# Can sulfate signatures in ice cores verify the source volcano?

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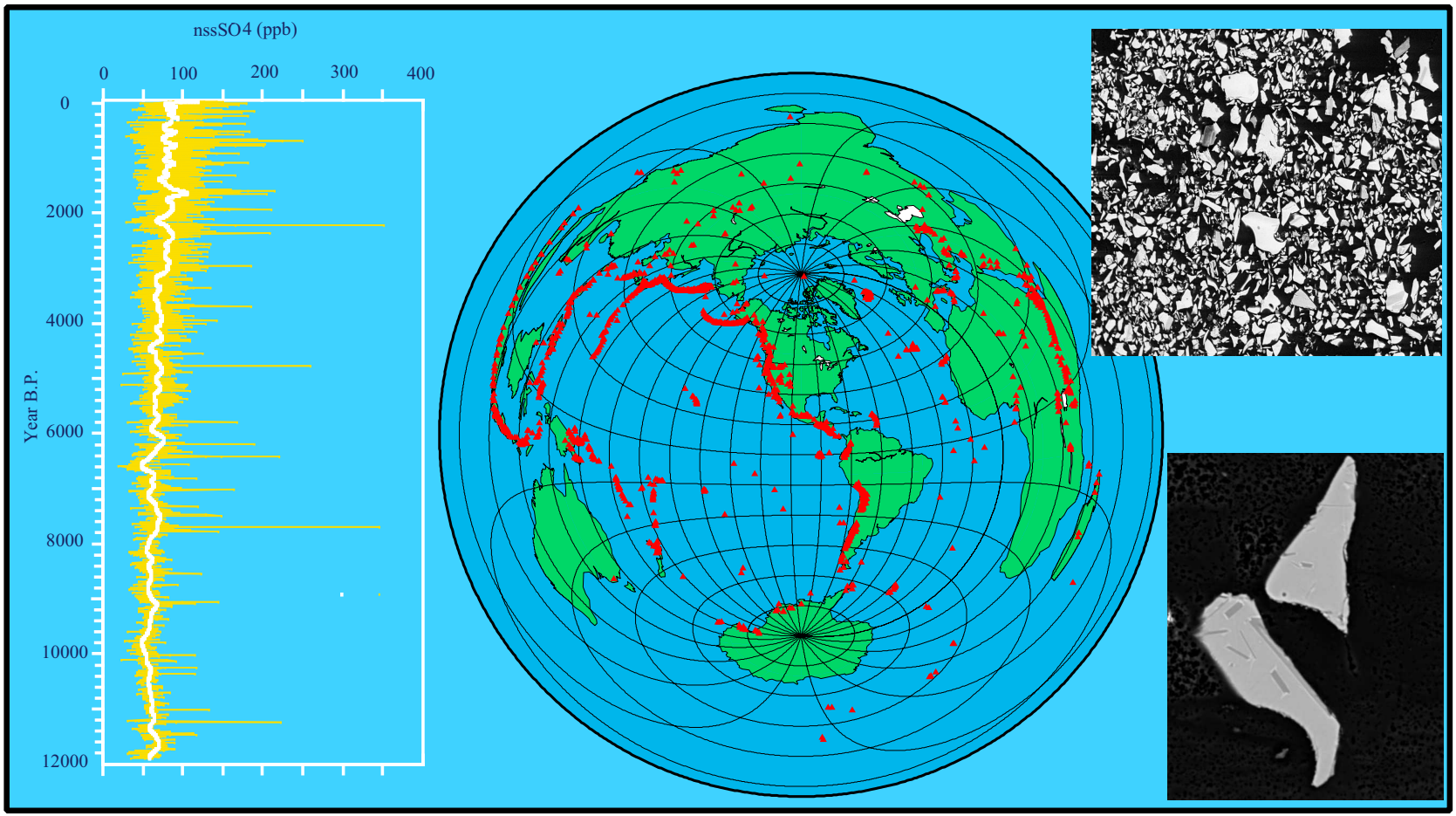
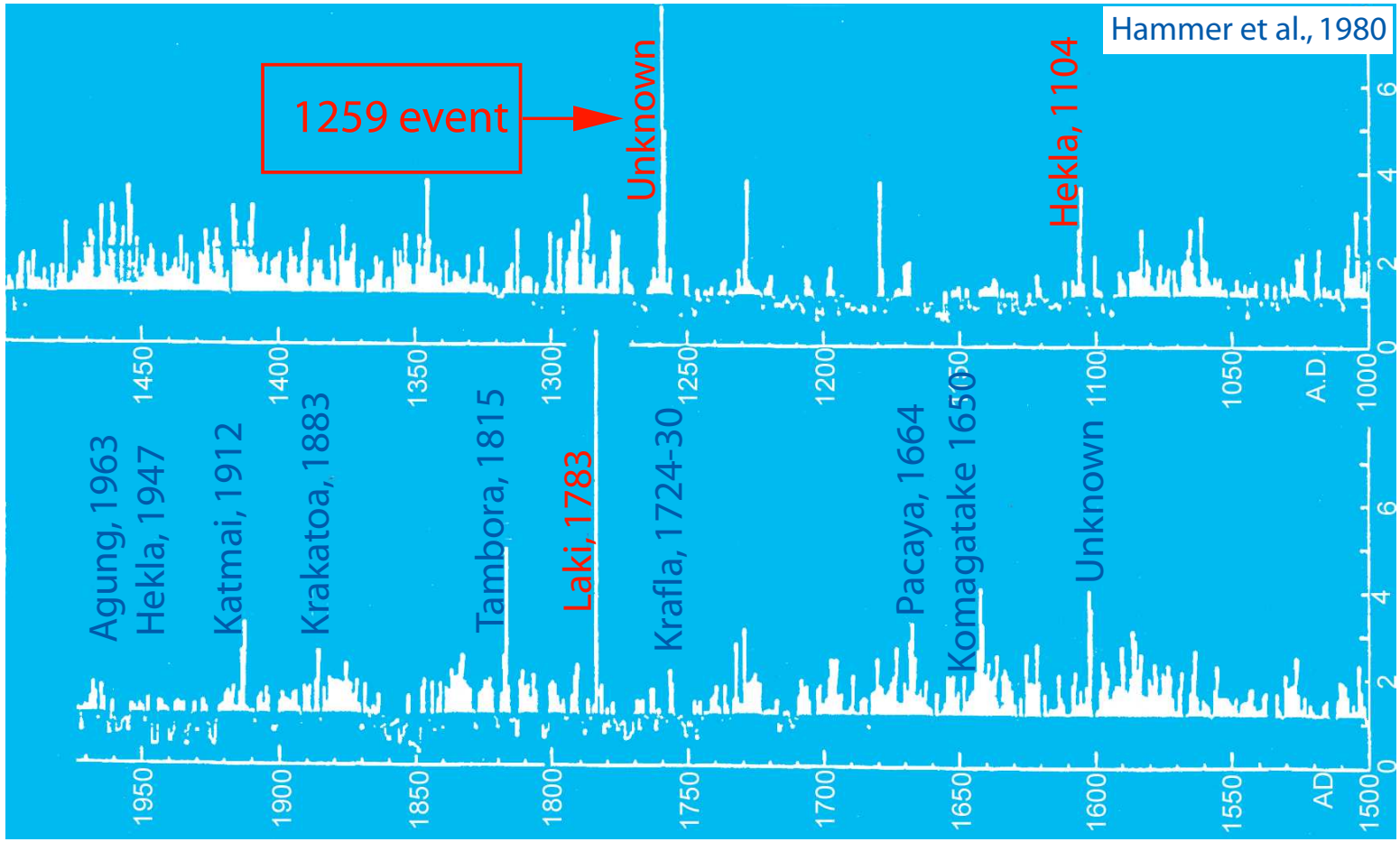
# Volcanic signal in ice cores





