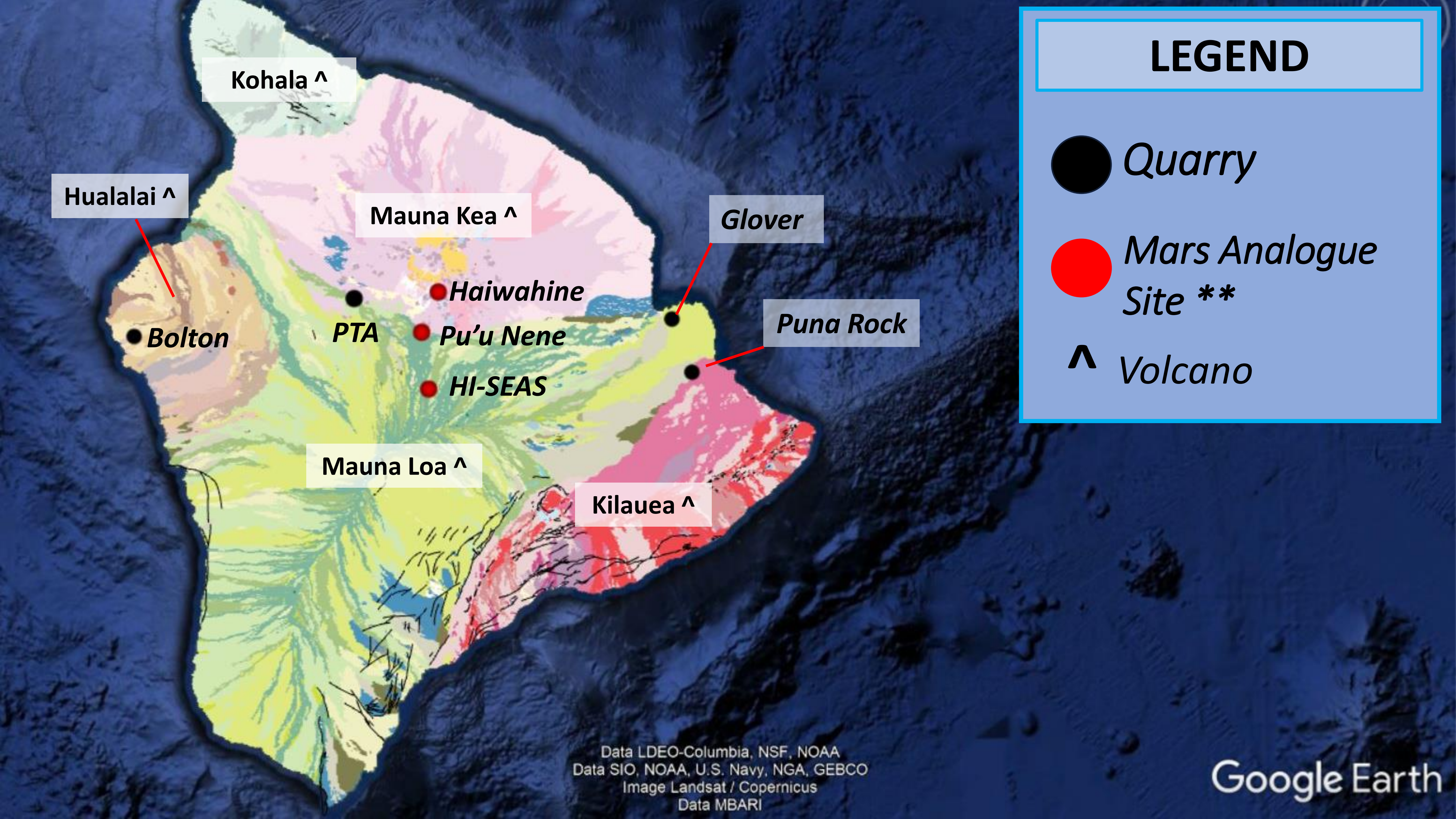
PISCES
Pacific International Space Center for Exploration Systems

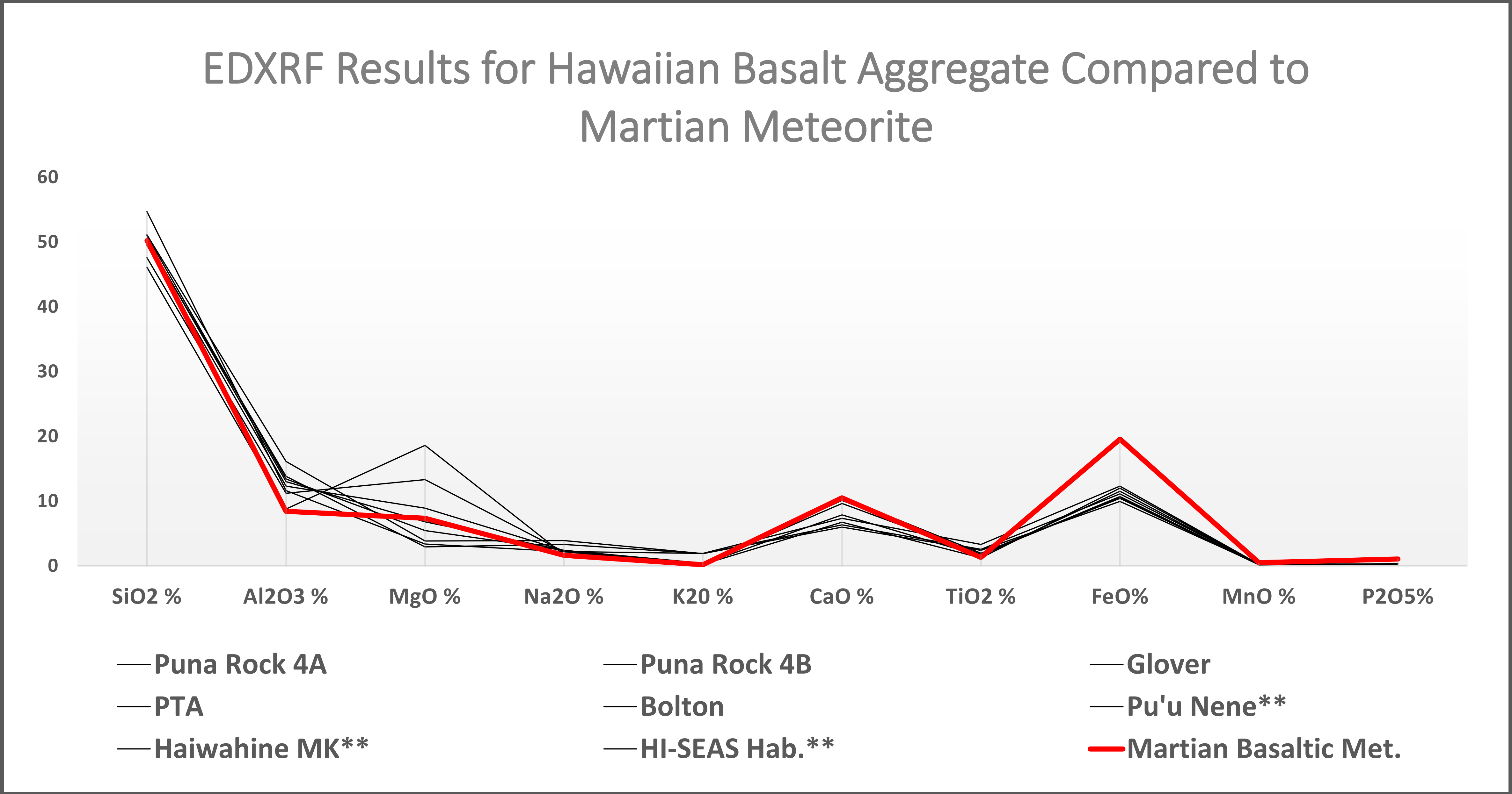
CHARACTERIZATION OF HAWAIIAN BASALT AGGREGATE & THE EFFECTS OF CHEMICAL COMPOSITION ON SINTERABILITY:

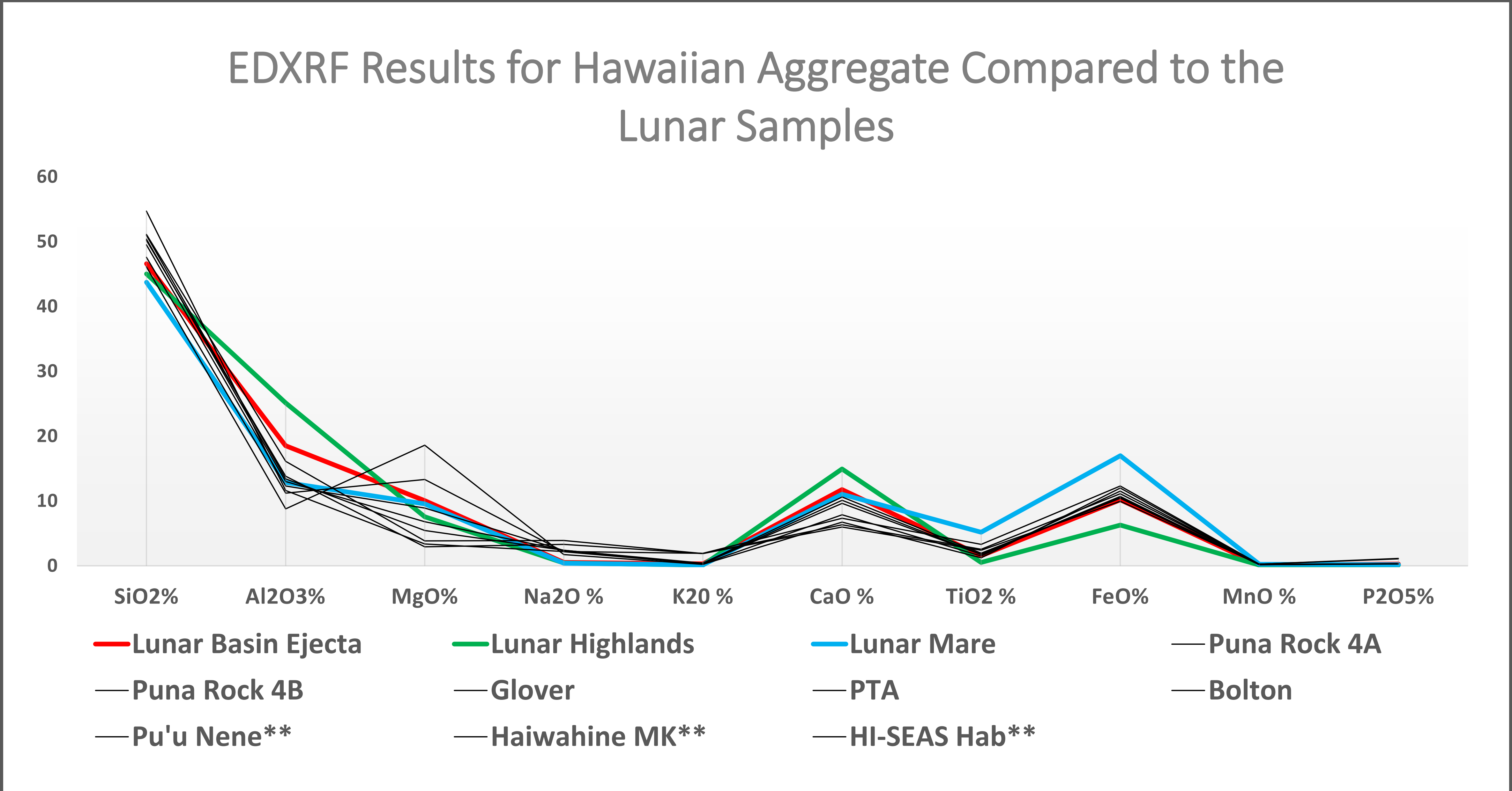
Implications for Future Lunar/Mars ISRU Applications.

Kyla Edison (Defore), Christian Andersen, Rodrigo Romo, Kye Harford & Kylie Higaki

Can a durable construction material be produced from basalts of varying chemical compositions?


Kohala ^
Hualalai ^
Mauna Kea ^
Glover
Haiwahine
PTA
Pu'u Nene
Bolton
Puna Rock
HI-SEAS
Mauna Loa ^
Kilauea ^
LEGEND
Quarry
Mars Analogue Site **
^ Volcano
Data LDEO-Columbia, NSF, NOAA
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
Data MBARI
Google Earth


EDXRF Results for Hawaiian Basalt Aggregate Compared to Martian Meteorite
60
50
40
30
20
10
0
SiO2 %
Al2O3 %
MgO %
Na2O %
K20 %
CaO %
TiO2 %
FeO%
MnO %
P2O5%
Puna Rock 4A
Puna Rock 4B
Glover
PTA
Bolton
Pu'u Nene**
Haiwahine MK**
HI-SEAS Hab.**
Martian Basaltic Met.


EDXRF Results for Hawaiian Aggregate Compared to the Lunar Samples
60
50
40
30
20
10
0
SiO2%
Al2O3%
MgO%
Na2O %
K20 %
CaO %
TiO2 %
FeO%
MnO %
P2O5%
Lunar Basin Ejecta
Lunar Highlands
Lunar Mare
Puna Rock 4A
Puna Rock 4B
Glover
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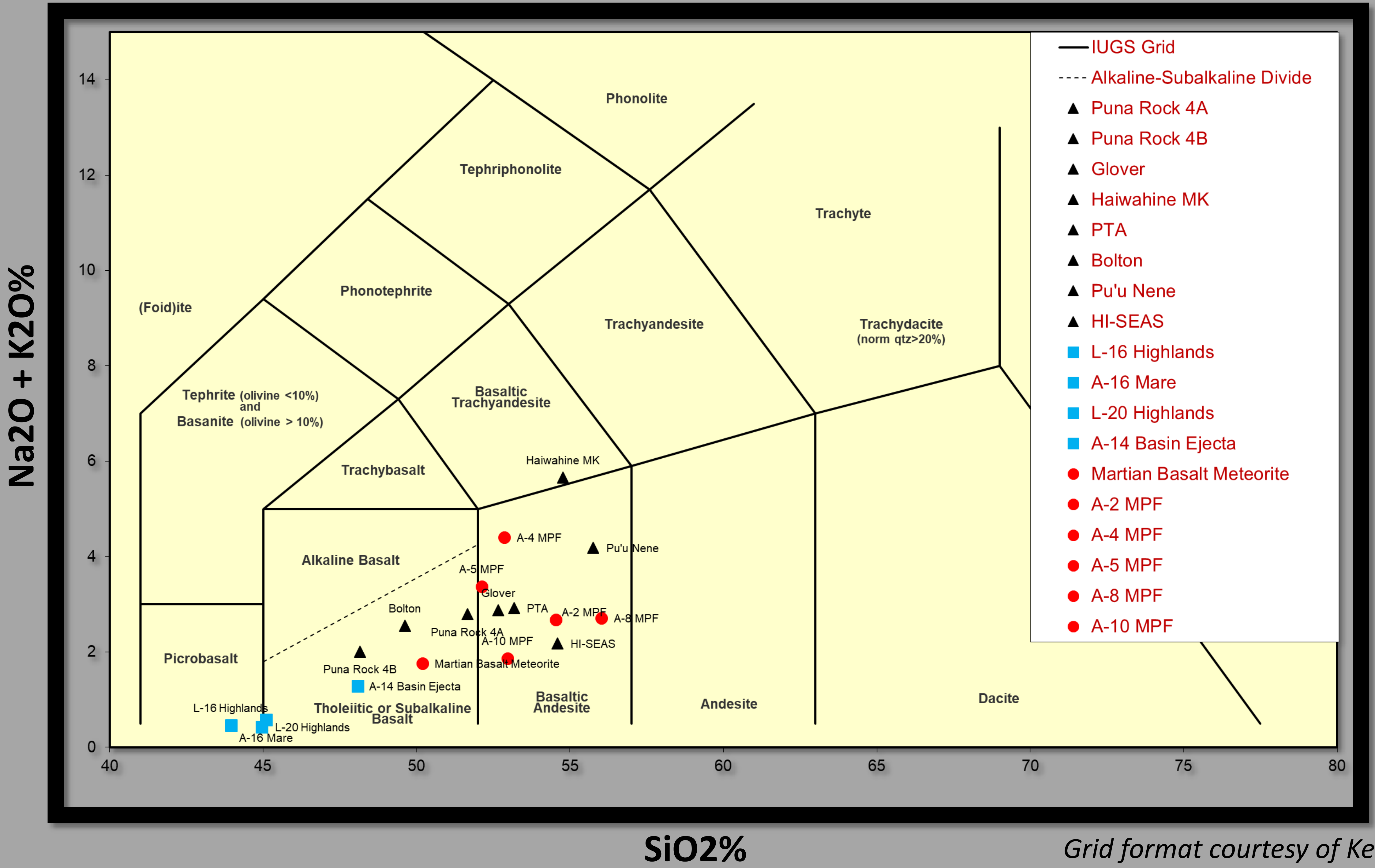
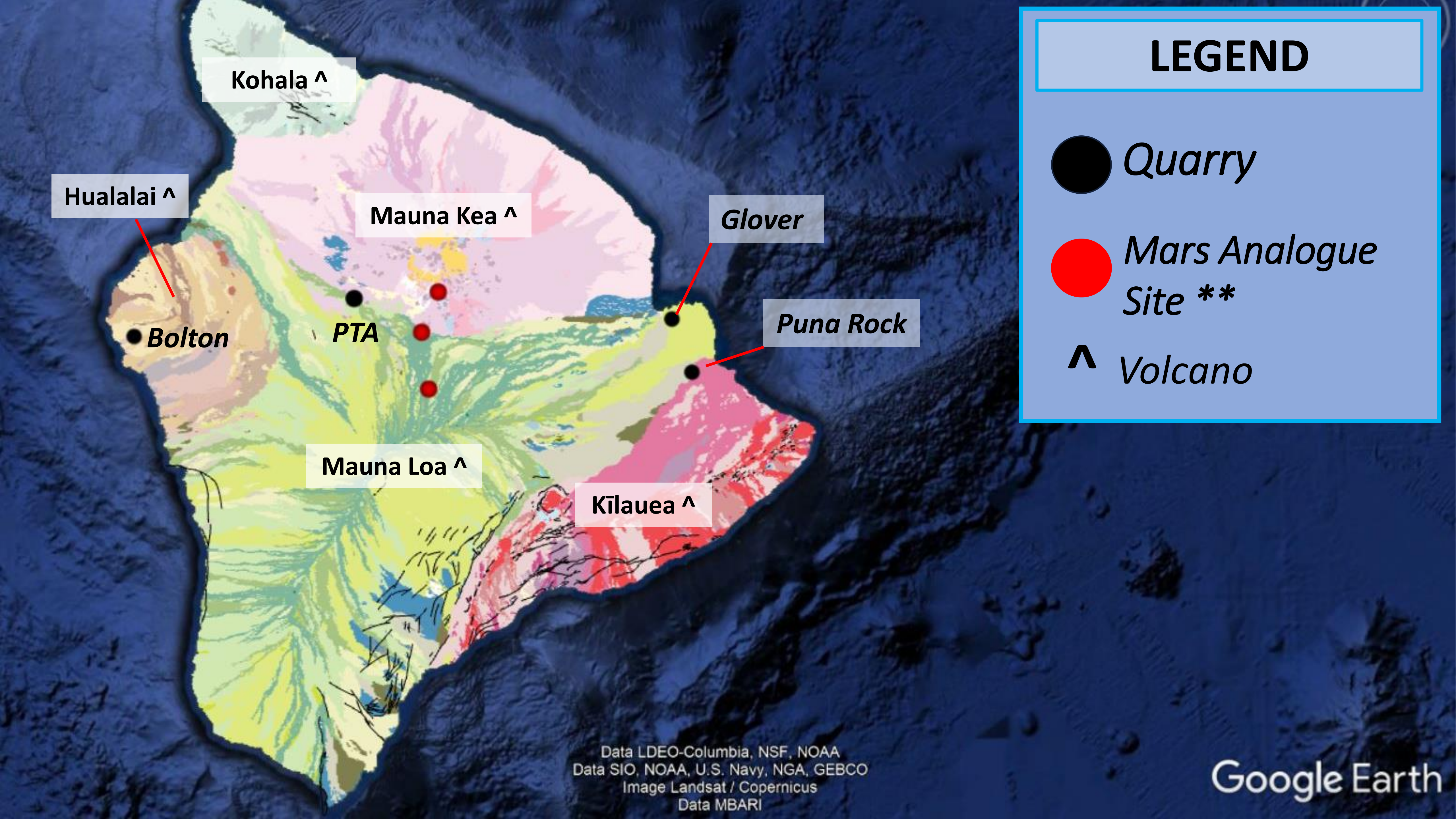


