ASTR/GEOL-2040: Search for life in the Universe: Lecture 22

- Atmospheric escape
- Martian meteorites
- ALH 84001

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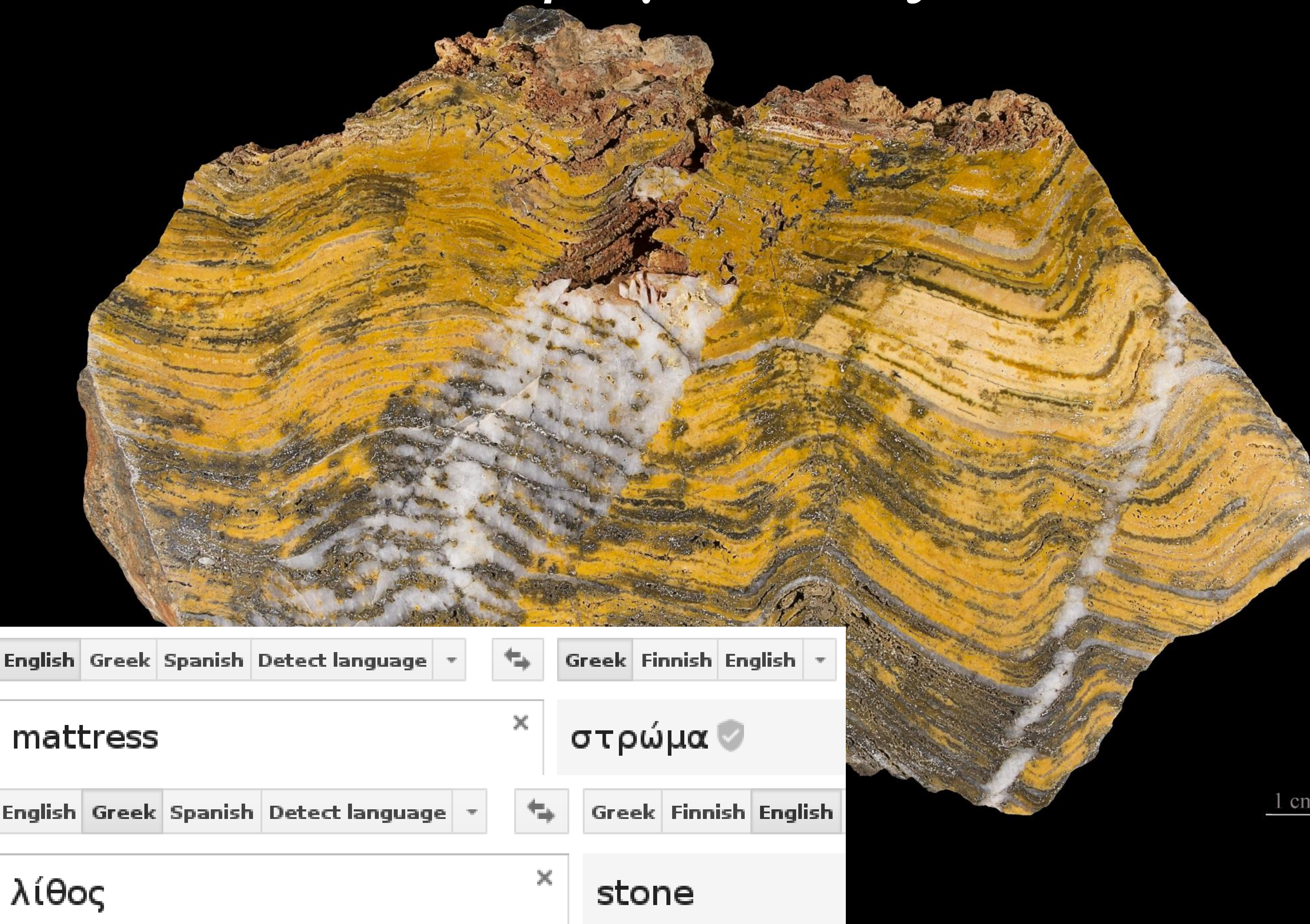
(Office hours: Mondays 2:30 – 3:30 in X590 and Wednesdays 11-12 in D230)

Modern stromatolites (Lect 14)

Stromatolites are

A. Iron-reducing lithotrophs extracting energy from the rocks they are living on
B. Photosynthesizing cyanobacteria growing on top of each other
C. Hydrothermal alkaline vents harboring methanogens that life of hydrogen and CO_2
D. sedimentary rocks in Western Australia where the oldest microfossils have been found

Στρώμα λίθος



More evidence for early life
Accumulation of organics

- Photosynthesizing cyanobacteria
- Grow on top of each other
- Layered structure

Martian atmosphere

Gas	%	Source	Sink
CO_2	95.3%	Evap, outgassing	condensation
N_2	2.7%	Outgassing	Escape
40Ar	1.2%	Outgassing	
O_2	0.1%	CO_2 photodiss	Photoreduction
CO	0.07%	CO_2 photodiss	Photooxidation
H_2O	0.03%	Evap./desorp.	Condens./adsorp.

Comparison

	CO_2	H_2O	N_2
Venus	1.0×10^{-6}	0.001×10^{-6}	2×10^{-6}
Earth	1.6×10^{-6}	280×10^{-6}	2.4×10^{-6}
Mars	0.08×10^{-6}	5×10^{-6}	0.04×10^{-6}

Mars really does have a problem

Lecture 13: Water loss on Venus

- Same reason as for Mars
- UV light: $H_2O \rightarrow H_2 + \frac{1}{2} O_2$
  → photolysis
- H_2 lost through thermal escape
- Why?

Thermal escape?