# Crête, 1974 Ice Core, Greenland





# Possible source of the 1259 event



- Three large eruptions between 28 March and 4 April 1982 El Chichon stripped off the vegetation and exposed deposits of older events (Tilling et al., 1984)

| Sample | Radiometric age | Calibrated age with range ($\pm 1\sigma$) |
|---|---|---|
| EC-220 | 550±60 | 1320-1433 C.E. |
| EC-184 | 550±60 | 1320-1433 C.E. |
| EC-201 | 570±60 | 1320-1393 C.E. |
| EC-218 | 600±70 | 1281-1408 C.E. |
| CHAR-1 | 650±100 | 1277-1400 C.E. |
| EC-222 | 700±70 | 1252-1396 C.E. |

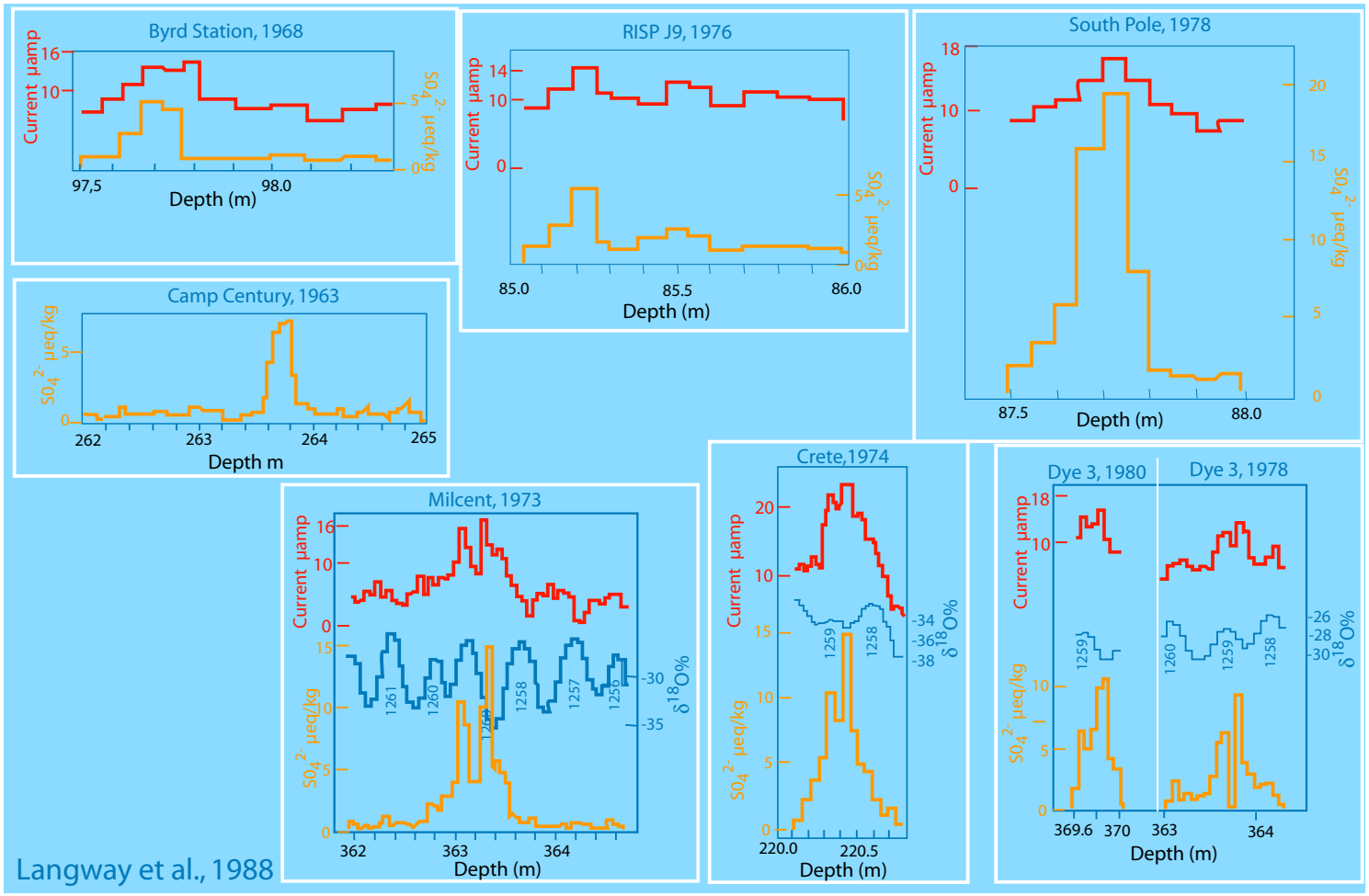
# El Chichon !!!



