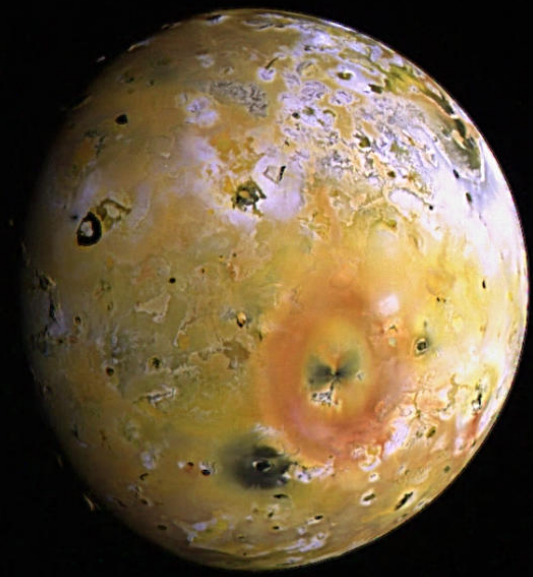
Volcanic Eruption Classification on Io and Earth From Low-Resolution Remote-Sensing Data

Ashley Davies
Jet Propulsion Laboratory-
California Institute of Technology

and

Laszlo Keszthelyi
United States Geological Survey,
Astrogeology Branch, Flagstaff, AZ



Division of Planetary Science Conference 37
Cambridge, UK, September 2005

Introduction

New Io data will be mostly low-spatial resolution for at least the next decade (AO): (New Horizons is the exception)

Comparing low-res thermal emission data from Io and Earth:

- Similar eruption styles have the same mass and thermal flux densities [1-3]
- Ionian eruptions are typically more voluminous and areally more extensive

We have been looking at the classification of near-IR thermal emission data to:

- understand how mode of emplacement can be constrained
- better model the eruption process taking place

Shape & evolution of integrated spectrum constrains style:

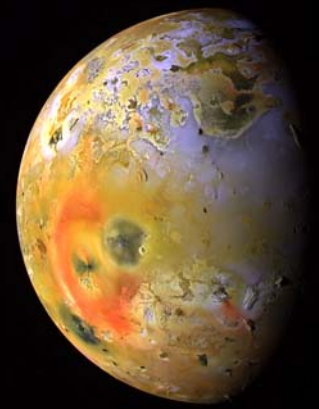
- e.g., used to determine emplacement mode at Prometheus, Pele, Pillan in low-spatial resolution *Galileo* NIMS data [2, 4]

[1] Keszthelyi *et al.,* 2001, LPSC-32 #1523. [2] Davies et al., 2001. [3] Davies, 2003a,b, JGR,GRL. [4] Howell, 1997.

Constraining eruption style from low-res observations

Outbursts

- 1990 time-series data [1-3]; 1996 event [4]; Pillan 1997 [5]: Tvashtar (g'based + SSI) [6]; Surt 2001 using AO [7]
- modelled as fire-fountains and associated flows

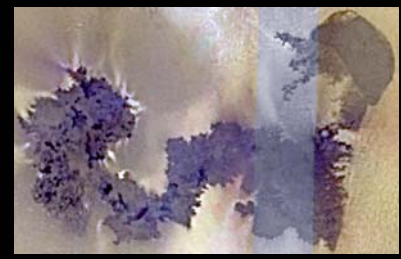


Pele:

- Constrained from IRIS data [8-9]; identified as active lava lake from low-spatial resolution time-series NIMS data [10]

Zamama, Prometheus, Amirani *et al.:*

- Crust-dominated; laminar emplacement; NIMS data [11]



Approach has limitations (Loki)

- *Probably* a lake (or magma sea [11], given its size).

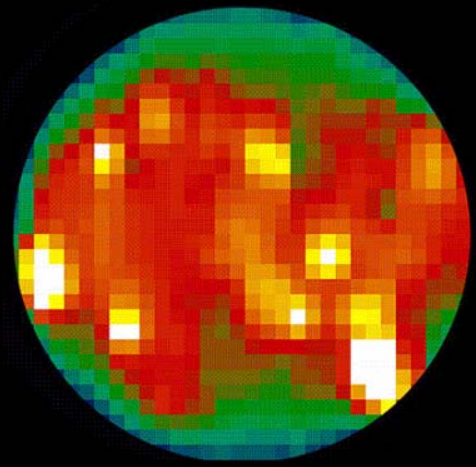
[1-3] Veeder et al., 1994; Blaney et al., 1995; Davies 1996 [4] Stansberry et al., 1997 [5] Davies et al., 2001 [6] Marchis et al., 2002 [7] see Milazzo et al, 2005 [8] Carr, 1986 [9] Howell, 1997 [10] Davies et al., 2001 [10] Davies et al., 1997 [11] Matson et al., 2004.