- Escape velocity?
  - Apollo 8 (Borman, Lowell, Anders)
- ½ $mv_e^2 = GMm/R$
  - $v_e = (2GM/R)^{1/2} = 11.2$ km/s
  - ½ $mv_H^2 = k_B T$
- H_2 is so light

M: mass of Earth
R: radius of Earth

Thermal escape velocity on Mars?

- $v_e = (2GM/R)^{1/2} = 11.2$ km/s

A. 4 times higher on Mars
B. 2 times higher on Mars
C. Same on Mars as on Earth
D. 2 times lower on Mars
E. 4 times lower on Mars

Both M and R are lower

- But density about the same
- Density = ρ = Mass/Volume ~ M/R^3
- So M ~ ρR^3
- $v_e = (2GM/R)^{1/2} \sim (2G\rho R^3/R)^{1/2}$
- $v_e = (2G\rho R^2)^{1/2} \sim (2G\rho)^{1/2} R$
- $v_e \sim R$

Again: escape velocity on Mars?

- $v_e = (2GM/R)^{1/2}$ = 11.2 km/s on Earth

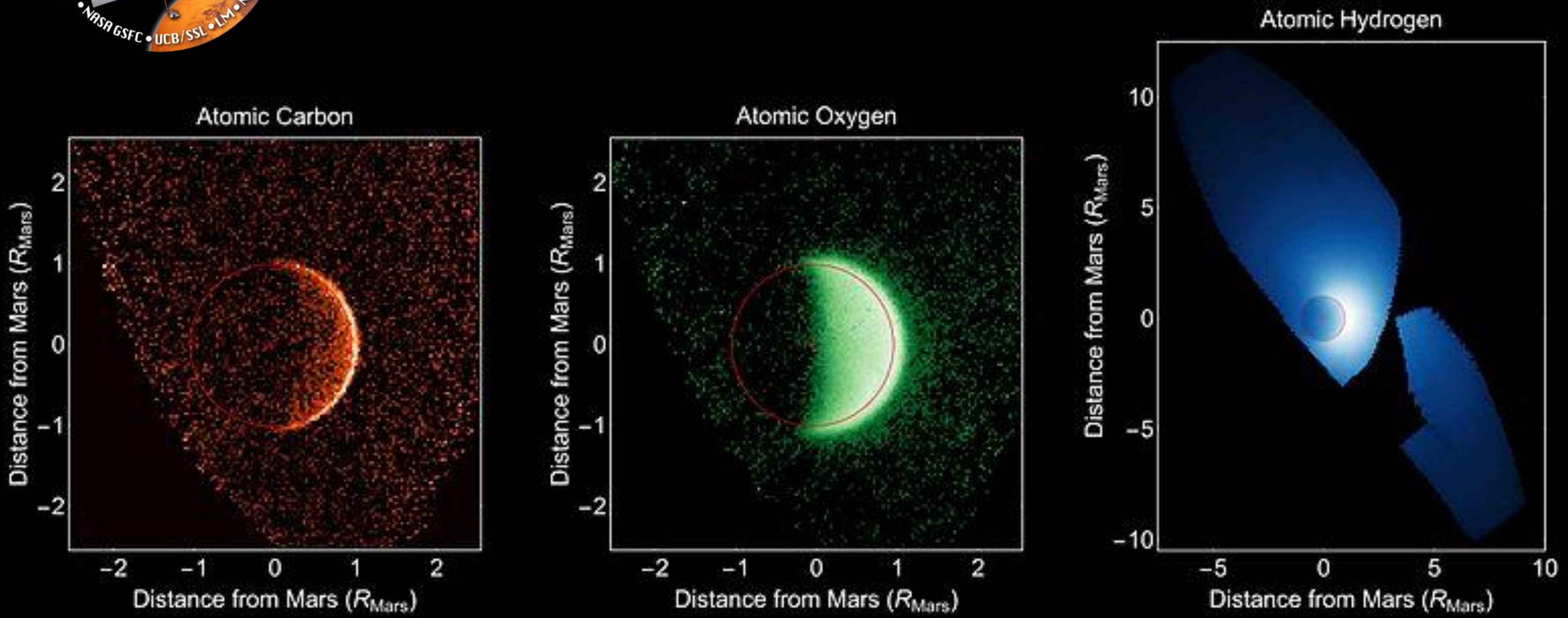
A. 4 times higher on Mars
B. 2 times higher on Mars
C. Same on Mars as on Earth
D. 2 times lower on Mars
E. 4 times lower on Mars

Again: escape velocity on Mars?

- $v_e = (2GM/R)^{1/2}$ = 11.2 km/s on Earth

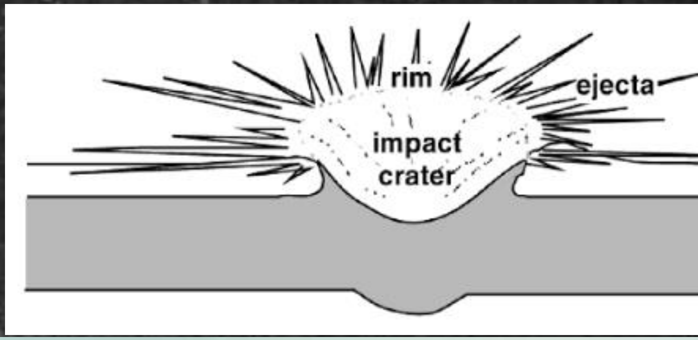
A. 4 times higher on Mars
B. 2 times higher on Mars
C. Same on Mars as on Earth
D. 2 times lower on Mars
E. 4 times lower on Mars