- Stothers and Rampino(1983) correlated unknown peak at A.D. 1258$\pm$1 of Hammer et al., (1980) with unusual atmospheric phenomena in Europe
- Tilling et al., (1984) speculate that this peak may reflect prehistoric explosive activity of El Chichon $\sim$600 years ago

# 1259 in different ice cores





# Source of the 1259 event



- A major volcanic eruption in A.D. 1259 close to the Equator in the Northern Hemisphere
- One of the largest events that took place in the last 10,000 years (Langway et al., 1988).

# Microprobe data by Palais et al., 1992



| Sample | GISP2 | South Pole | El Chichon[1] | El Chichon |
|---|---|---|---|---|
| $SiO_2$ | 69.13 (2.95) | 70.07 (1.13) | 70.00 (0.52) | 70.81 (0.68) |
| $TiO_2$ | 0.51 (0.11) | 0.50 (0.12) | 0.24 (0.03) | 0.30 (0.15) |
| $Al_2O_3$ | 15.43 (1.50) | 15.28 (1.30) | 16.59 (0.29) | 15.38 (0.57) |
| $Fe_2O_3$ | 3.73 ()0.62 | 3.32 (0.30) | 1.35 (0.07) | 1.69 (0.19) |
| MnO | n.a | n.a | 0.04 (0.04) | n.a |
| MgO | 0.95 (0.43) | 0.86 (0.15) | 0.18 (0.05) | 0.28 (0.08) |
| CaO | 2.03 (0.40) | 1.82 (0.57) | 1.92 (0.09) | 2.28 (0.25) |
| $Na_2O$ | 3.40 (0.63) | 3.41 (0.82) | 4.65 | 3.49 (0.61) |
| $K_2O$ | 4.80 (1.09) | 4.74 (0.44) | 5.03 (0.04) | 5.77 (0.32) |
| n | 15 | 10 | 8 | 8 |

[1] Sigurdsson and Carey

# El Chichon as a source for 1259 event



- The composition of glass shards from the 550-700 yrs. B.P. eruption of El Chichon is quite similar to shards found in the two 1259 A.D. ice core layers. Slight differences do occur, however, in $TiO_2$,$Fe_2O_3$, MgO contents (Palais et al., 1992)
- The similarity in composition of glass shards suggests that, at this point, the El Chichon eruption seems to be a likely source of the ash found in the ice layers