Grid format courtesy of Ken Hon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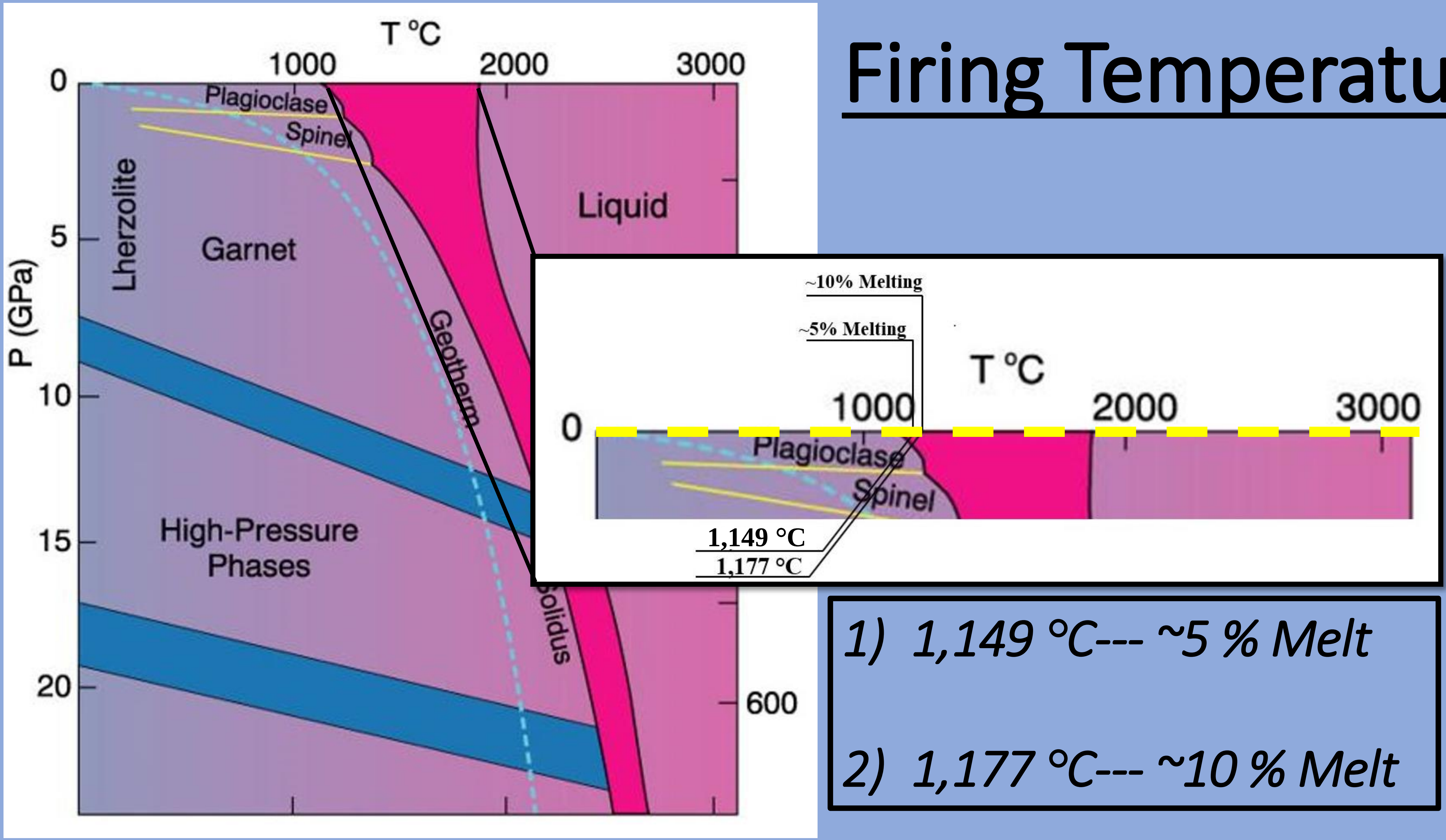
Google Earth