Stripping by solar wind



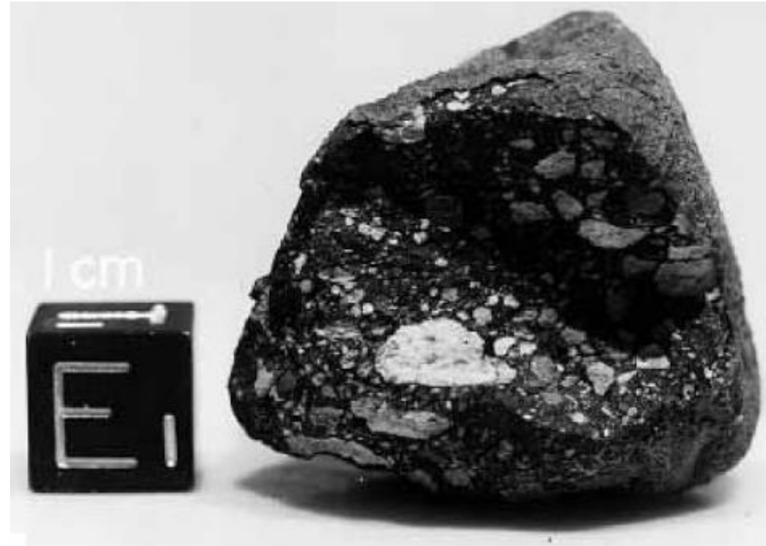
- Lightest molecules are seen to escape
- Mars lost 99% of its atmosphere

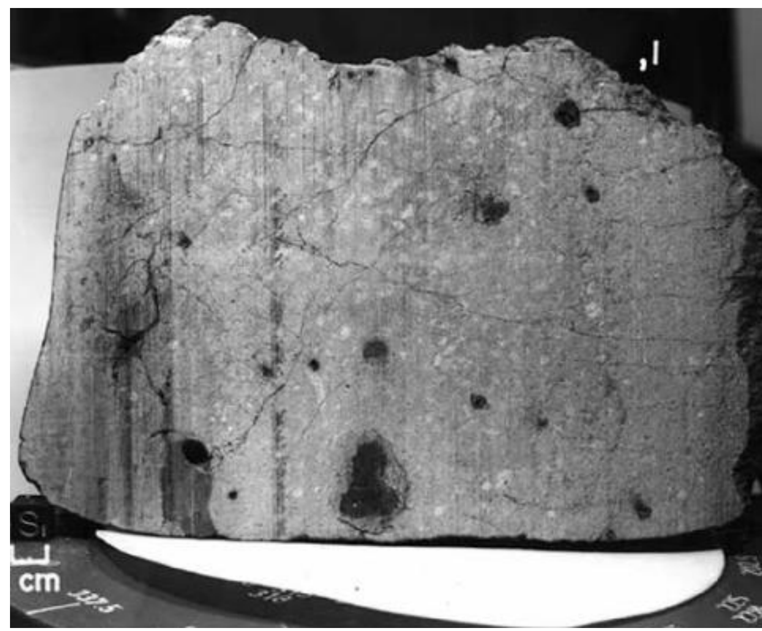
Meteorites from ejecta?



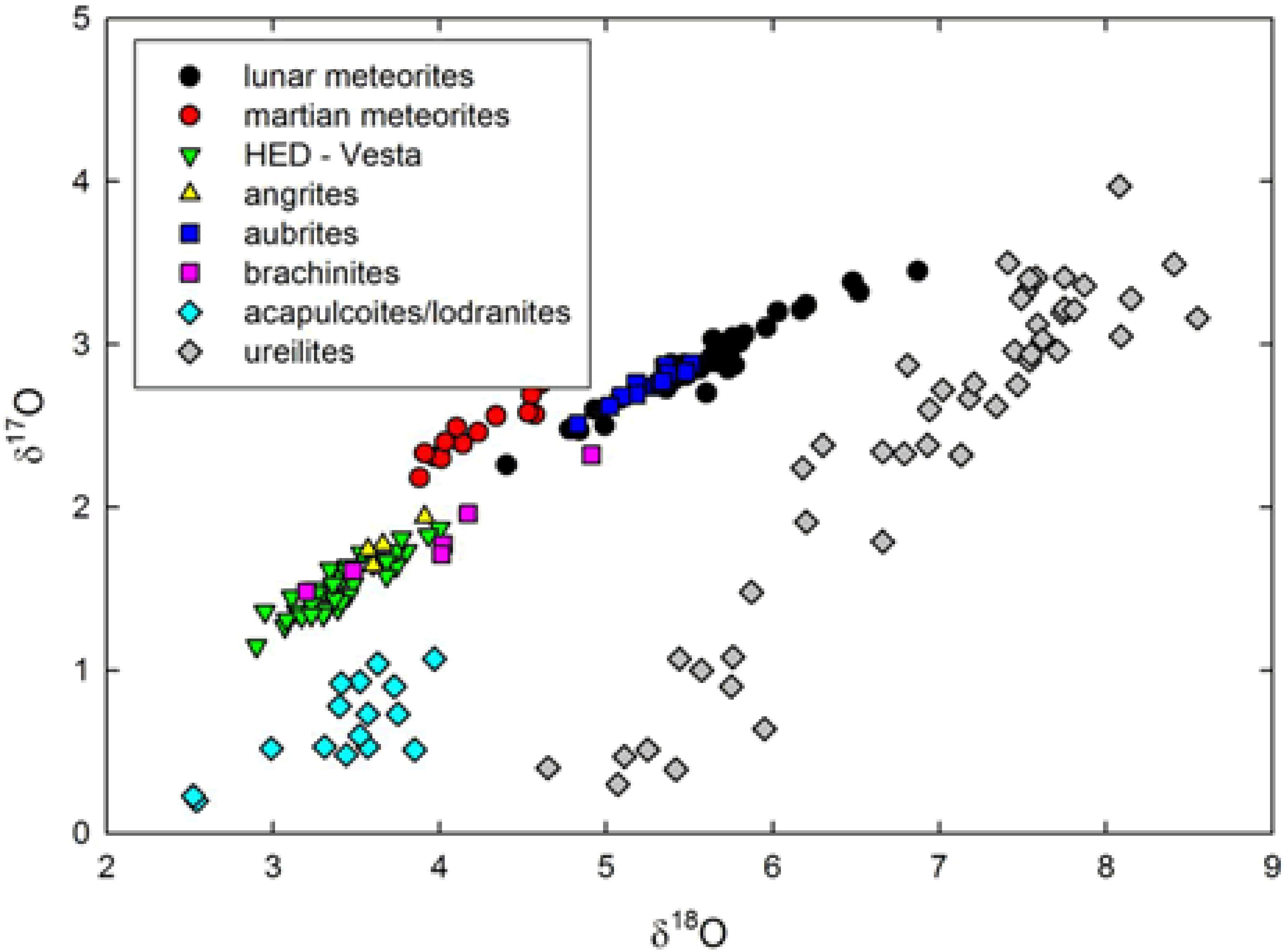
Meteorites from Moon or Mars?

