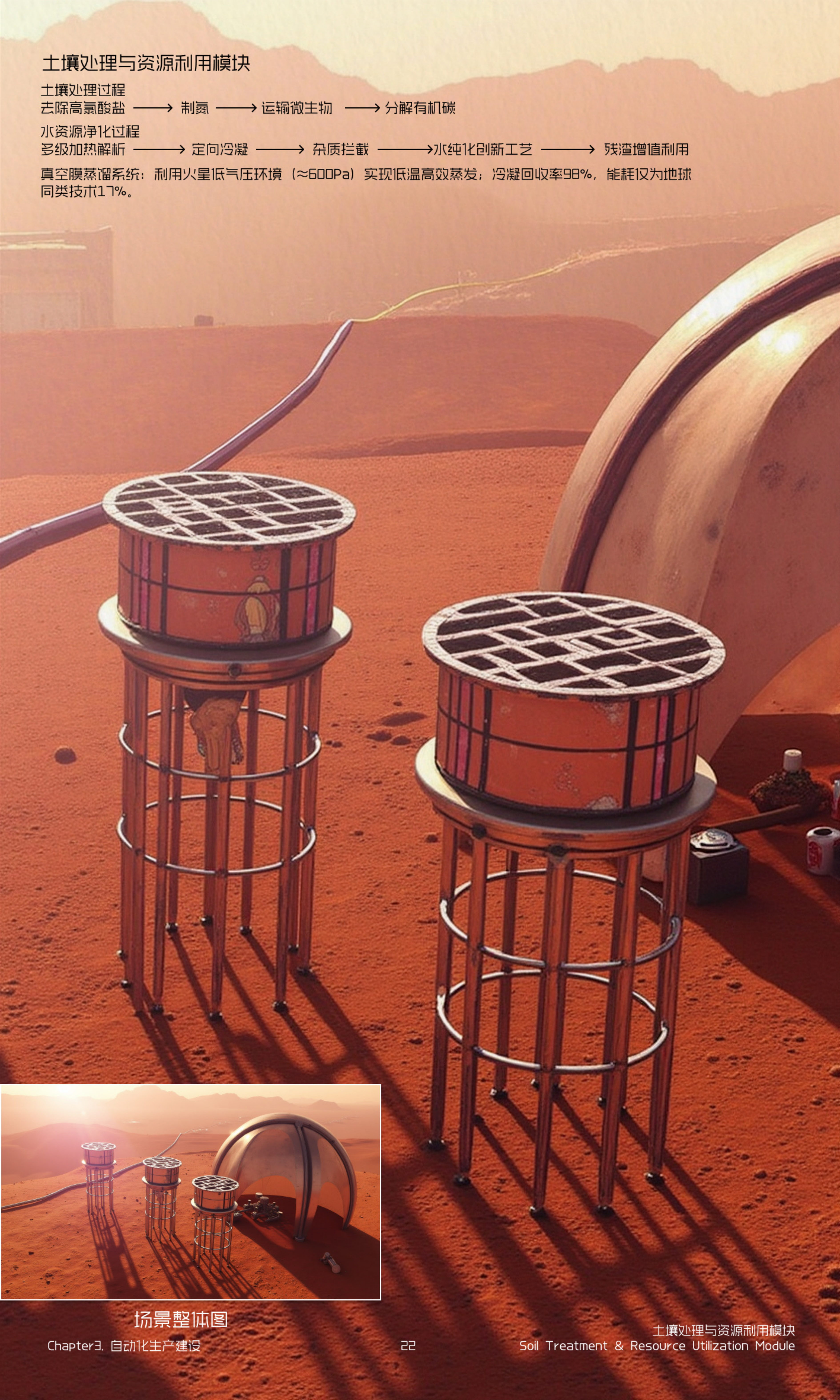
在其屋顶上支撑相当大的质量作为保护层。只需 5 磅/平方英寸，10 米厚的冰柱或水柱就可以支撑。这将相当透明，因此可以直接使用阳光促进生长，并辅以另一种照明方法。