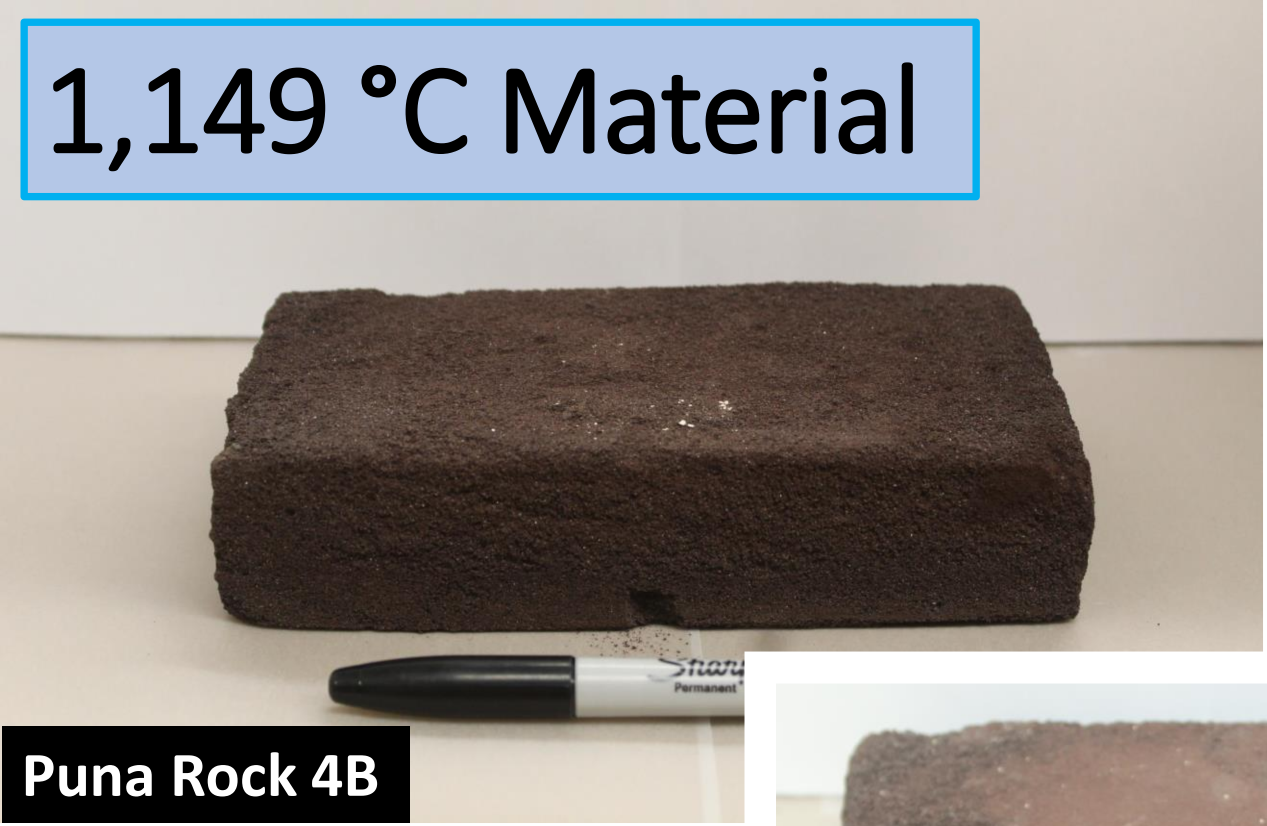
Firing Temperatures



1) *1,149 °C--- ~5 % Melt*

2) *1,177 °C--- ~10 % Melt*

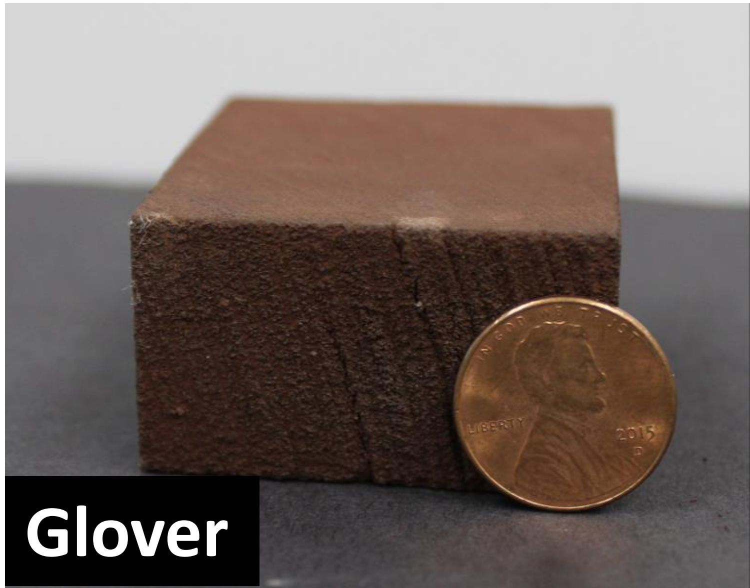
1,149 °C Material

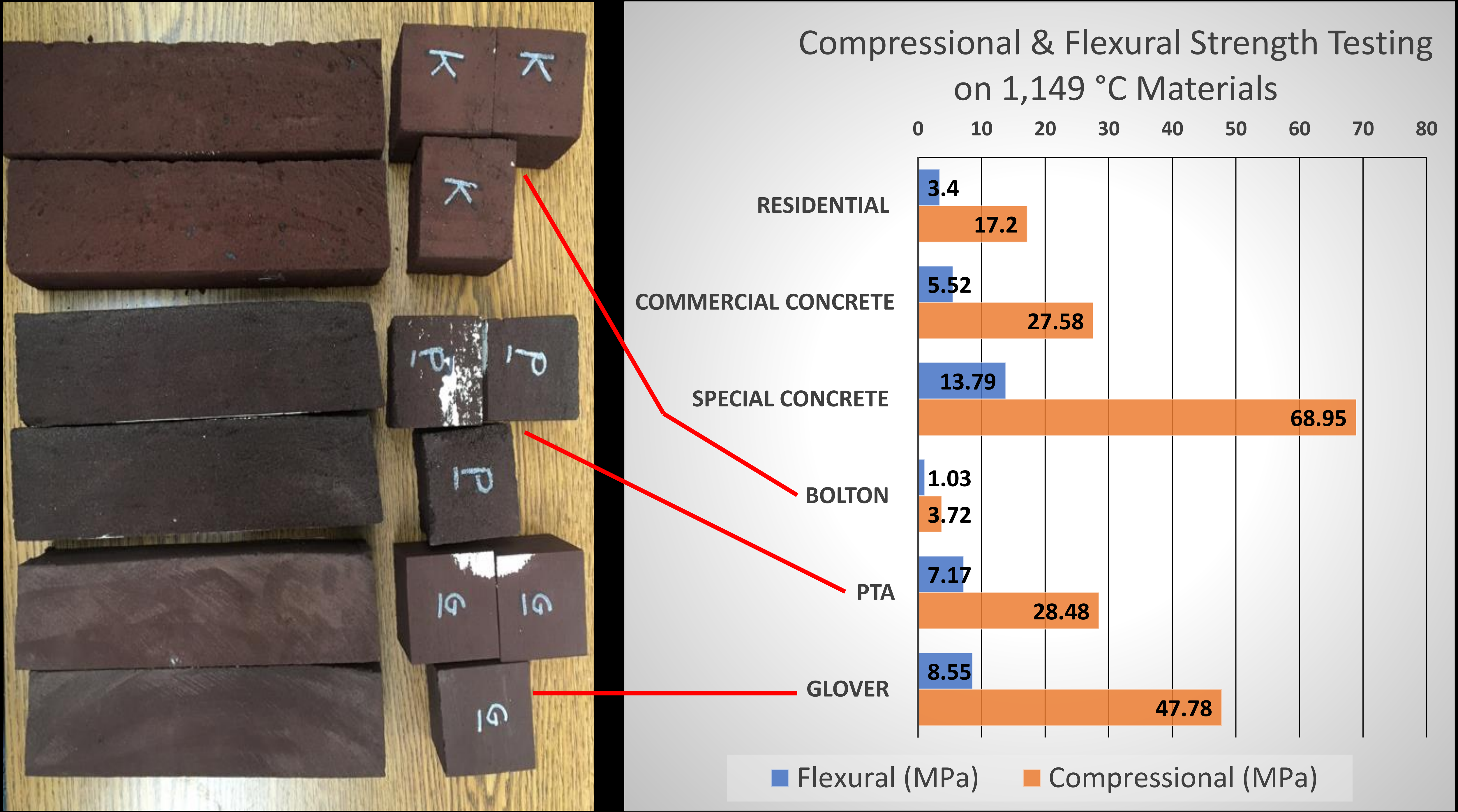

Puna Rock 4B


PTA

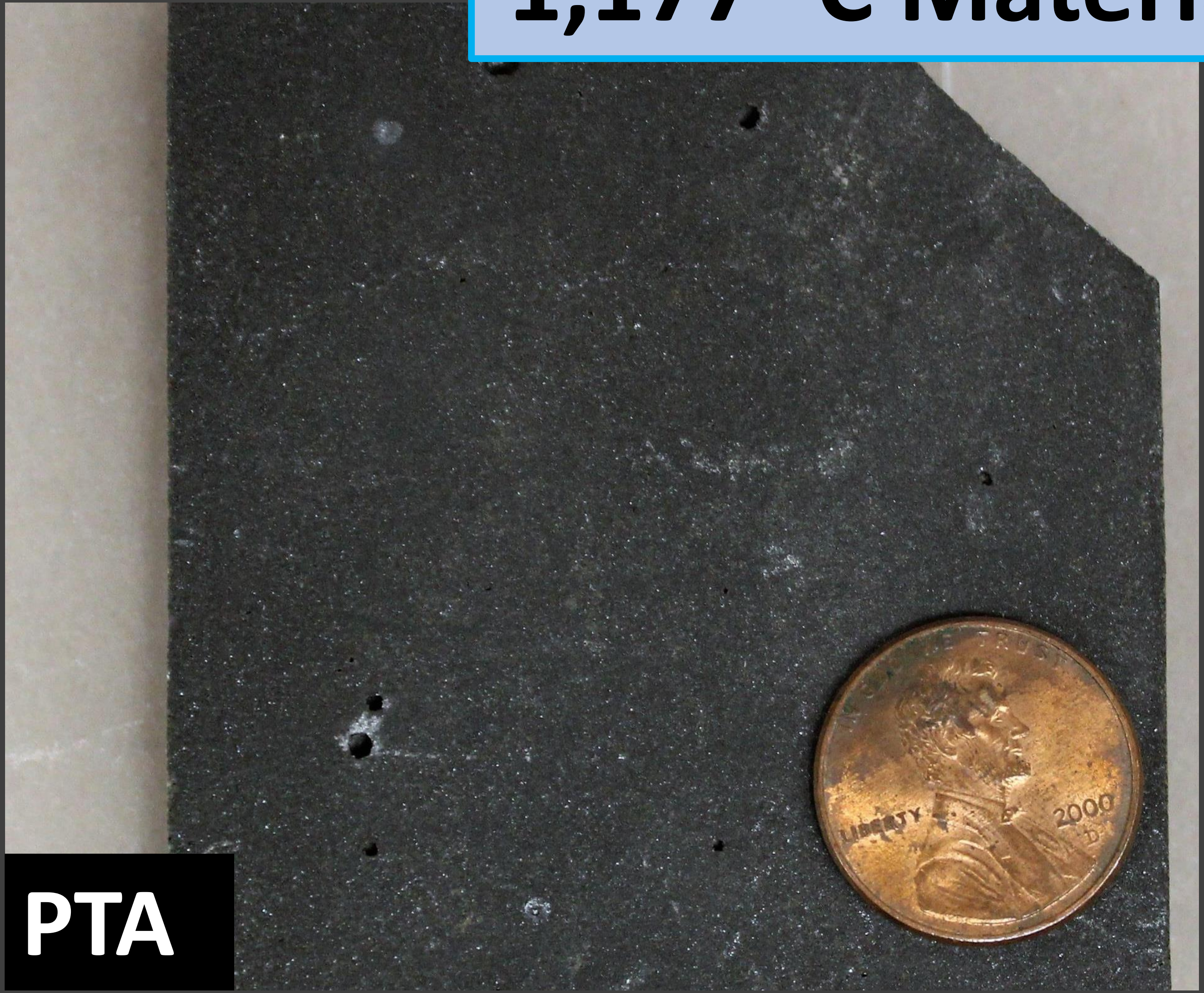

Bolton

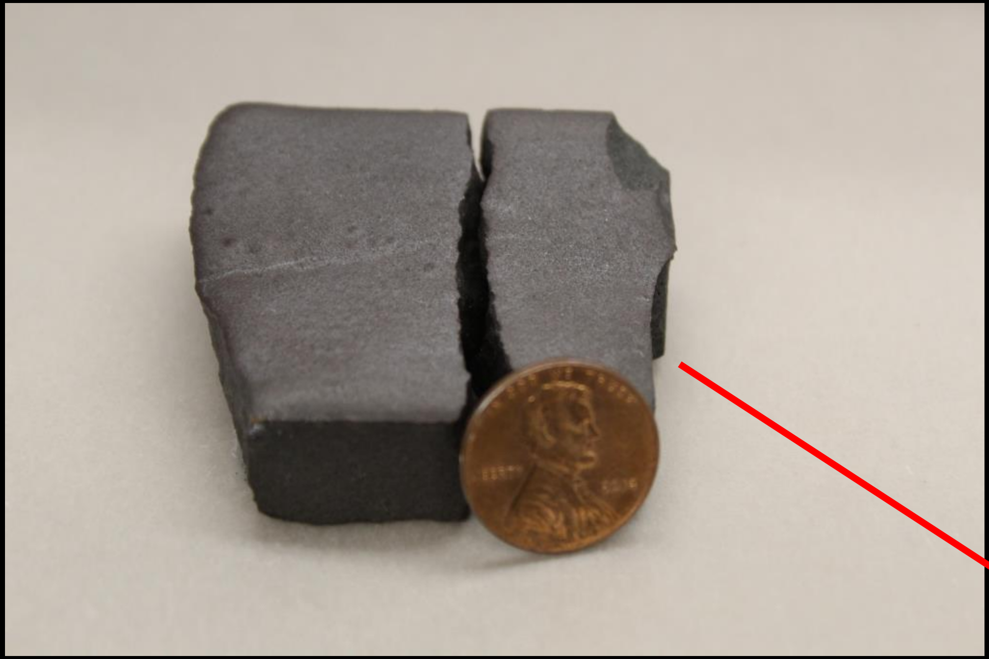

Puna Rock 4A