Data used

Io data: *Galileo* NIMS

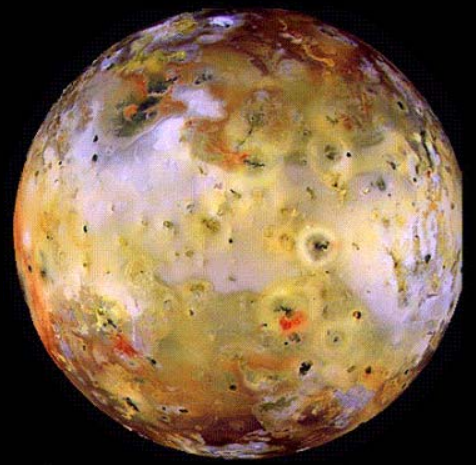
- 0.7-5.2 microns
- sensitive to current & recent volcanic activity on scale of seconds-months+

NIMS G2 1996 4.8μm



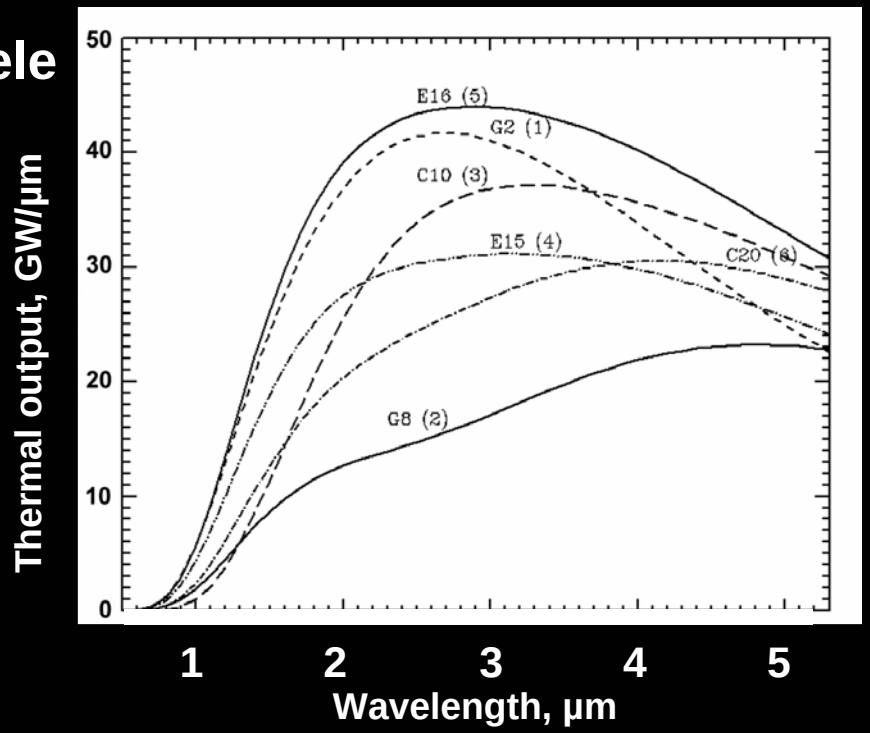
Earth data: Landsat-7

- Kilauea (4), Etna (3), Lonquimay
- Used analysis of 30-m data to determine integrated thermal emission spectrum (supplied by A. Harris)