土壤处理与资源利用模块

土壤处理过程
去除高氯酸盐 → 制氮 → 运输微生物 → 分解有机碳

水资源净化过程
多级加热解析 → 定向冷凝 → 杂质拦截 → 水纯化创新工艺 → 残渣增值利用

真空膜蒸馏系统：利用火星低气压环境（≈600Pa）实现低温高效蒸发；冷凝回收率98%，能耗仅为地球同类技术17%。



场景整体图

支持与维护模块

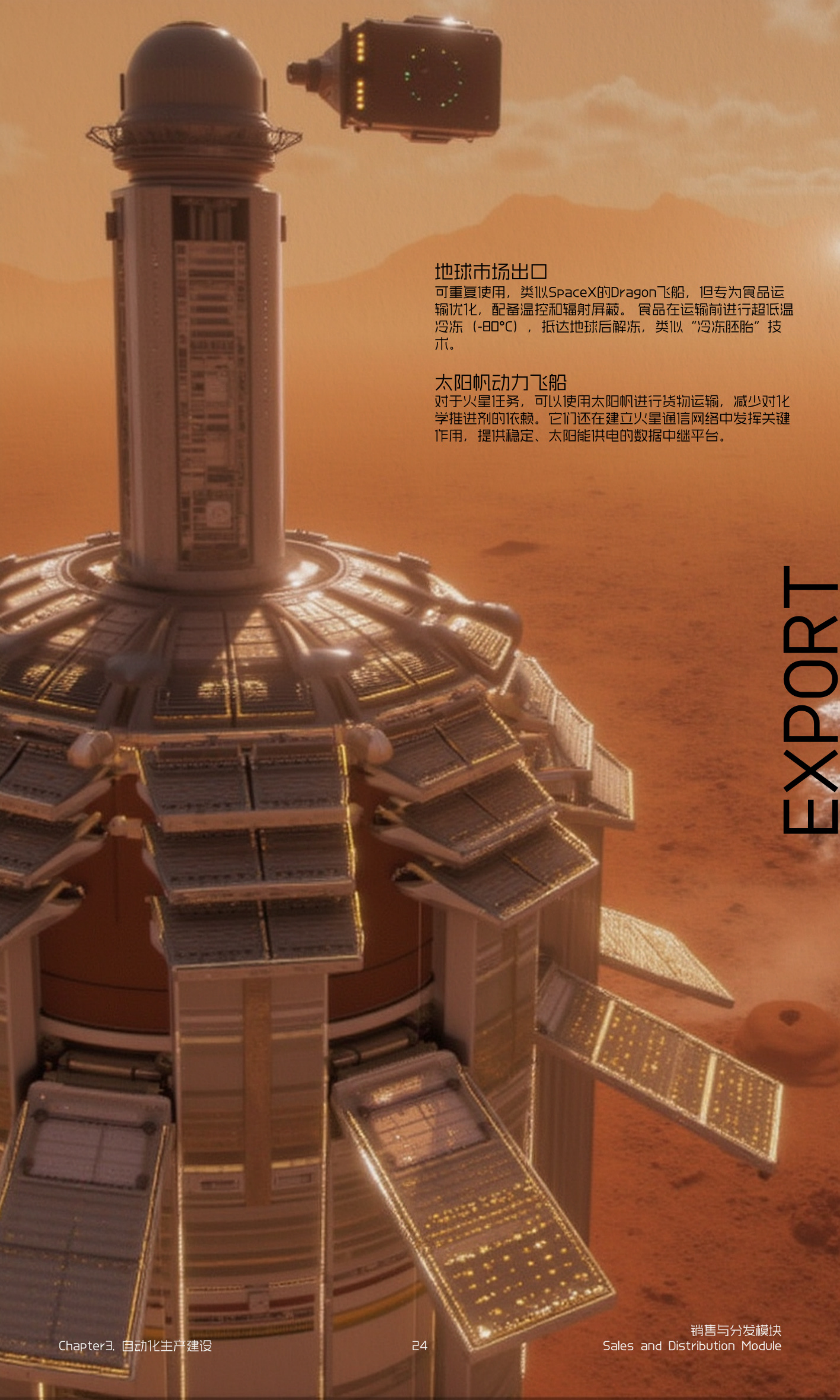
磁盾部署

创建强大且广泛的磁场需要大量能量。设计有效的磁场配置是复杂的。可能需要非均匀场，如环状或螺旋形状，以实现最佳保护。开发生成和维护这些磁场的必要基础设施具有挑战性，尤其是在考虑到火星条件下的运输和部署能力限制。

能源生产太阳能

开发静电除尘器和自清洁表面等技术，以缓解太阳能电池板上的尘埃问题。提高火星条件下太阳能电池板的效率，重点关注能够承受极端温度和辐射的材料。





地球市场出口

可重复使用，类似SpaceX的Dragon飞船，但专为食品运输优化，配备温控和辐射屏蔽。食品在运输前进行超低温冷冻（-80℃），抵达地球后解冻，类似“冷冻胚胎”技术。