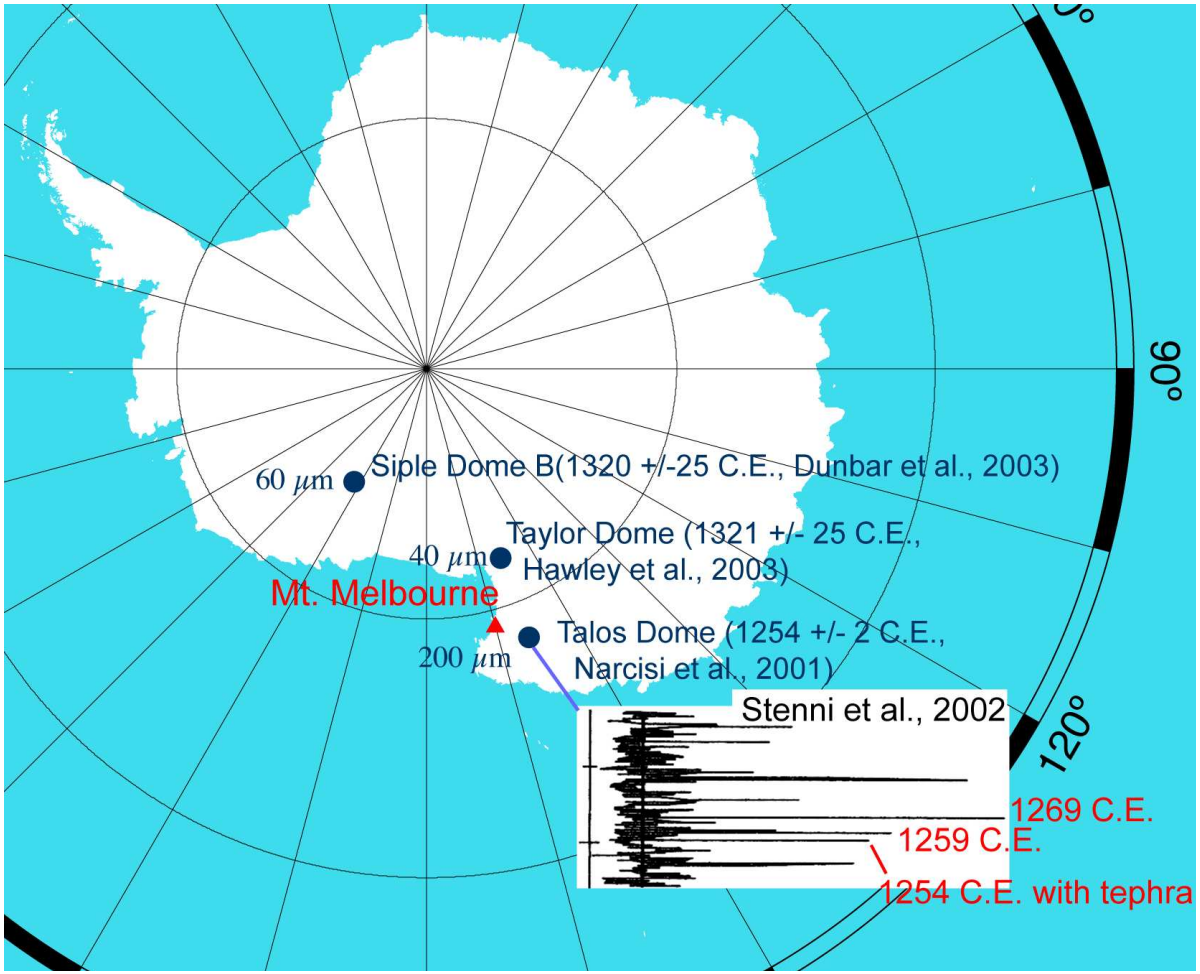
# More ice cores...



| Year | Ice Core | Reference |
|---|---|---|
| 1259 | South Pole 1984 | Delmas et al., 1992 |
| 1260 | Plateau Remote | Cole-Dai et al., 2000 |
| 1259 | Talos Dome | Stenni et al., 2002 |
| 1260 | South Pole 2001 | Budner and Cole-Dai, 2003 |
| 1259 | Amundsenisen (DML cores | Traufetter et al., 2004 |