- Ejecta from impacts thought implausible…
  - Apollo: 1969 – 1972
  - ALHA81005 first lunar meteorite (lunar highlands)
  - 31 g
- EETA79001
  - gases agreed w/ Viking
  - weathered basaltic rock, 8 kg

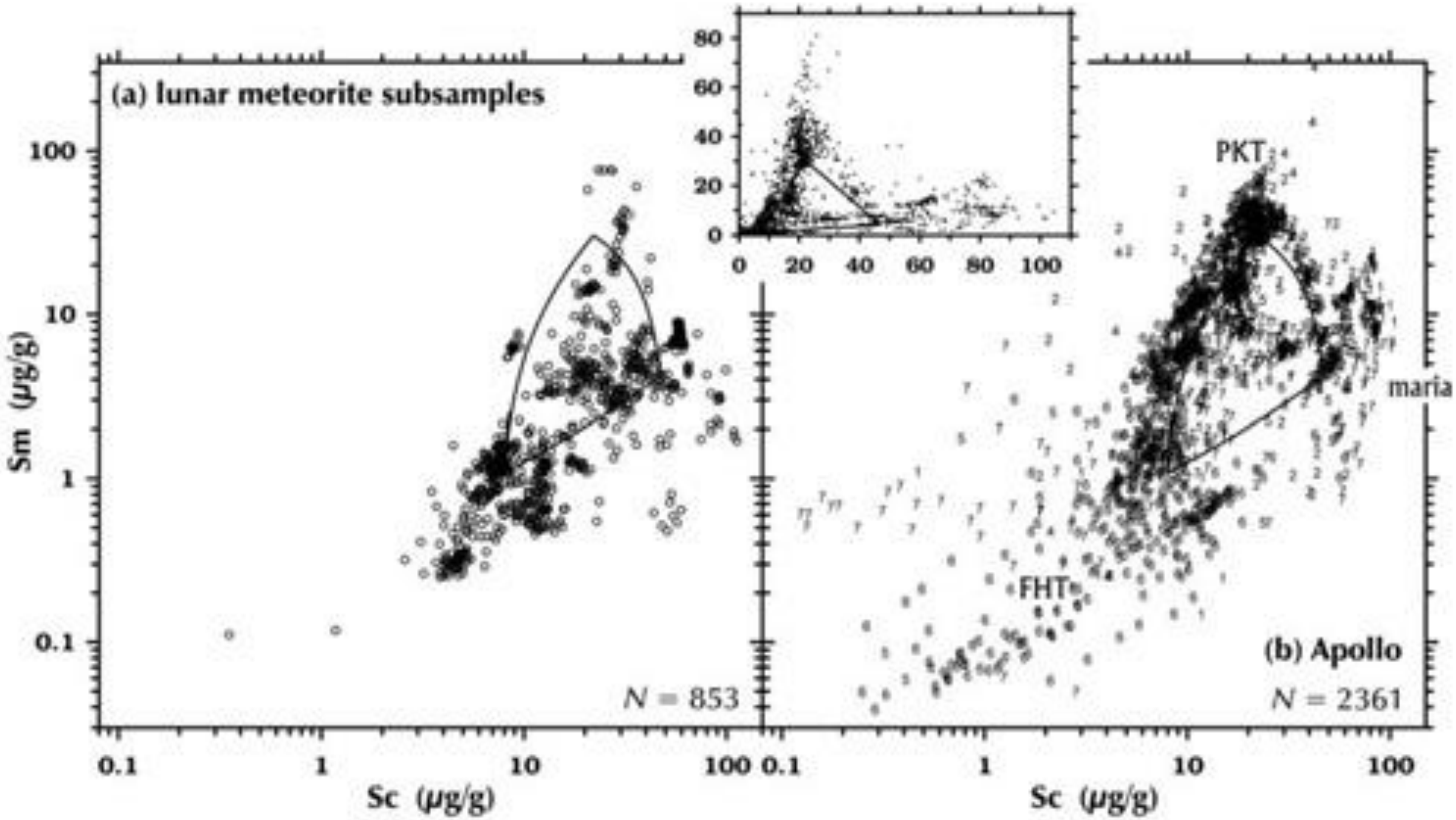




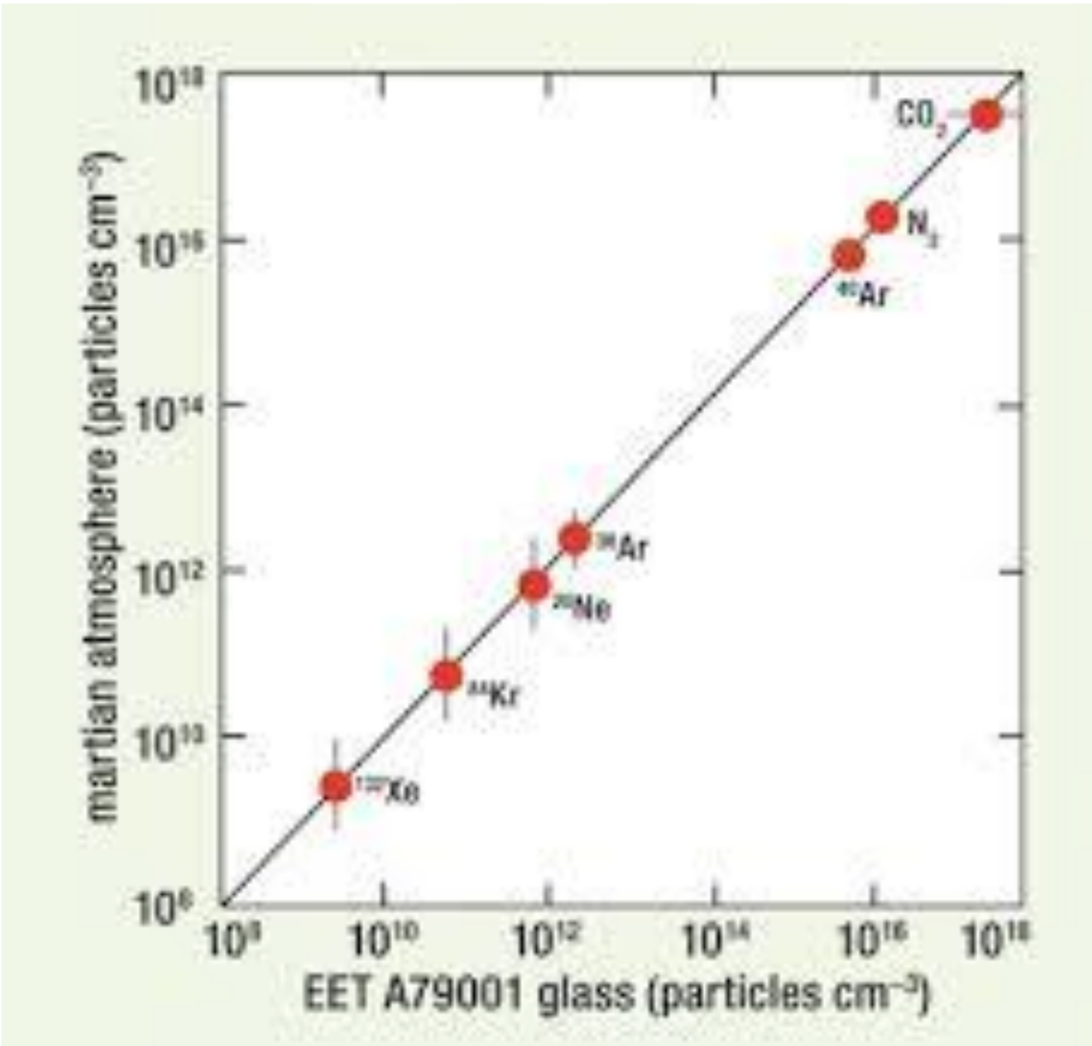
Initial classification



Mineralogical comparison



Martian atmosphere in meteorite



Gas	%		
CO_2	95.3%		
N_2	2.7%		
Ar	1.2%		
O_2	0.1%		
CO	0.07%		
H_2O	0.03%		

& many other isotopes

3rd most abundant element in Martian atmosphere?

A. Hydrogen
B. Helium
C. Neon
D. Argon
E. Nitrogen

3^{rd} most abundant element in Martian atmosphere?

A. Hydrogen