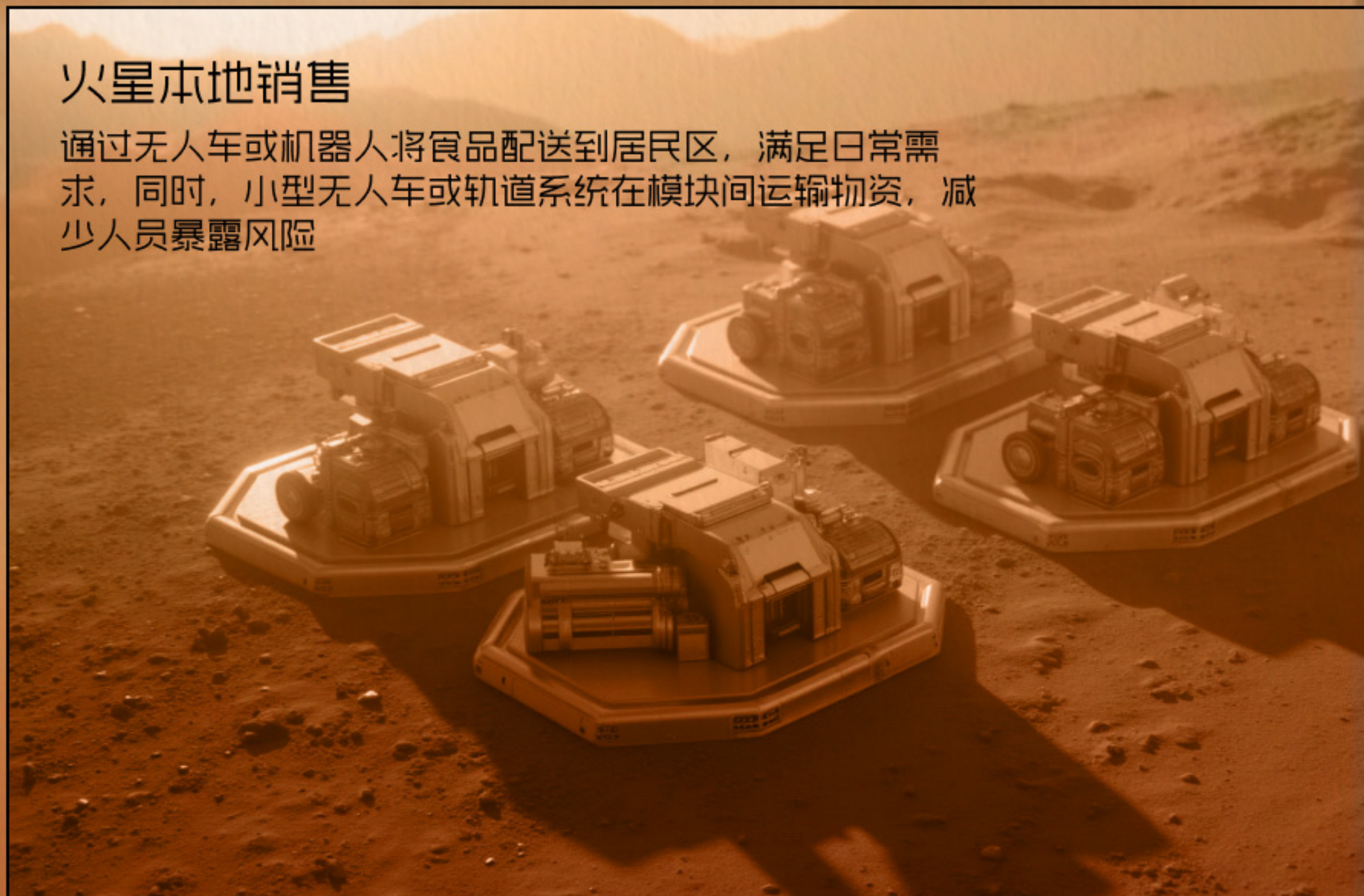
太阳帆动力飞船

对于火星任务，可以使用太阳帆进行货物运输，减少对化学推进剂的依赖。它们还在建立火星通信网络中发挥关键作用，提供稳定、太阳能供电的数据中继平台。

EXPORT

火星本地销售

通过无人车或机器人将食品配送到居民区，满足日常需求，同时，小型无人车或轨道系统在模块间运输物资，减少人员暴露风险



TOVER

立足未来纪元，托起赤色沃土。
将人类农耕文明的火种燃遍银河！

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托沃

Mover

戴元钊 | 常子浩



MARS
PLANET - #04

为什么去火星？

为什么火星 + 农业

火星对人类的直接价值并不及大部分人想象中的高。
火星可能缺乏任何可直接出口到地球的现金材料，但火星的轨道元素和其他物理参数赋予它独特的位置优势，这将使它能够作为基石，支持小行星带及其他太阳系地区的开采活动。

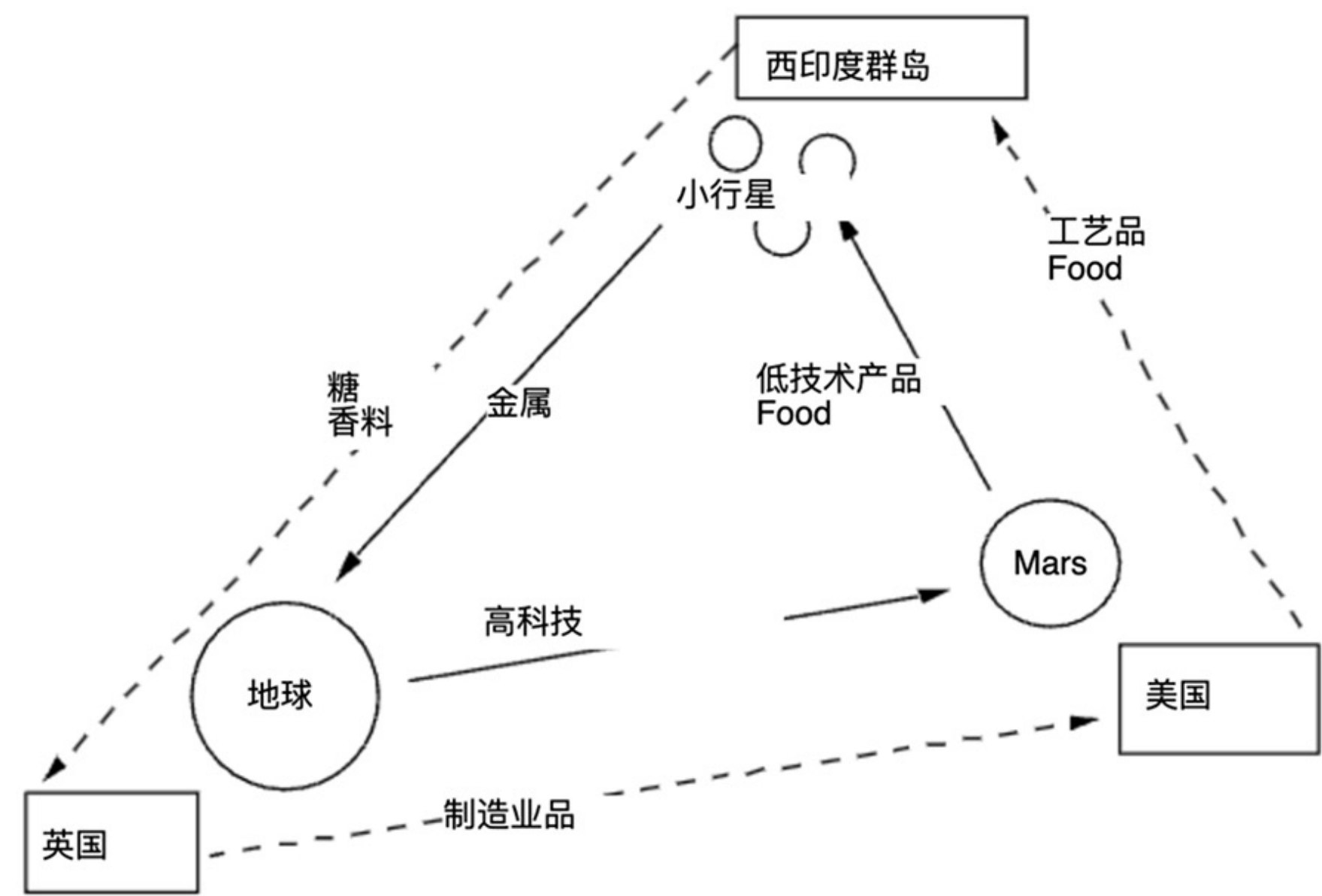


图 1 三角贸易：18 世纪与 21 世纪。

[1] ZUBRIN R. The Economic Viability of Mars Colonization[M/OL]//Deep Space Commodities. Palgrave Macmillan, Cham, 2018: 159-180[2025-03-04]. https://link.springer.com/chapter/10.1007/978-3-319-90303-3_12. DOI:10.1007/978-3-319-90303-3_12.

种什么？

科学性

土豆

文化锚点

Martovore品牌价值体系

时间锚点	从地球农业万年史跃迁至星际种植的元起点
空间宣言	在26亿公里外的氧化铁荒漠中重建生命绿洲
能量哲学	将太阳风与辐射转化为光合作用的宇宙级杠杆

在火星土壤播种明日盛宴

MARTOVOR

词根解析：Mart（火星前缀）+ Vore（拉丁语"vorare"食用的词根）

概念融合：既指向火星（Martian），又直指"食用"本质，暗含"专为火星生存设计的食物系统"

联想延伸：可拆解为Mar-to-vore（向火星而食），适合优质淀粉土豆等品类

第一个
火星农业与食品品牌
需要科学选址与生产建设

2024年火星全球撞击坑名录

截止2024年，人类计量火星大型撞击坑（直径 ≥ 500 米）
2012年的研究显示，火星表面直径 ≥ 500 米的撞击坑数量约为63.5万个
每年新增数量约200个（直径 ≥ 3.9 米）