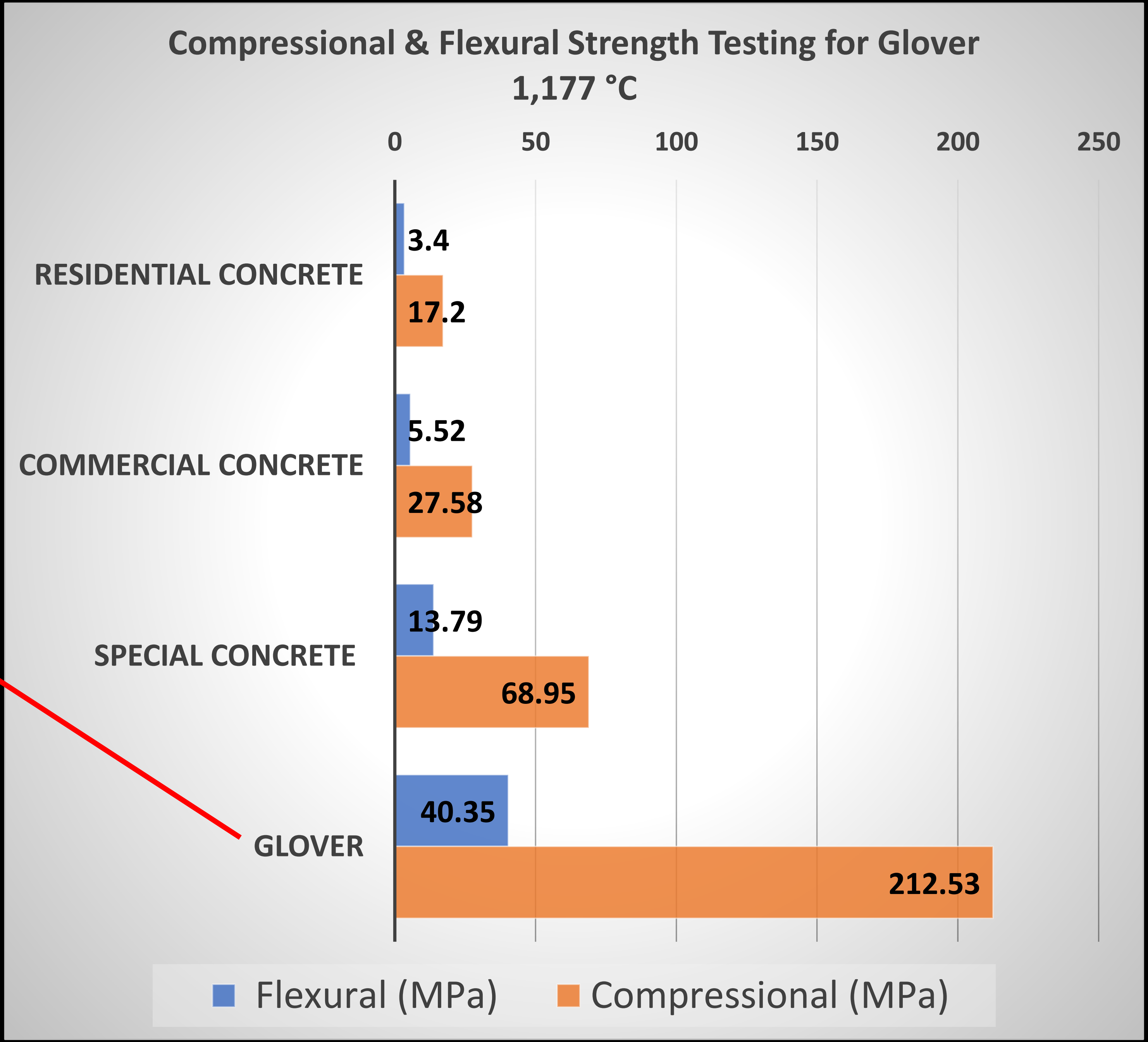

Glover

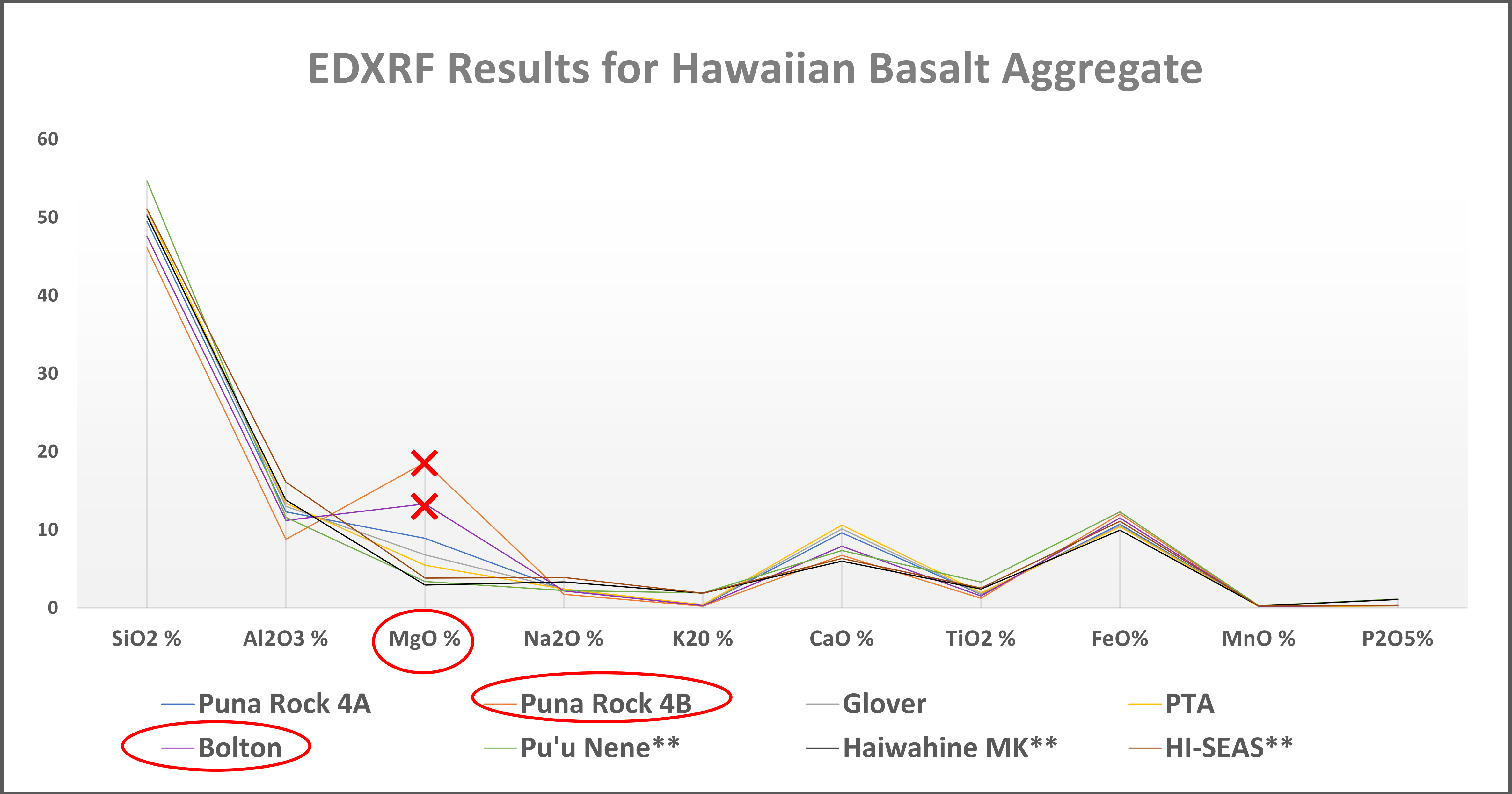

Compressional & Flexural Strength Testing on 1,149 °C Materials
0
10
20
30
40
50
60
70
80
RESIDENTIAL
3.4
17.2
COMMERCIAL CONCRETE
5.52
27.58
SPECIAL CONCRETE
13.79
68.95
BOLTON
1.03
3.72
PTA
7.17
28.48
GLOVER
8.55
47.78
Flexural (MPa)
Compressional (MPa)