B. Helium
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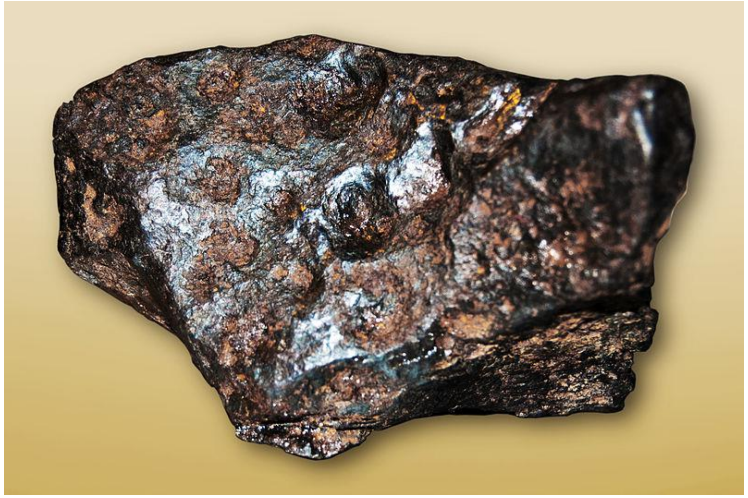
E. Nitrogen

ALH – Allan Hill – post office?



4.55 Gyr

50,000 yr

Because the United States Board on Geographic Names commonly recognizes names of natural features derived from the nearest post office, the feature acquired the name of "Meteor Crater" from the nearby post office named Meteor.[2] The site was formerly known as the **Canyon Diablo Crater** and fragments of the meteorite are officially called the Canyon Diablo Meteorite.[3] Scientists refer to the crater as **Barringer Crater** in honor of Daniel

Allan Hills nearest post office?