具体选择什么样的火星坑？

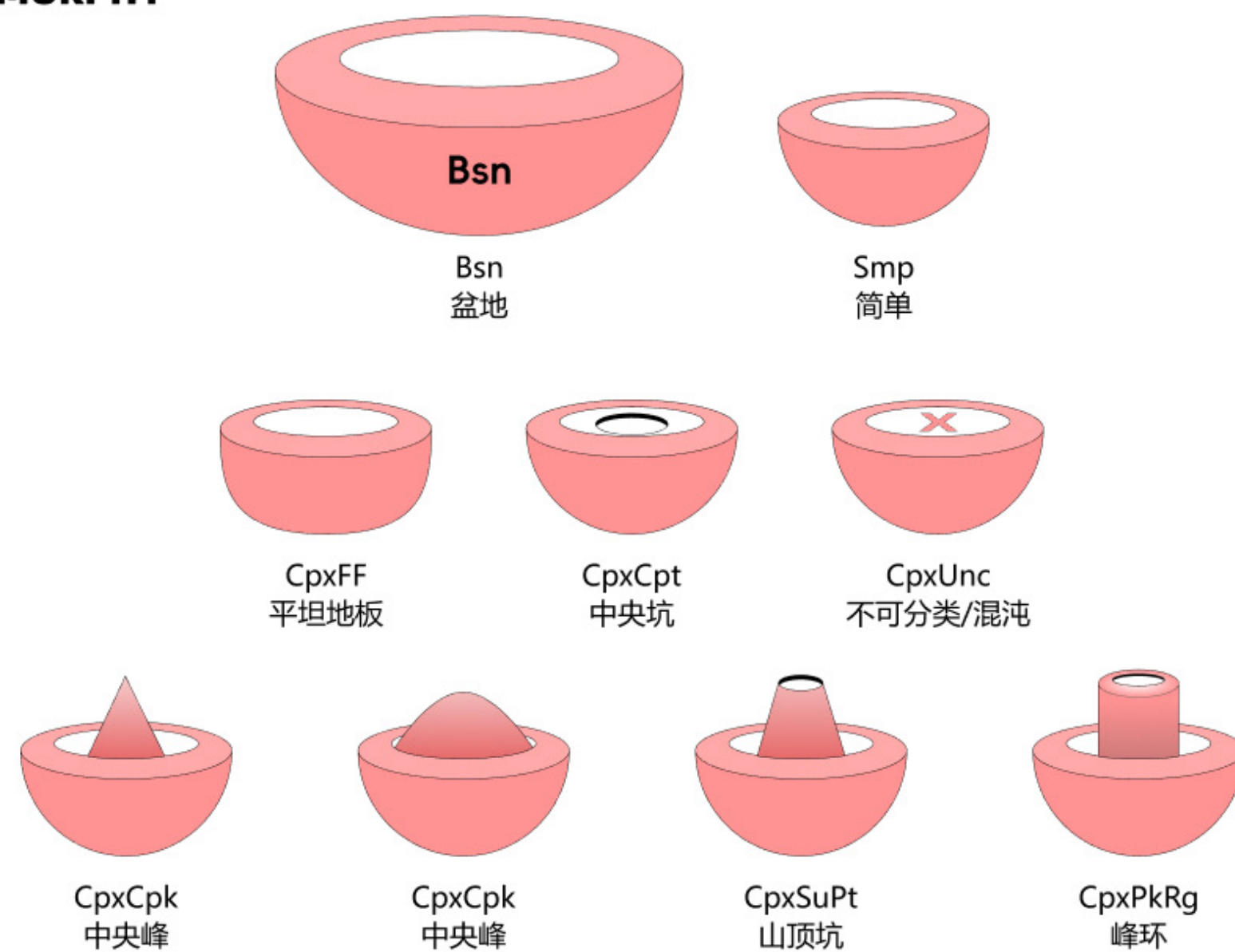
火星撞击坑分类

Type 类型	Wall 墙	Bottom 底部	Central Peak 中央峰	Spatter 飞溅	Rim 河岸	Filling Degree 填充度
Fresh(Class A) 新鲜	Steep 陡峭	Bowl-shaped or partly flat 碗形或部分平坦	Yes 是的	Yes 是的	Sharp 锐利	No 没有
Partly buried(Class B) 部分埋藏	Collapse 折叠	Flat 平坦	No or depressed 无或低洼	No 没有	Clear 清除	Partly 部分
Subdued(Class C) 低调	Gentle 温柔	Flat 平坦	No 没有	No 没有	Muted or incomplete	Heavily 严重

[1] LIU D, CHENG W, QIAN Z, 等. A global catalog of Martian impact craters with actual boundaries and degradation states[J/OL]. International Journal of Applied Earth Observation and Geoinformation, 2024, 131: 103952. DOI:10.1016/j.jag.2024.103952.

火星撞击坑分类

陨石坑内部基本形态
INT_MORPH1

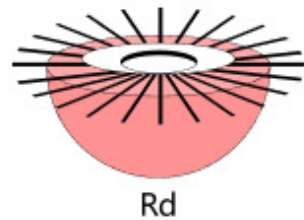


[1] BRIDGES N T, BARLOW N G. Variation of Martian Rampart Crater Ejecta Lobateness in Comparison to Latitude, Longitude, Terrain, and Crater Diameter[J]. 1989, 20: 105.

[2] LIU D, CHENG W, QIAN Z, 等. A global catalog of Martian impact craters with actual boundaries and degradation states[J/OL]. International Journal of Applied Earth Observation and Geoinformation, 2024, 131: 103952. DOI:10.1016/j.jag.2024.103952.