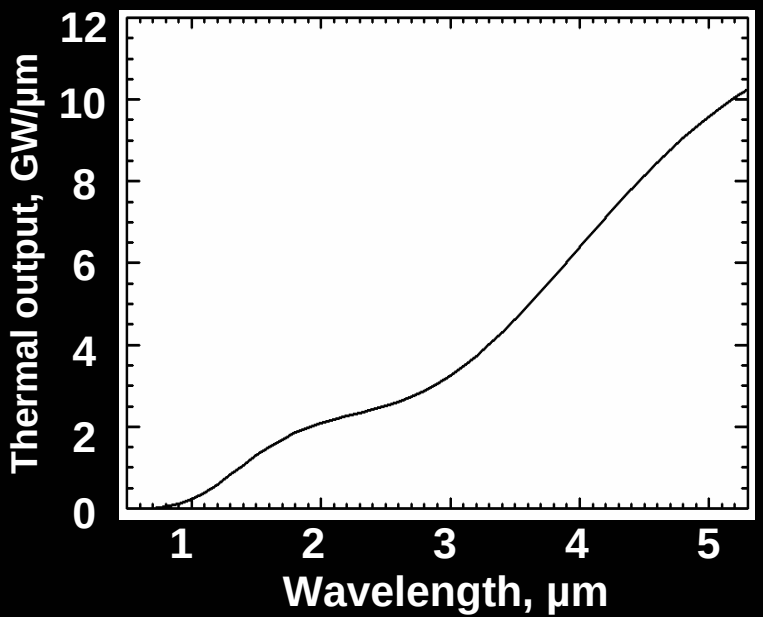


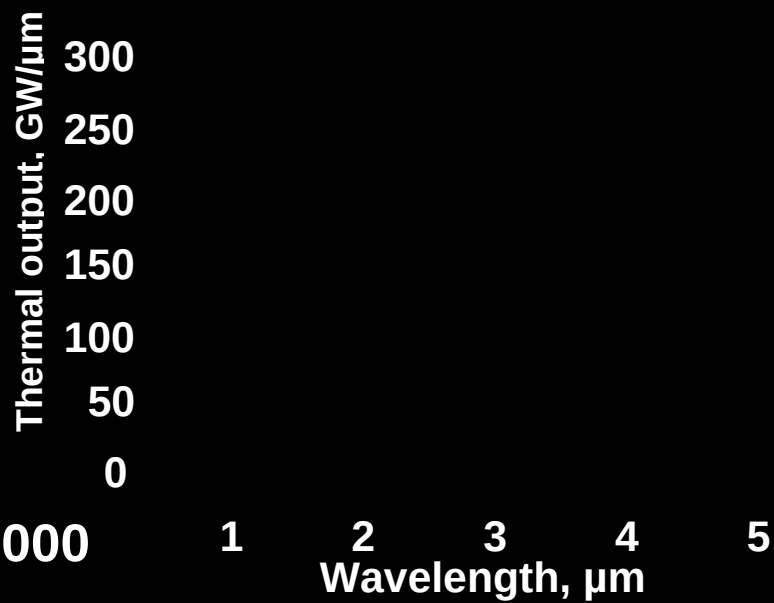
Thermal ‘signature’