1,177 °C Material






Compressional & Flexural Strength Testing for Glover
1,177 °C
0
50
100
150
200
250
RESIDENTIAL CONCRETE
3.4
17.2
COMMERCIAL CONCRETE
5.52
27.58
SPECIAL CONCRETE
13.79
68.95
GLOVER
40.35
212.53
Flexural (MPa)
Compressional (MPa)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SiO2 %
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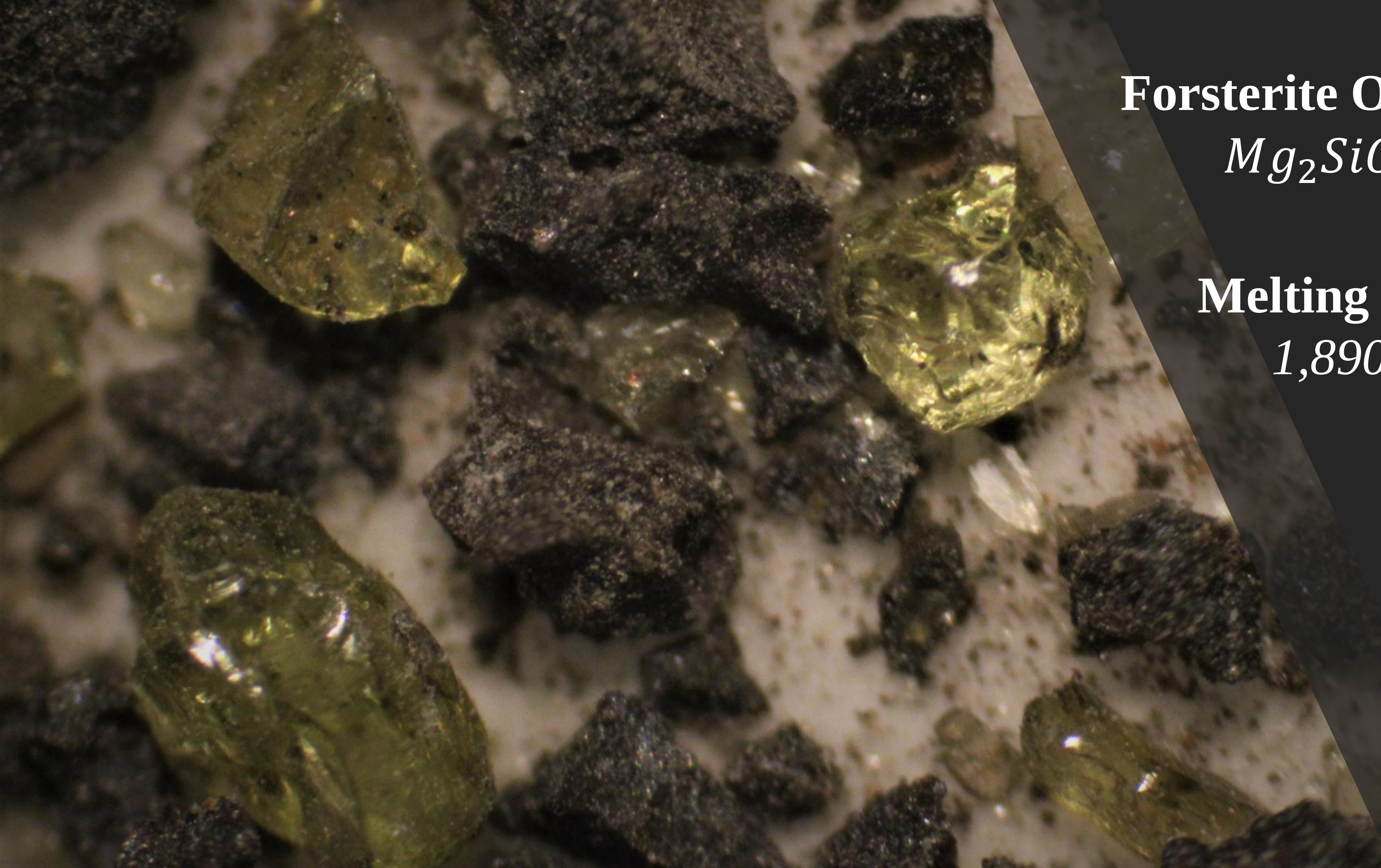
K20 %
CaO %
TiO2 %
FeO%
MnO %
P2O5%
Puna Rock 4A
Puna Rock 4B
Glover
PTA
Bolton
Pu'u Nene**
Haiwahine MK**
HI-SEAS**

How does an abundance of olivine affect sinterability?



Forsterite Olivine:

Mg_2SiO_4

Melting Point:

1,890 °C

X-Ray Diffraction (XRD) Mineralogy Results for Hawaiian Basalt Aggregate

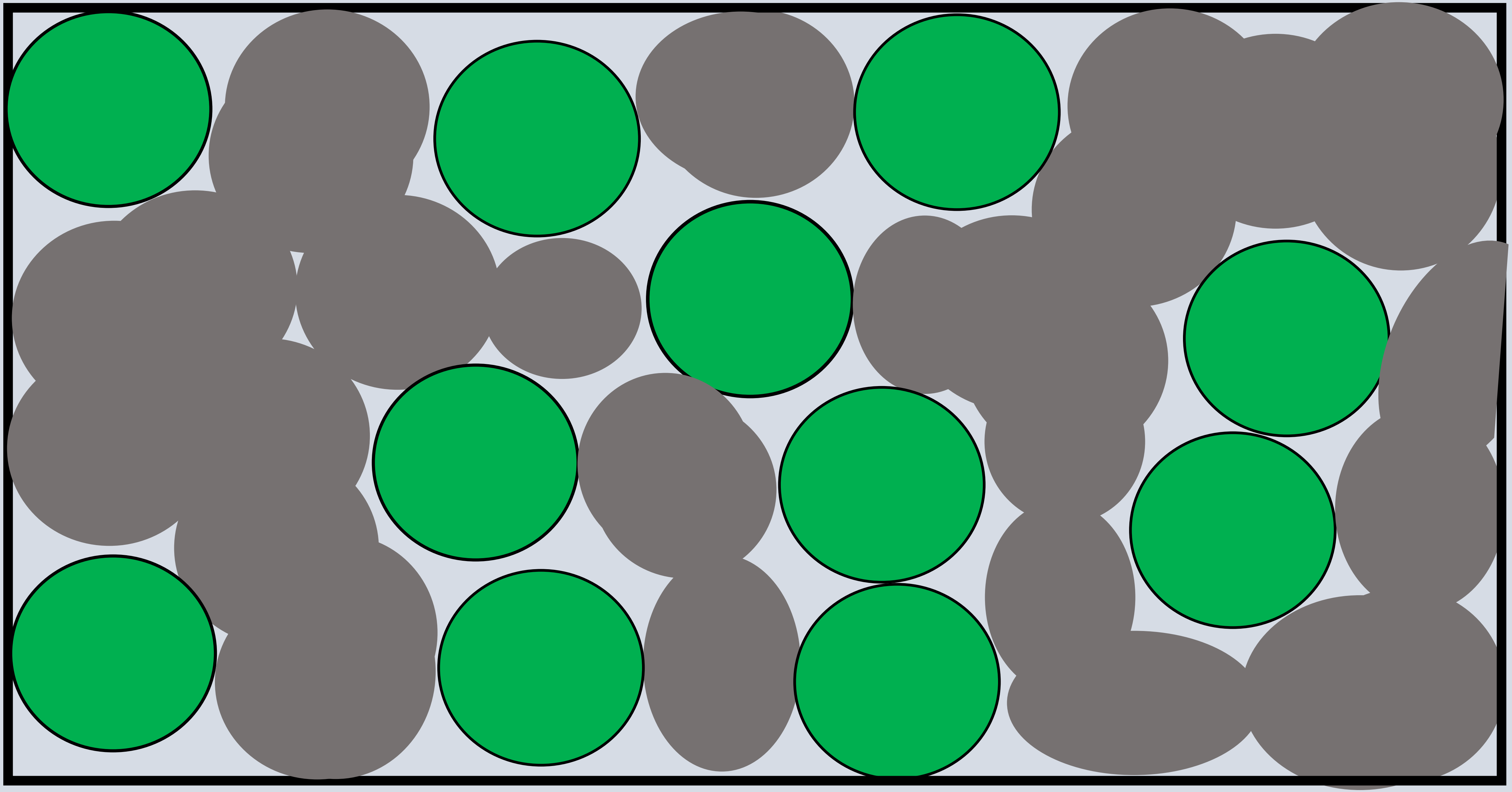
^ Volcano of origin

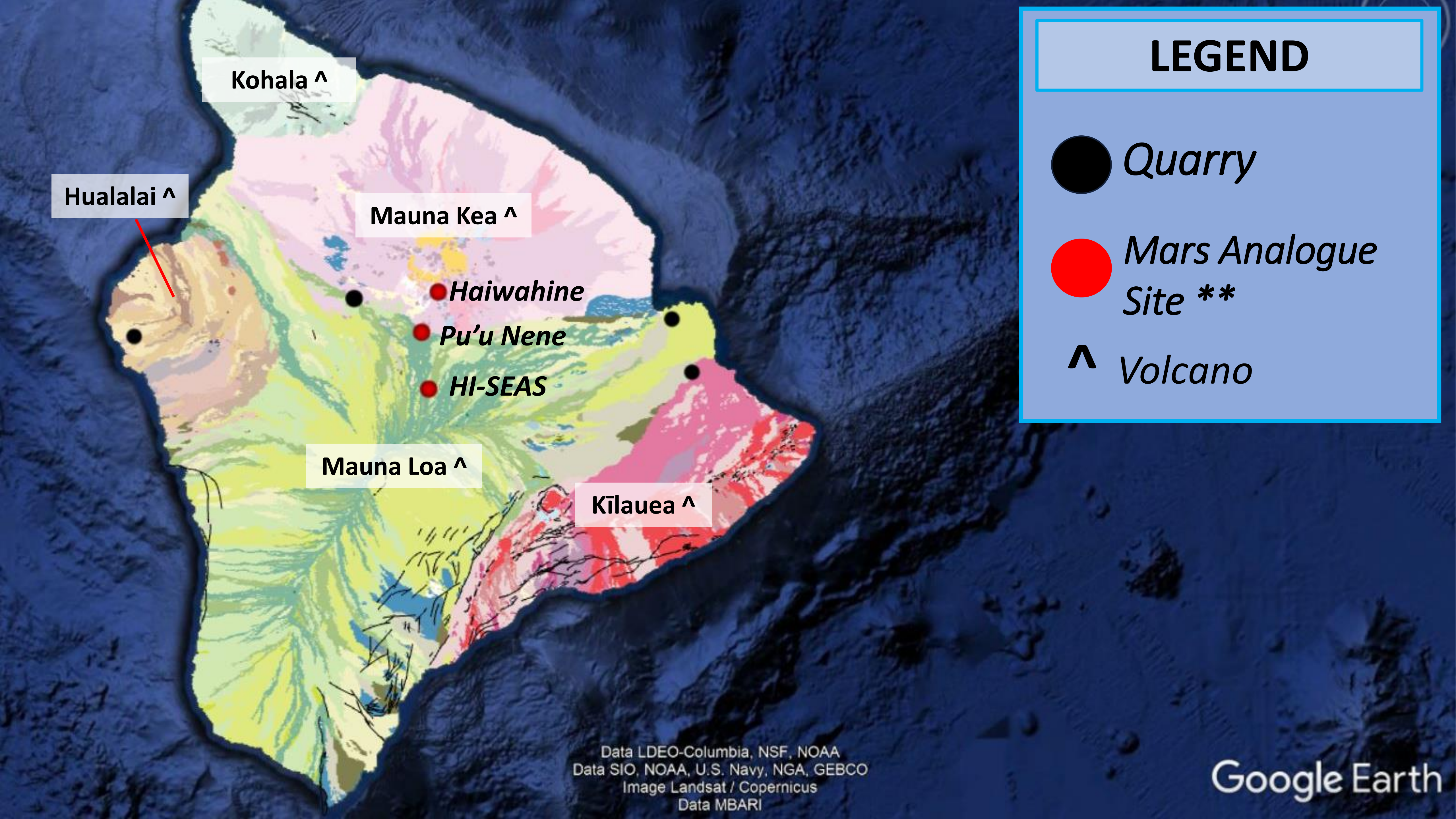
Good Sinterability

Needs Work

Poor Sinterability

Sample Name	Olivine	Plagioclase	Pyroxene	Glass
Glover ***(Mauna Loa^ Flow)***	***0***	***42.7***	***24.9***	***16.9***
PTA ***(Mauna Loa^ Flow)***	***0***	***46.4***	***30.5***	***12.5***
Bolton ***(Hualalai^)***	***33.6***	***27.1***	***24***	***10.7***
Puna Rock 4A ***(Mauna Loa^?)***	*4.5*	*44*	*29.8*	*11.6*
Puna Rock 4B ***(Kīlauea ^)***	***33.6***	***29.7***	***22.3***	***3.3***





Kohala ^
Hualalai ^
Mauna Kea ^
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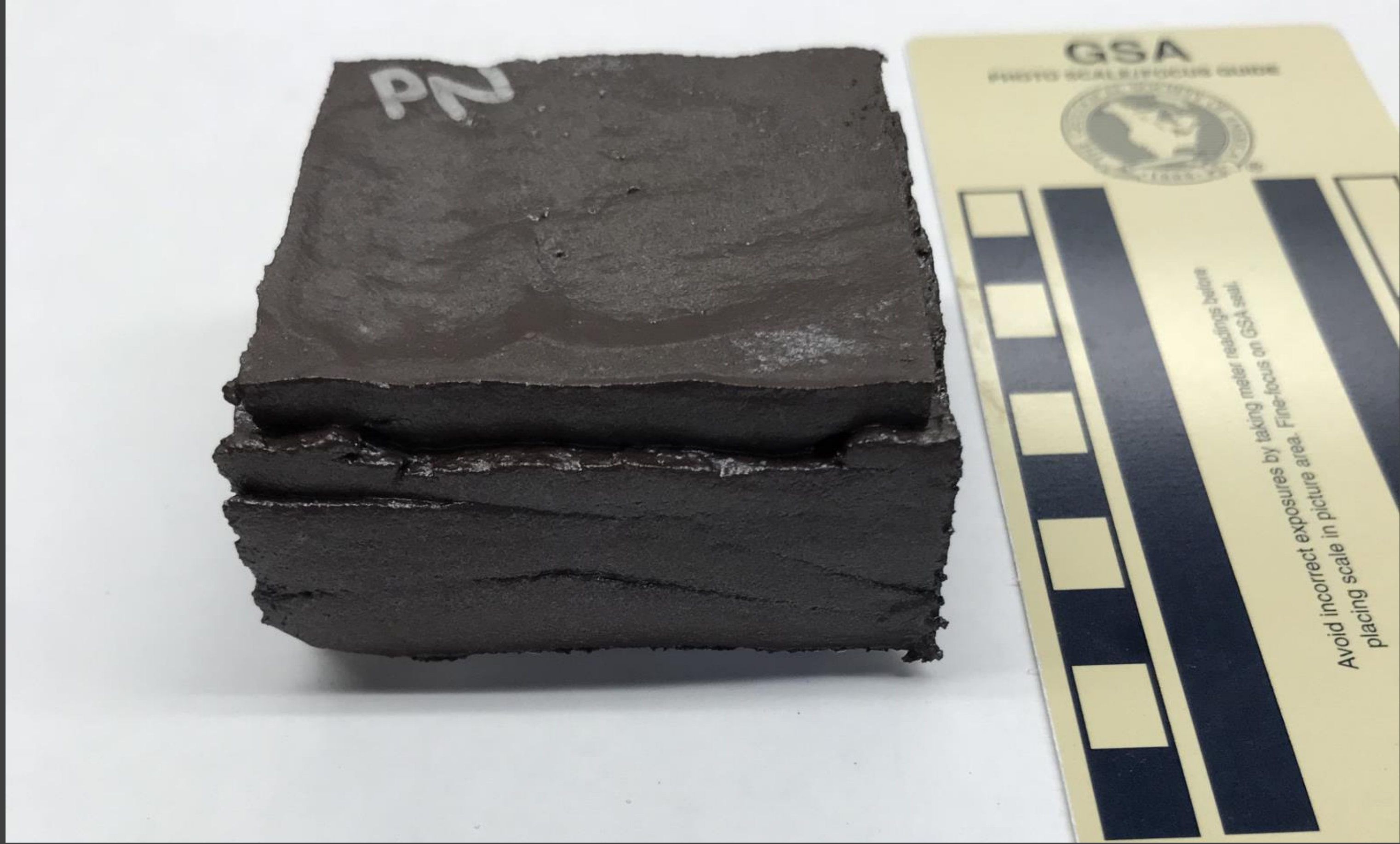
Basalt Scoria