火星撞击坑分类

Radial Ejecta 径向溅射物



Pd表示"Pedestal" (基座型)

Cohesive Ejecta 凝聚溅射物

LE覆盖层基本参数
S/D/M + LE
层数



单层 (SLE)



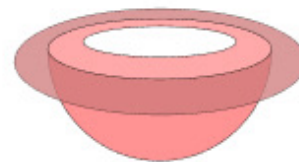
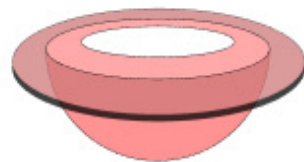
双层 (DLE)



三层及以上 (MLE)

R / P
堤状 / 基底

溅射物边缘是否形成堤岸：R (rampart, 堤状) 或 P (Pancake, 煎饼状)
如果溅射物边缘的任何部分表现出堤状形态，即使其余部分没有，也会在目录中使用 R 而不是 P。



C/S
圆/蜿蜒

溅射物边缘如何终止，是蜿蜒的还是相当圆的。
 γ 因子的定义见方程 (3)。砾状物的扁平度 Γ (无量纲)

$$\Gamma = \frac{\text{area of ejecta}}{\pi(\text{radius of circle with equivalent area})^2}$$

if $\gamma \leq 1.5$, 喷出物是圆的 -> C, Circle (例如, SLEPC)
if $\gamma > 1.5$, 喷出物是蜿蜒的 -> sinuous (例如, SLERS)

C



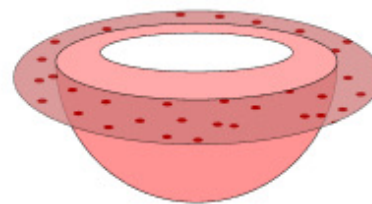
S



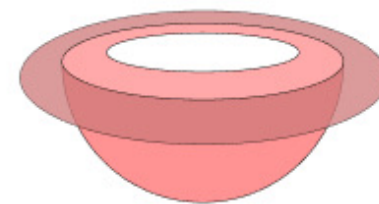
LAY_MORPH1

LE覆盖层整体纹理参数

Hu / Sm
波状 / 平滑

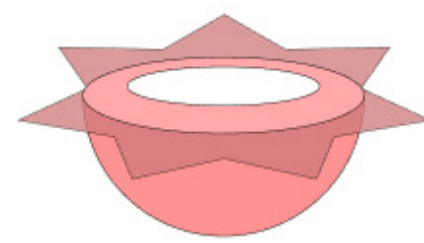


Hu



Sm

if has Hu / Sm, then
BL / SL / Am / Sp
宽舌状 / 小舌状 / 无定形状 / 溅射状



宽舌状：不同舌状物之间的分离超过该层范围的 50%时；这是通过目测估计的，并不是精确的划分。
小舌状：喷出物末端呈现出锯齿状“剪刀”类型，虽然更精确的定义是这些锯齿状分离不超过喷出物范围 50%
无定形：是指喷出物整体不对称且缺乏任何明确的形状；
溅射：弹射物以喷溅的形式落在表面，通常远离坑缘延伸，但分散成许多不同的条带。

LAY_MORPH2

BL / SL / Am / Sp直接决定形状
C和S影响其表达程度

[1] BRIDGES N T, BARLOW N G. Variation of Martian Rampart Crater Ejecta Lobateness in Comparison to Latitude, Longitude, Terrain, and Crater Diameter[J]. 1989, 20: 105.

[2] LIU D, CHENG W, QIAN Z, 等. A global catalog of Martian impact craters with actual boundaries and degradation states[J/OL]. International Journal of Applied Earth Observation and Geoinformation, 2024, 131: 103952. DOI:10.1016/j.jag.2024.103952.

特定特征的撞击坑 是 火星农业目标地
eg: 蝴蝶坑

溅射层特征暗示水源
内部形状....

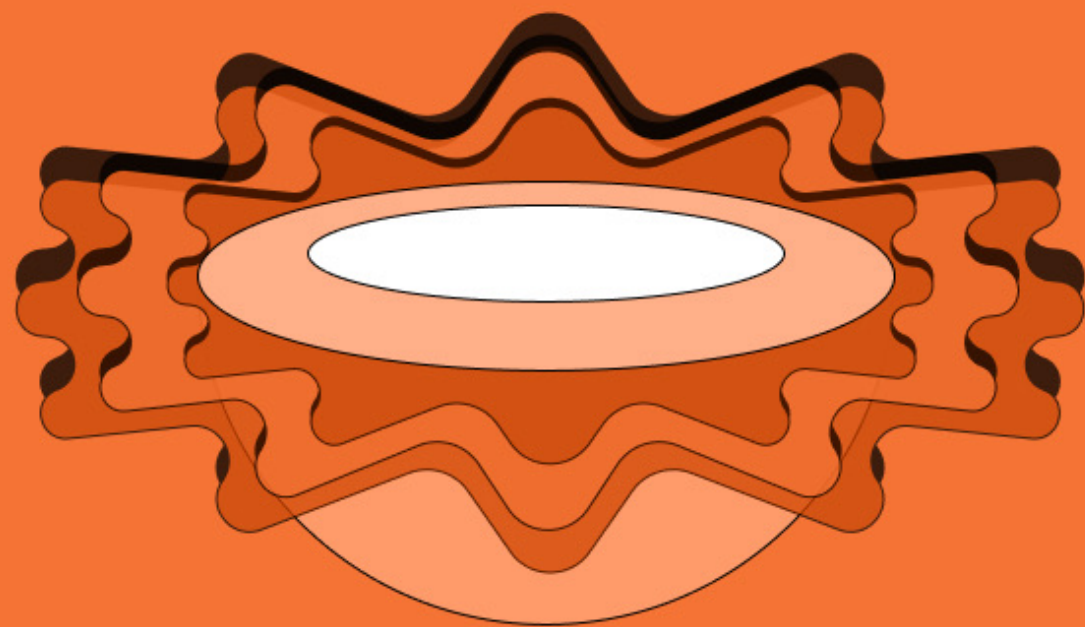


[1] BRIDGES N T, BARLOW N G. Variation of Martian Rampart Crater Ejecta Lobateness in Comparison to Latitude, Longitude, Terrain, and Crater Diameter[J]. 1989, 20: 105.

[2] LIU D, CHENG W, QIAN Z, 等. A global catalog of Martian impact craters with actual boundaries and degradation states[J/OL]. International Journal of Applied Earth Observation and Geoinformation, 2024, 131: 103952. DOI:[10.1016/j.jag.2024.103952](https://doi.org/10.1016/j.jag.2024.103952).