Pele

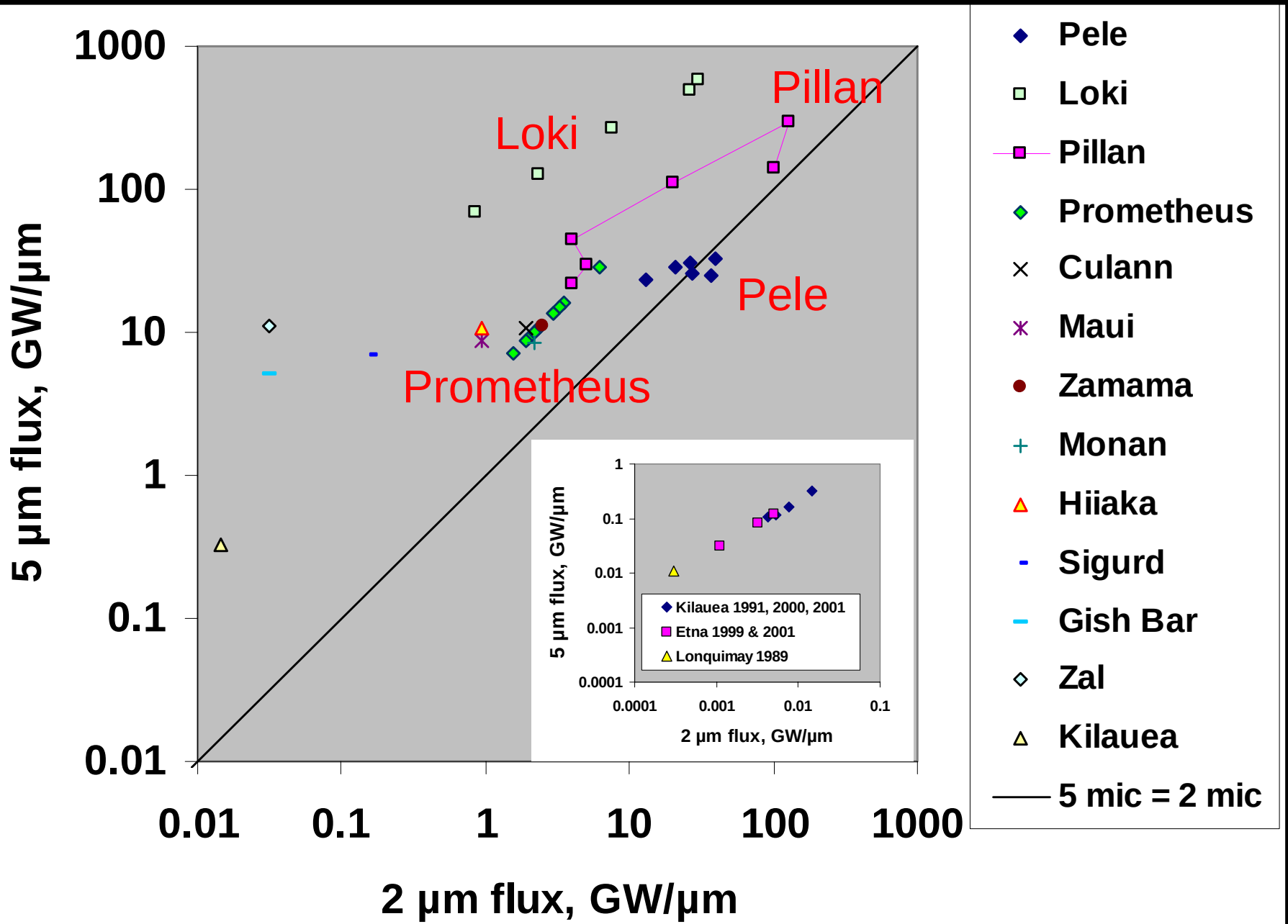


Prometheus





Pillan, 1997-2000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5 µm flux, GW/µm
2 µm flux, GW/µm
Pillan
Loki
Pele
Prometheus
Pele
Loki
Pillan
Prometheus
Culann
Maui
Zamama
Monan
Hiiaka
Sigurd
Gish Bar
Zal
Kilauea
5 mic = 2 mic
1
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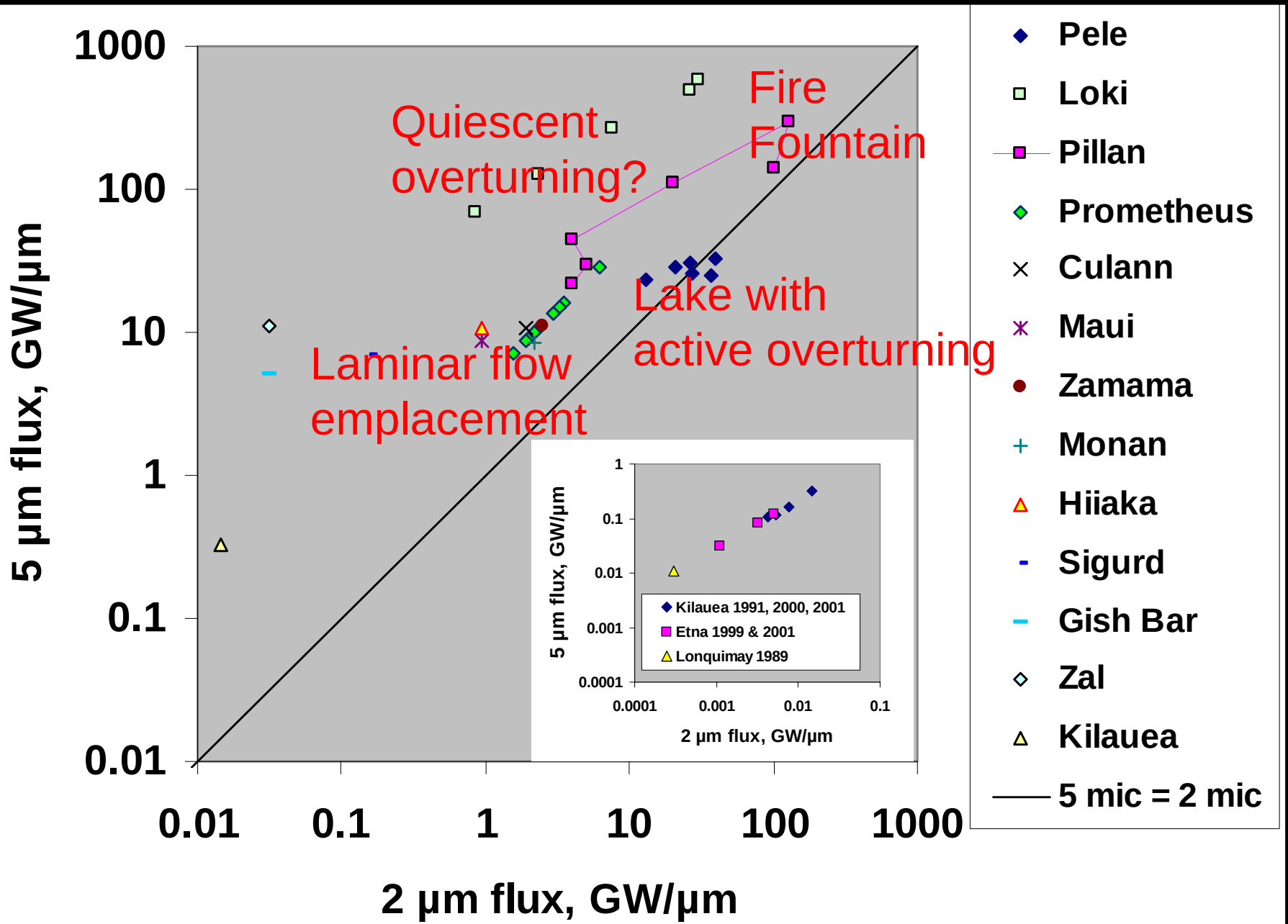
5 µm flux, GW/µm
2 µm flux, GW/µm
Kilauea 1991, 2000, 2001
Etna 1999 & 2001
Lonquimay 1989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5 µm flux, GW/µm