Coordinates: 51.386°N 106.045°W

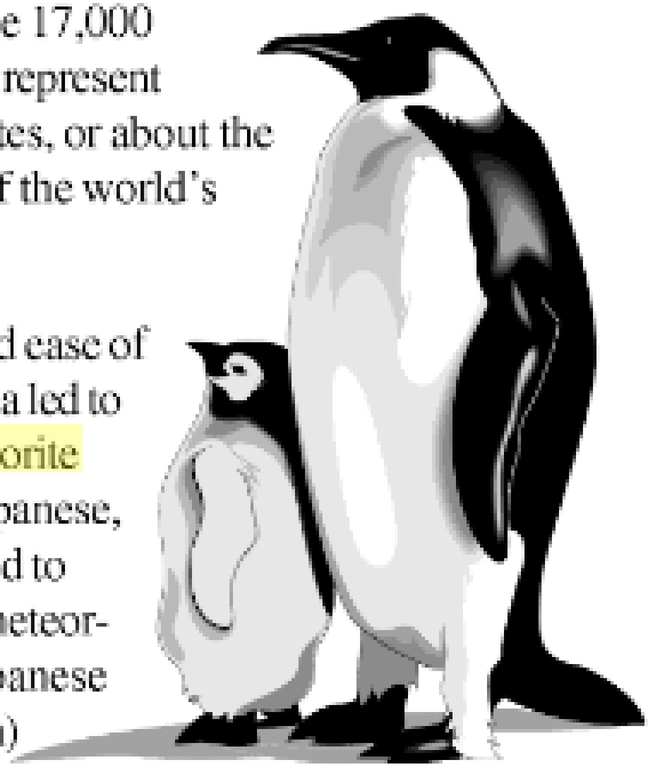
The Allan Hills Post office was located at Sec 22 Twp 31 R1 W3 from July 1, 1919 to closing on Dec 31, 1951. Another post office was open for a short time from August 1, 1914 to April 1, 1918 on Sec 15 in the same Township.[5]

But it fell in Antarctica

ALH84001[1]) is a meteorite that was found in Allan Hills, Antarctica on December 27, 1984 by a team of U.S. meteorite hunters from the ANSMET project. Like other members of the group of SNCs (shergottite, nakhlite, chassignite), ALH84001 is thought to be from Mars. However, it

shower. It is estimated that the 17,000 Antarctic meteorite fragments represent about 3,000 separate meteorites, or about the same as the total for the rest of the world's collection. (See Lesson 18)

The concentration process and ease of finding meteorites in Antarctica led to national and international meteorite programs organized by the Japanese, Americans and Europeans, and to yearly expeditions to collect meteor-ites. The Japanese JARE (Japanese Antarctic Research Expedition)



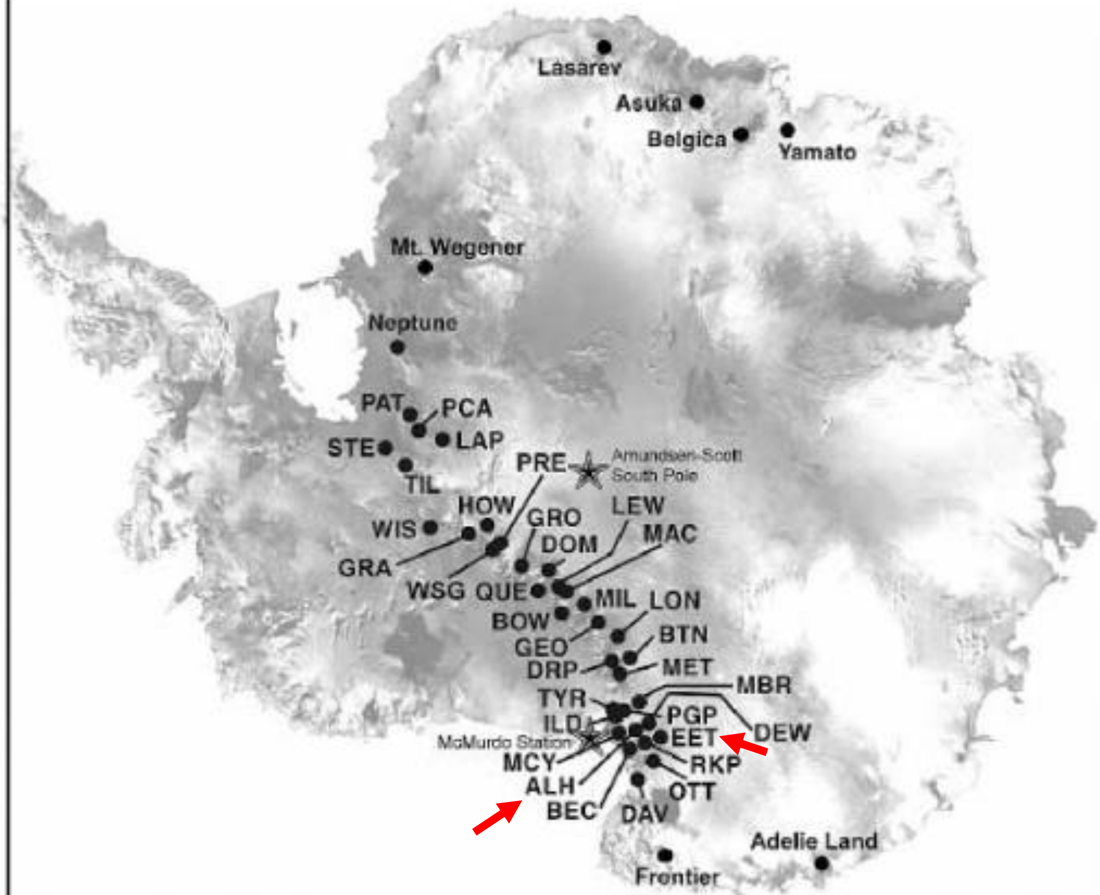
Sherghati 1865, El-Nakhla 1911, Chassigny 1815
+ ungrouped ones → pyroxene [Greek: fire+stranger]