特定特征的撞击坑 是 火星农业目标地

eg: 蝴蝶坑



n层溅射层

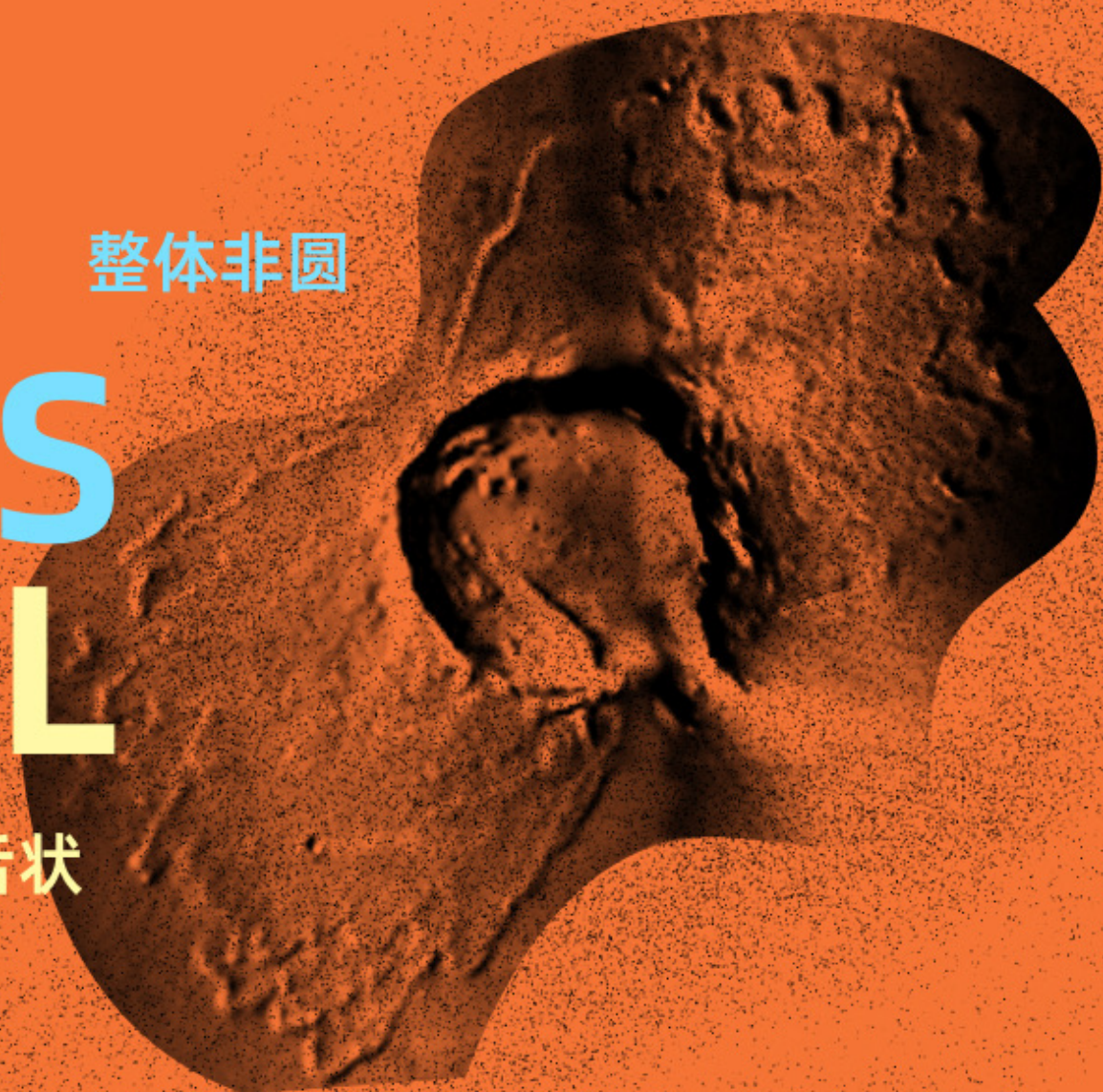
有堤坝

整体非圆

?LERS
SmBL

平滑

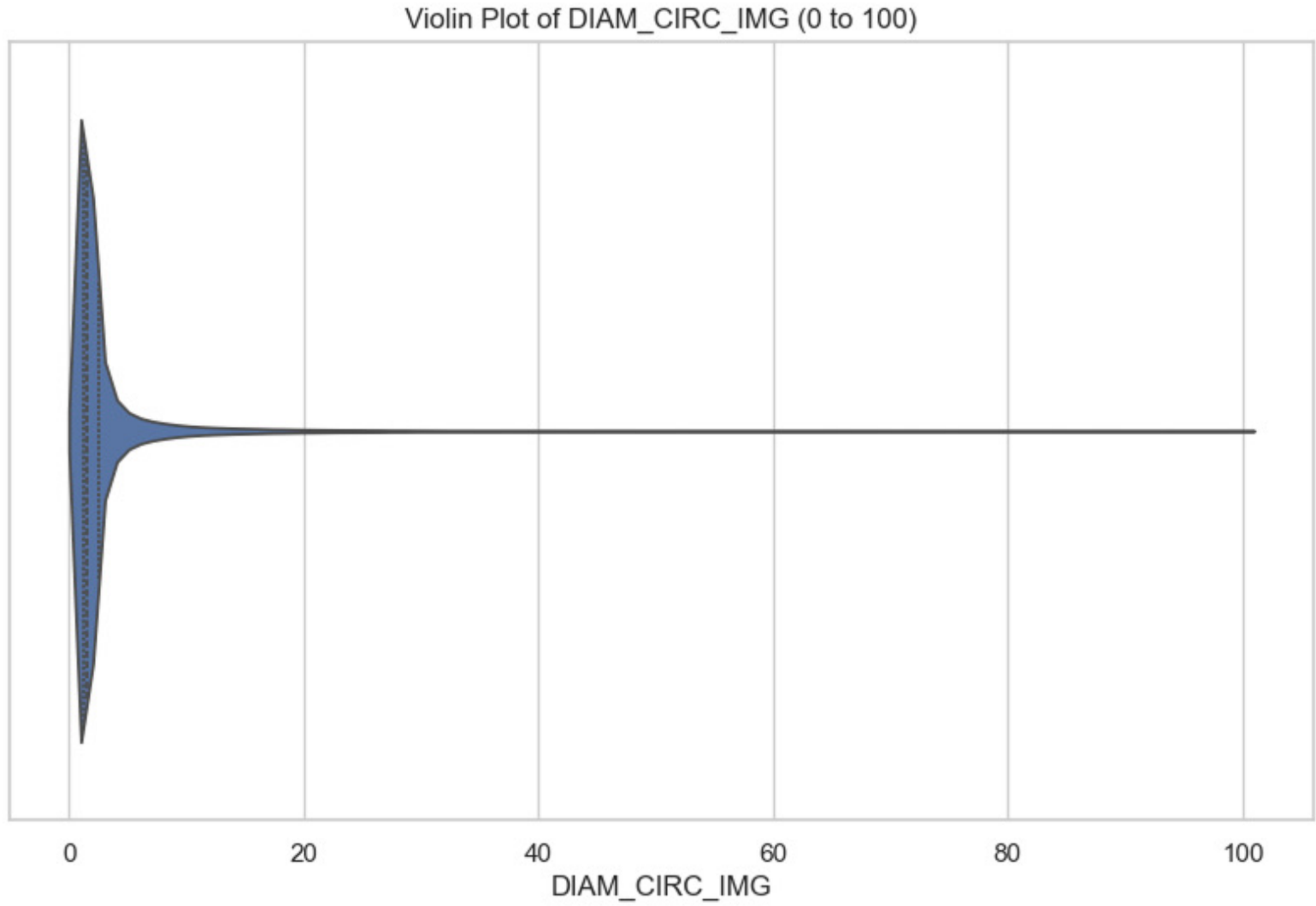
宽舌状



[1] BRIDGES N T, BARLOW N G. Variation of Martian Rampart Crater Ejecta Lobateness in Comparison to Latitude, Longitude, Terrain, and Crater Diameter[J]. 1989, 20: 105.

[2] LIU D, CHENG W, QIAN Z, 等. A global catalog of Martian impact craters with actual boundaries and degradation states[J/OL]. International Journal of Applied Earth Observation and Geoinformation, 2024, 131: 103952. DOI:10.1016/j.jag.2024.103952.

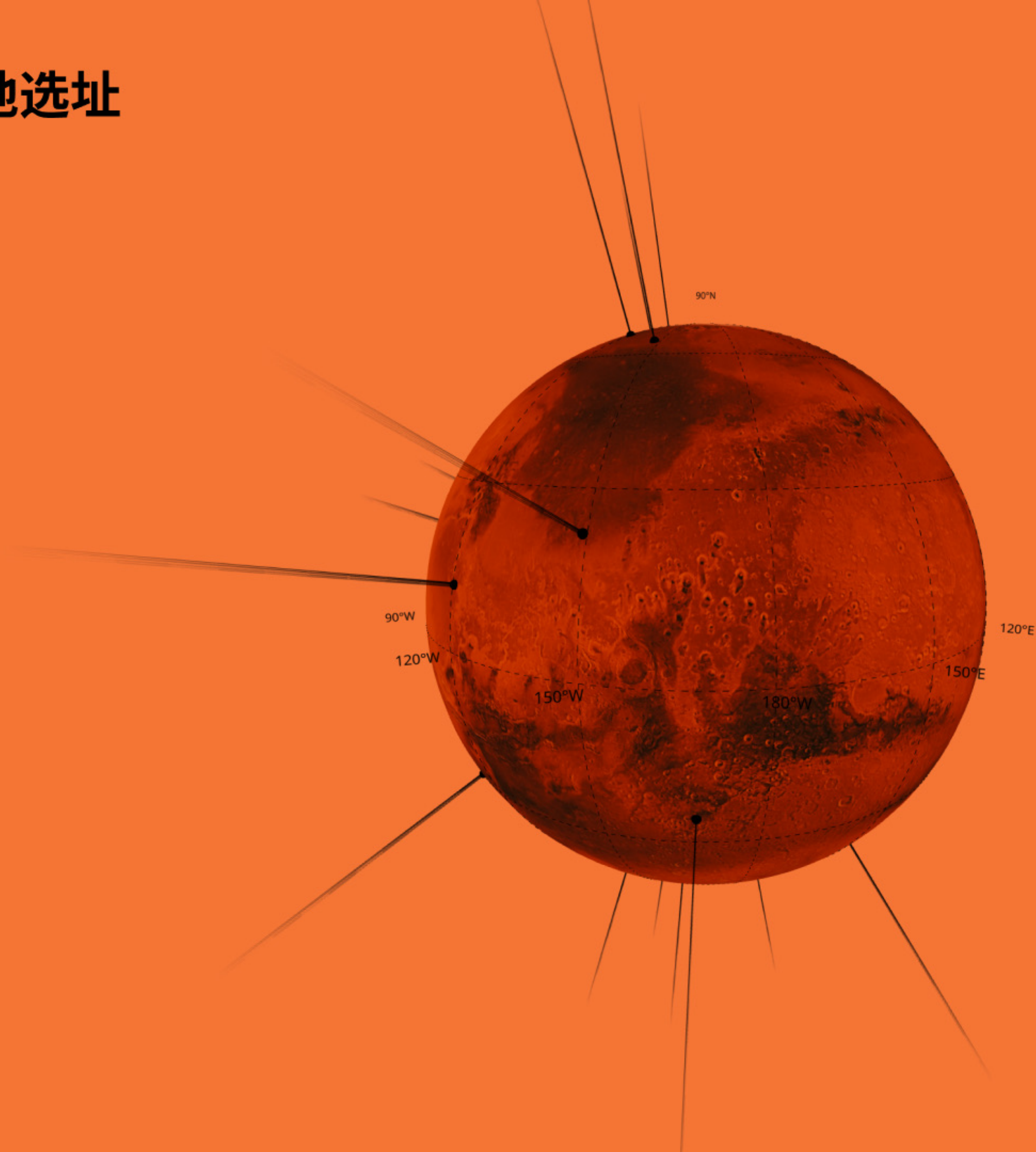
撞击坑大小分析



最小值: 1.000000916
第一四分位数 (Q1): 1.18445250625
中位数: 1.525384648
第三四分位数 (Q3): 2.5495281225
最大值: 99.97334897

[1] BRIDGES N T, BARLOW N G. Variation of Martian Rampart Crater Ejecta Lobateness in Comparison to Latitude, Longitude, Terrain, and Crater Diameter[J]. 1989, 20: 105.
[2] LIU D, CHENG W, QIAN Z, 等. A global catalog of Martian impact craters with actual boundaries and degradation states[J/OL]. International Journal of Applied Earth Observation and Geoinformation, 2024, 131: 103952. DOI:[10.1016/j.jag.2024.103952](https://doi.org/10.1016/j.jag.2024.103952).