2 µm flux, GW/µm
Quiescent overturning?
Fire Fountain
Lake with active overturning
Laminar flow emplacement
Pele
Loki
Pillan
Prometheus
Culann
Maui
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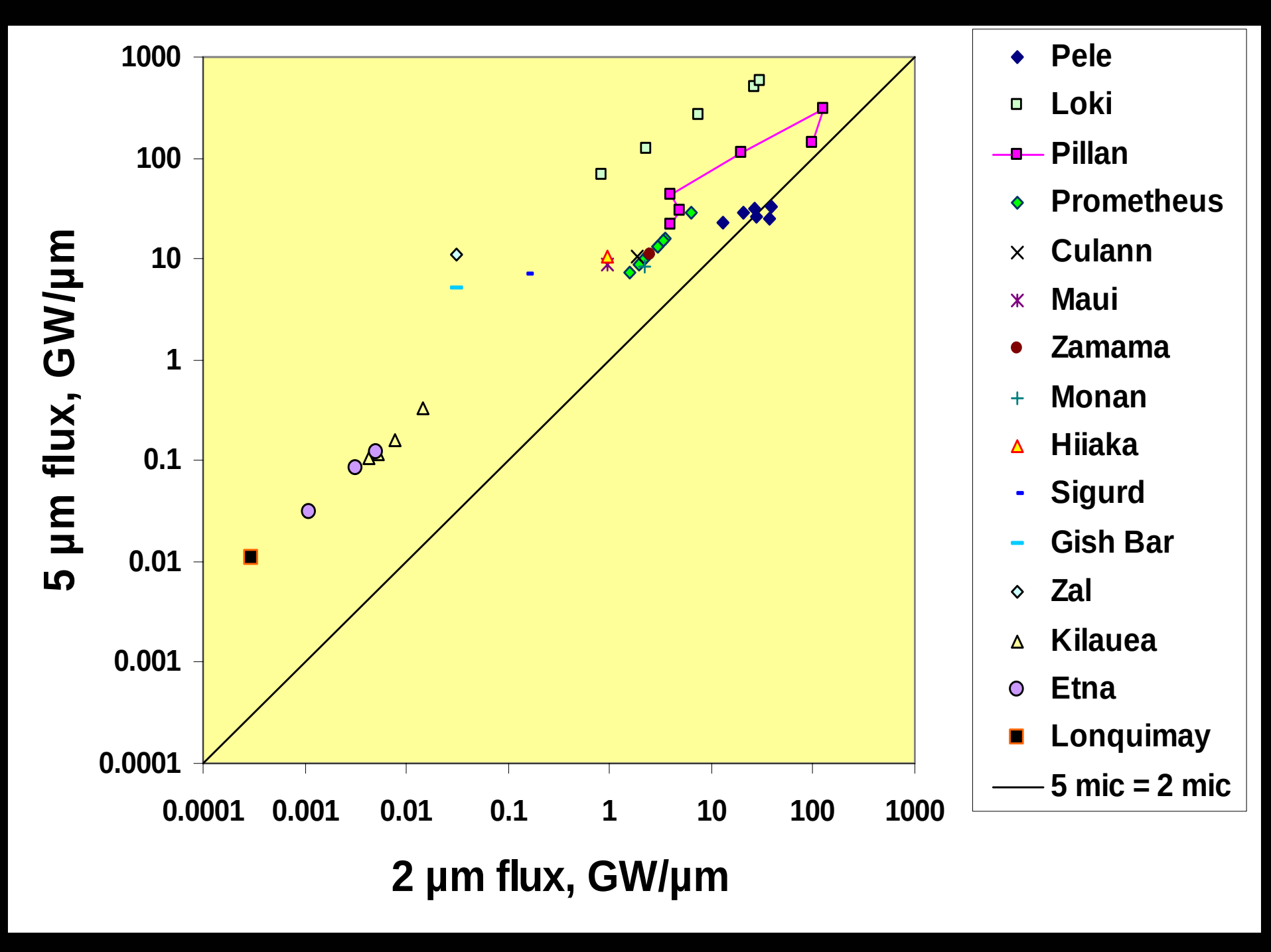
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5 µm flux, GW/µm
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100
1000
2 µm flux, GW/µm
Pele
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Sigurd
Gish Bar
Zal
Kilauea
Etna
Lonquimay
5 mic = 2 mic