Post offices in Antarctica

Naming Meteorites

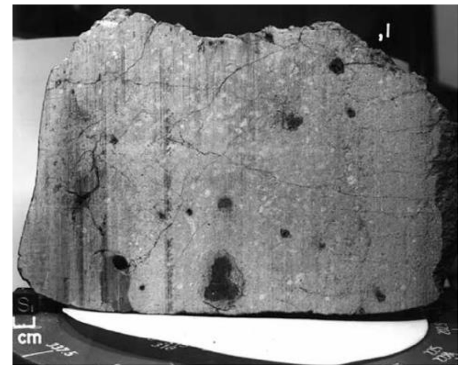
Noblesville, Allende
Sikhote-Alin
Canyon Diablo
Gibeon, Brenham
ALH90411, EET83227

Meteorites are named after the nearest town (Noblesville, IN) or post office so their names are often picturesque. Because meteorites have been found the world over, the list of meteorite names looks like a geography lesson. When meteorites are found far from towns, they may be named after their county of origin (Sioux County, NB), or after a nearby river (Calkalong Creek,



***Antarctic meteorite locations**. Meteorites are found mostly along the 3,000 km Transantarctic Mountains that diagonally cut the continent. These sites are remote from the U.S. research stations South Pole and McMurdo (indicated with stars).*