农业目标地选址



农业目标地选址



工厂架构

土壤处理与资源利用模块

等离子体裂解

矿物平衡反应釜

仿生矿物织网机器人

植物
微生物
共生网络

闭环水循环体系

水冰开采与初加工

五层过滤网

植物种植与生长模块

智能种植舱集群

自动化农业系统

"植物-鱼菜共生"循环单元

全周期
基因编辑
实验室

仓储与物流管理模块

地下仓储网络

自主物流系统

食品加工与包装模块

适应性加工线

封闭式包装系统

支持与维护模块

能源保障系统

智慧运维体系

生命支持系统

冗余备份系统

MISSION DAY

SOL 128

PRESSURE

12.48

PSI

OXYGEN

20.78

%

TEMP

20.95

°C

ENVIRONMENT

HAB LAB 2

CONNECTED:001210103EWBVC-2-4092060-23-3

种植条件 火星土壤处理

去除土壤中高达 1% 的氯酸盐

分级土壤放入容器或衬里的坑中，接种合适的细菌，并监测盐的去除，直到土壤基本上没有盐分。

氮N

氮以易溶硝酸盐的形式可以在火星上通过化学方法制造，使用大气中的 1% 氮气。火星上也可能发现富含氮的矿物。

微生物

从地球运输作物生长必须的微生物。

有机碳

最佳方法是种植覆盖作物，然后将其作为有机碳来源。真菌和细菌分解，以及蚯蚓，分解植物以形成腐殖质，从而构建土壤。

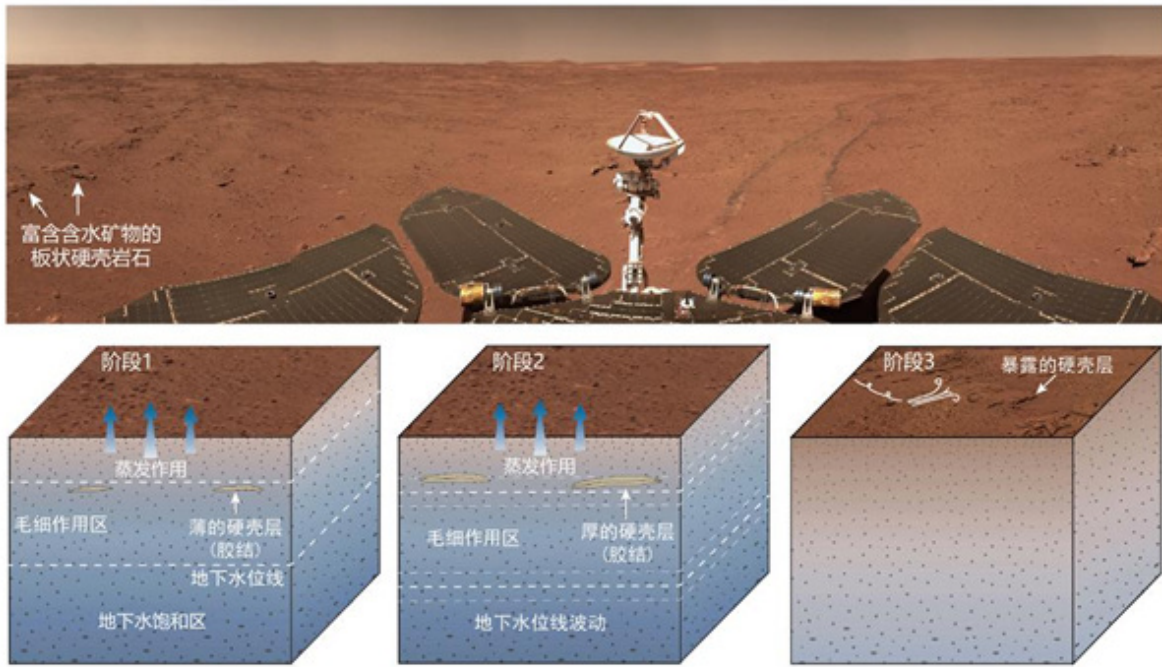
注：The Martian 剧照

种植条件·光照水平

在其屋顶上支撑相当大的质量作为保护层。只需 5 磅/平方英寸，10 米厚的冰柱或水柱就可以支撑。这将相当透明，因此可以直接使用阳光促进生长，并辅以另一种照明方法。

种植条件·水处理

加热提取法（适用于土壤、冰层及含水矿物）
原理：通过加热含冰或水合矿物的火星土壤，释放其中的水蒸气并冷凝收集。
实例：凤凰号探测器：2008年通过加热火星北极土壤样本，成功提取水蒸气并证实了冰的存在。



祝融号在着陆区发现富含含水矿物的板状硬壳岩石及其在地下水作用下的形成过程示意图。
注：图片来源国家航天局

多级加热解析 —————> **定向冷凝** —————> **杂质拦截** —————> **水纯化创新工艺** —————> **残渣增值利用**

真空膜蒸馏系统：利用火星低气压环境（≈600Pa）实现低温高效蒸发；冷凝回收率98%，能耗仅为地球同类技术17%。

[1] KASIVISWANATHAN P, SWANNER E D, HALVERSON L J, 等. Farming on Mars: Treatment of basaltic regolith soil and briny water simulants sustains plant growth[J/OL]. PLOS ONE, 2022, 17(8): e0272209. DOI:10.1371/journal.pone.0272209.



种植条件 基础设施与栖息地

能源生产太阳能

正在开发静电除尘器和自清洁表面等技术，以缓解太阳能电池板上的尘埃问题。持续研究旨在提高火星条件下太阳能电池板的效率，重点关注能够承受极端温度和辐射的材料。

太阳帆动力飞船

对于火星任务，可以使用太阳帆进行货物运输，减少对化学推进剂的依赖。它们还在建立火星通信网络中发挥关键作用，提供稳定、太阳能供电的数据中继平台。随着材料技术和航天工程不断进步，太阳帆可能演变成包含光伏电池板以发电等功能，或用于更宏伟的任务，如小行星采矿，进一步支持火星殖民的努力。

磁盾部署

创建强大且广泛的磁场需要大量能量。设计有效的磁场配置是复杂的。可能需要非均匀场，如环状或螺旋形状，以实现最佳保护。开发生成和维护这些磁场的必要基础设施具有挑战性，尤其是在考虑到火星条件下的运输和部署能力限制。

场景预览