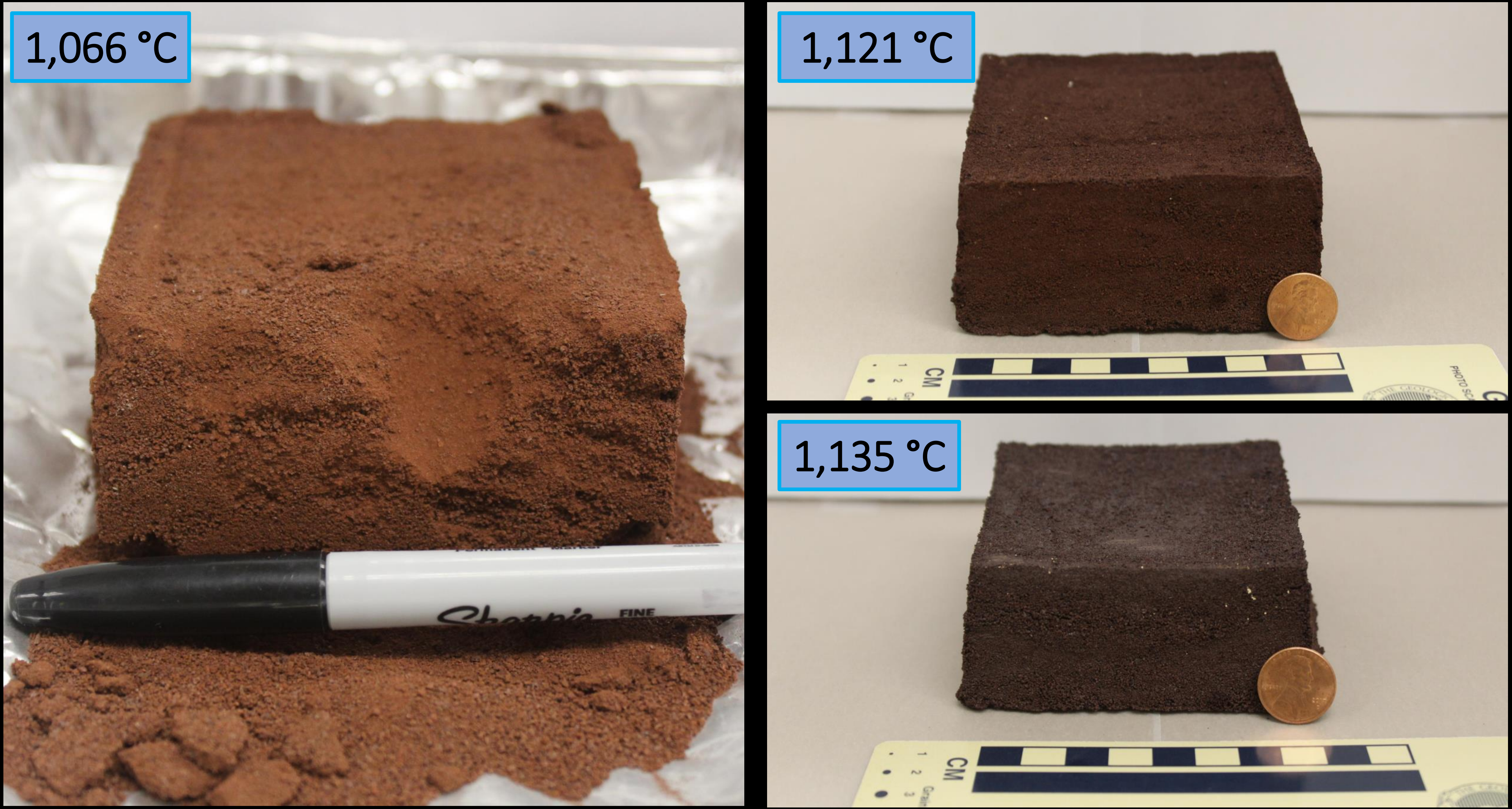


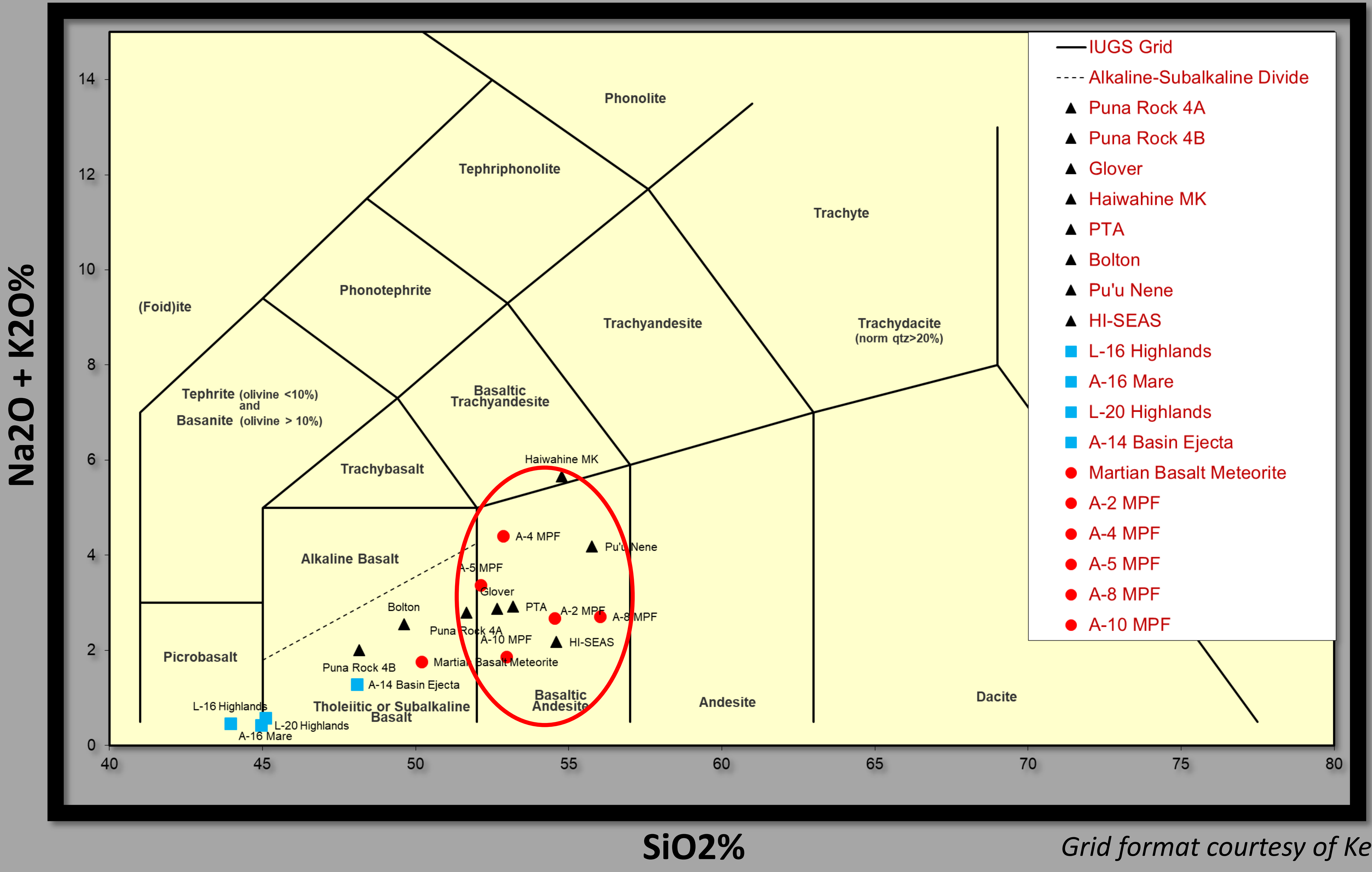
1,149 °C Bake with Analogue Site Scoria

X-Ray Diffraction (XRD) Mineralogy Results Combined

Best | Needs Work | Possibly Sinterable

Sample Name	Olivine	Plagioclase	Pyroxene	Glass
Glover	*0*	*42.7*	*24.9*	*16.9*
PTA	*0*	*46.4*	*30.5*	*12.5*
Bolton	***33.6***	***27.1***	***24***	***10.7***
Puna Rock 4A	*4.5*	*44*	*29.8*	*11.6*
Puna Rock 4B	*33.6*	*29.7*	*22.3*	*3.3*
HI-SEAS**	***3.1***	***27.4***	***25.1***	***30.2***
Pu'u Nene**	***0.1***	***37.5***	***7.9***	***51.2***
Haiwahine MK**	***9***	***43.9***	***11.4***	***25.6***
L-16 Lunar Highlands	*10*	*14.2*	*57.3*	*16.7*
A-16 Lunar Mare	*3.9*	*69.1*	*8.5*	*18*
A-14 Lunar Basin Ejecta	*6.7*	*31.8*	*31.9*	*27.6*


1,066 °C
1,121 °C
1,135 °C
FINE
CM
CM



Grid format courtesy of Ken Hon

Sinterability Conclusions

Too much olivine and little glass does not sinter well due to olivine's high melting temperature.

Low olivine and high glass content drives the sintering temperature down, because glass readily melts.

Haiwahine MK results show that some olivine and a lot of glass sinters well. Although more work is needed.

Moving Forward

- Mixing high olivine regolith's with a higher percentage of glass to investigate if glass acts as an adhesive between olivine and other regolith grains.
- Thin section analysis (compare & contrast).
- The effects of grain size on sinterability and texture.
- Compressional and flexural testing for 1,177 °C tiles.
- Thermal conductivity, heat capacity & thermal shock testing for 1,177 °C tiles.
- Lava layering and the effects that may have on mining regolith.

Acknowledgements

- The Institute for Astronomy (IFA) Hilo with special mahalo to Marc Cotter & Mark Chun.
- University of Hawai'i at Mānoa with special mahalo to G. Jeff Taylor.
- University of Hawai'i at Hilo Geology Department with special mahalo to Steve Lundblad & Ken Hon.
- J.W. Glover, Puna Rock, Pohakuloa Training Area (PTA) and Bolton Inc. Quarries.
- Kye Harford & Kylie Higaki for their dedicated work towards this project.

References

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