*ALH – Allan Hill, EET – **Elephant** Moraine*

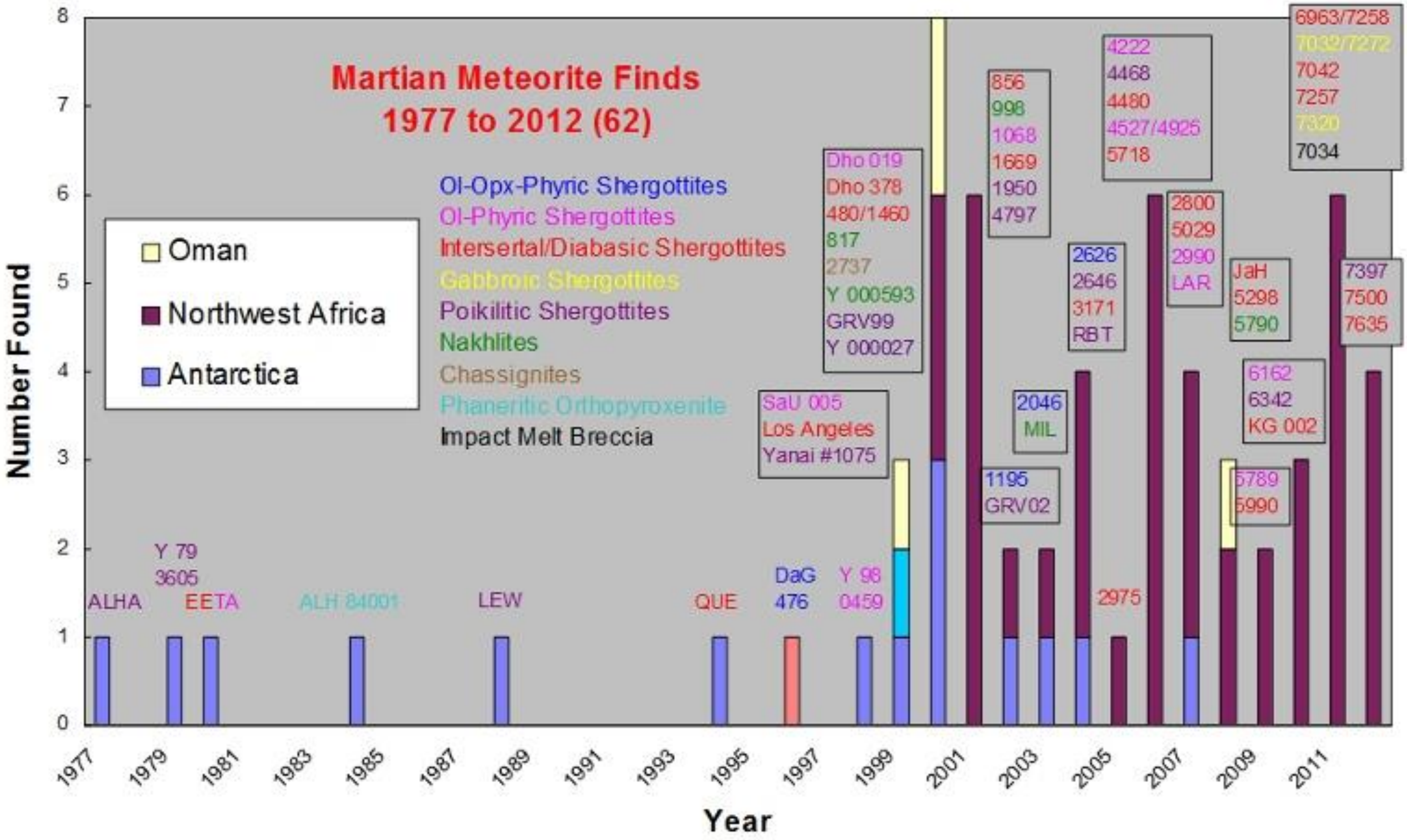


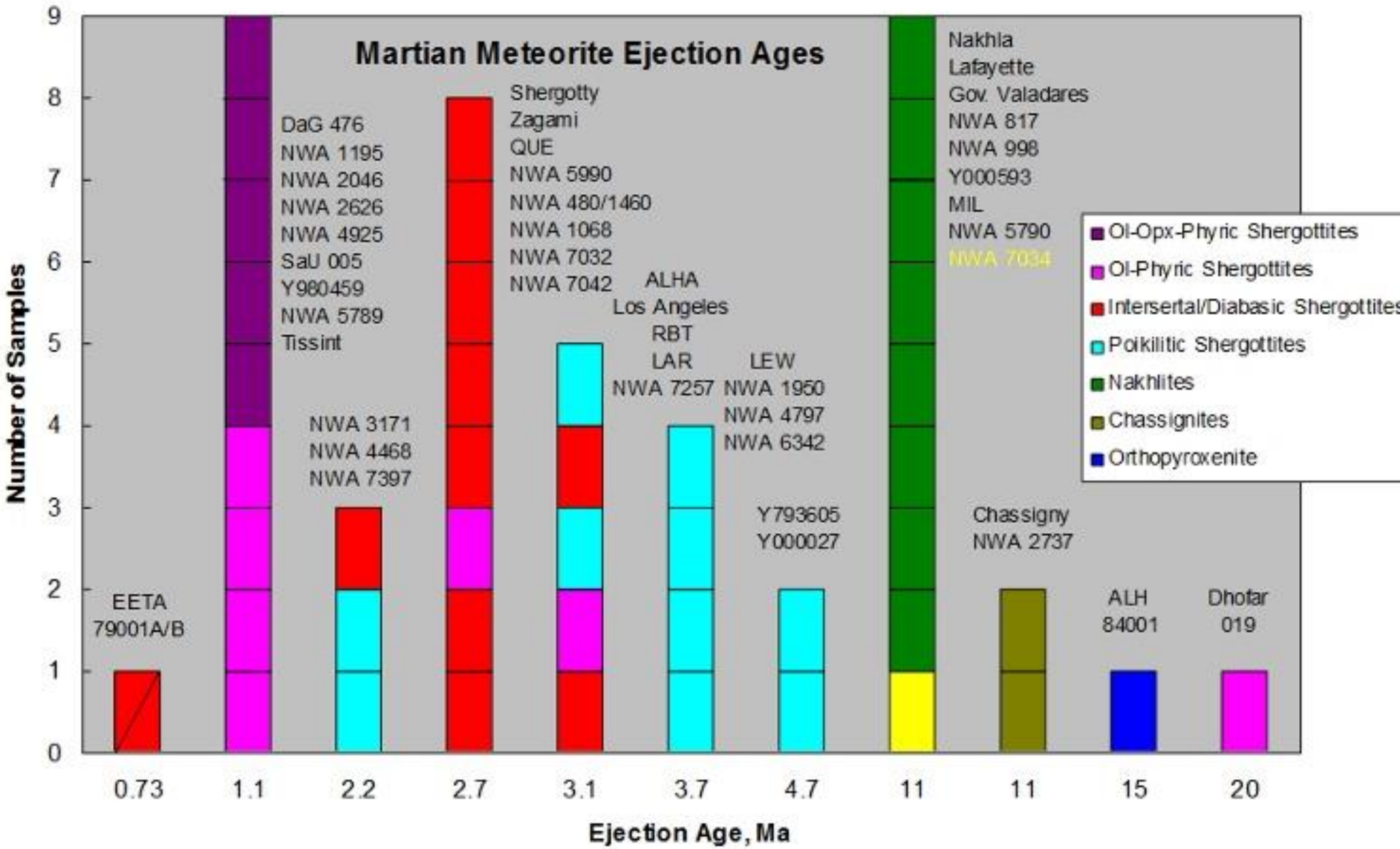
�Two common misconceptions about meteorite names are widespread: that meteorites should be named for the nearest post office; and, that meteorites should be named for populated places such as towns.� Neither of these is correct.

A new meteorite shall be named after a geographical locality near to the location of its initial recovery�. Every effort should be made to avoid unnecessary duplication or ambiguity, and to select a permanent feature which appears on widely used maps and is sufficiently close to the recovery site to convey meaningful locality information. Acceptable

Martian meteorites

in 1996: Mars 6 (press conf)
in 1997: Mars 12, Moon 15
in 2010: Moon 134
in 2014: Mars 132




Martian Meteorite Ejection Ages
Number of Samples
Ejection Age, Ma
0.73
1.1
2.2
2.7
3.1
3.7
4.7
11
11
15
20
EETA 79001A/B
DaG 476
NWA 1195
NWA 2046
NWA 2626
NWA 4925
SaU 005
Y980459
NWA 5789
Tissint
NWA 3171
NWA 4468
NWA 7397
Shergotty
Zagami
QUE
NWA 5990
NWA 480/1460
NWA 1068
NWA 7032
NWA 7042
ALHA
Los Angeles
RBT
LAR
NWA 7257
LEW
NWA 1950
NWA 4797
NWA 6342
Y793605
Y000027
Nakhla
Lafayette
Gov. Valadares
NWA 817
NWA 998
Y000593
MIL
NWA 5790
NWA 7034
Chassigny
NWA 2737
ALH 84001
Dhofar 019
Ol-Opx-Phyric Shergottites
Ol-Phyric Shergottites
Intersertal/Diabasic Shergottites
Poikilitic Shergottites
Nakhlites
Chassignites
Orthopyroxenite

ALH 84001's History

- 4.1 Gyr solidified from molten rock in southern highlands
- 4.0 – 4.1 Gyr: affected by nearby impact, but not ejected (shock metamorphism)
- 3.9 Gyr: infiltrated by water → carbonate grains at $+18^{o}$C, according to oxygen isotope

01 – 0.2 mm

- 0.016 Gyr = 16 Myr: blasted into space
- 0.013 Myr = 13,000 yr: fell in Antarctica
- 1984 found, 1993 recognized as Martian, → 1996

Wednesday

- More on ALH 84001
- Methane
- Meteorites
  - RGS pp. 109 – 119