2/5 μm ratios for Io and Earth volcanoes

Volcano	2/5 μm ratio	Eruption style
Gish Bar	0.006	cooled lava flows?
Lonquimay	0.027	lava dome
Loki	0.052 to 0.012	quiescent lava lake
Altjirra	0.037	cooling flows?
Etna 1	0.038	lava flows
Kilauea 1	0.039	insulated flow field
Etna 2	0.031 to 0.084	lava flows
Kilauea 2	0.045 to 0.047	insulated flow field
Maui	0.107	flows or quiescent/inactive lake
Amirani	0.162	insulated flow field
Culann	0.176	lava flows or lake
Zamama	0.229	insulated flow field
Prometheus	0.244	insulated flow field
Tupan	0.255	lake? ponded flow?
Monan	0.264	flows?
Pillan	0.091 to 0.725	fire fountain, turbulent flows
Pele	0.565 to 1.480	active lava lake

Summary

Insulated flows: e.g., Prometheus, Amirani, Zamama

- thermal output dominated by cool crust in range ~300–450 K
- 5 μm flux > 2 μm flux

Lava fountains & open-channel flows: Pillan 1997

- increased 2 μm flux due to extensive high-temperature areas
- with time, 2/5 μm ratio decreases as surfaces cool

Active, overturning lava lake: Pele

- 2 μm emission can match or exceed 5 μm emission.
- only volcano on Io that persistently exhibits this activity

Paterae: e.g., Culann, Tupan

- 2/5 μm ratios similar to those of insulated flows: could be ponded flows, inactive lava lakes, lava flows. If lava lakes, not seen to exhibit Pele-like behaviour.

Loki Patera

- A unique feature. Has very low 2/5 μm ratio in *Galileo* data.
- Thermal emission dominated by cool crust
- A huge lava lake of low-volatile content lava that quiescently overturns (?).

Conclusions

In low-spatial resolution data eruption style can be constrained if there is sufficient wavelength spread

Telling the difference between insulated flows and quiescent lava lakes is difficult as the 2/5 micron ratios are similar

Temporally, active lava lakes should overturn, increasing thermal emission at short wavelengths during active phase

Vigorously overturning lava lakes look like fire-fountain episodes except:

- Fire-fountains are short-lived
- Temporal behaviour constrains activity

This is a work in progress.

- Work is proceeding on more Earth and Io data.

Acknowledgements

AGD is supported by grants from the NASA Planetary Geology and Geophysics and Outer Planets Research programs.

This work was carried out at the Jet Propulsion Laboratory-California Institute of Technology, under contract to NASA.