# Antarctic source?





# Mt. Melbourne tephra correlation

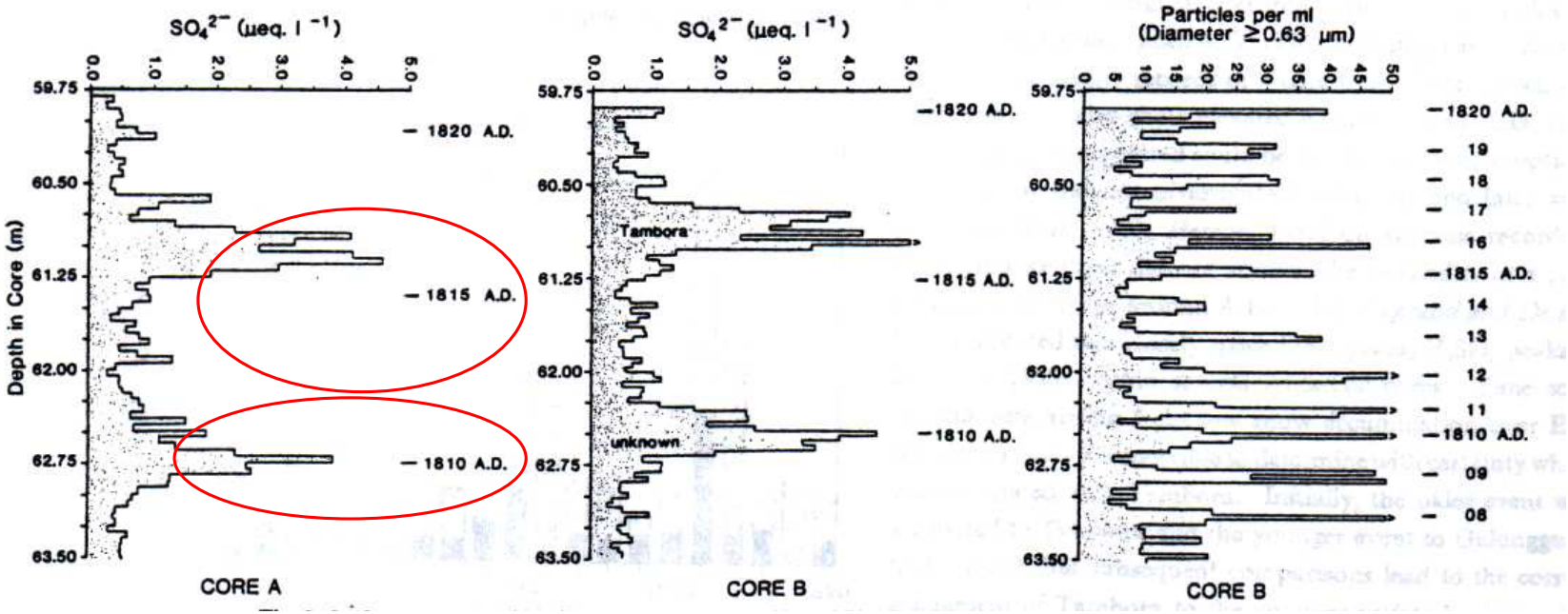


| Sample | SDMB 97.2-97.54 m | SDMB 97.45-97.7 m | Taylor Dome | Talos Dome |
|---|---|---|---|---|
| $P_2O_5$ | 0.08 (0.03) | 0.10 (0.01) | 0.05 (0.03) | 0.05 (0.04) |
| $SiO_2$ | 61.38 (0.75) | 61.91(0.70) | 61.82 (0.75) | 63.84 (0.80) |
| $TiO_2$ | 0.45 (0.03) | 0.43(0.05) | 0.42 (0.03) | 0.36 (0.08) |
| $Al_2O_3$ | 16.68 (0.29) | 16.59 (0.62) | 16.44 (0.32) | 16.14 (0.29) |
| MgO | 0.15 (0.02) | 0.14(0.03) | 0.15 (0.02) | 0.06 (-) |
| CaO | 1.20 (0.07) | 1.14(0.28) | 1.18 (0.08) | 1.10 (0.14) |
| MnO | 0.27 (0.04) | 0.27(0.05) | 0.24 (0.05) | 0.22 (0.07) |
| FeO | 6.56 (0.42) | 6.25(0.27) | 6.38 (0.18) | 6.37 (0.75) |
| $Na_2O$ | 7.41 (0.43) | 8.18(0.45) | 7.01 (0.46) | 7.30 (1.32) |
| $K_2O$ | 5.38 (0.12) | 4.57(0.70) | 5.37 (0.19) | 4.63 (0.31) |
| n | 6 | 8 | 6 | 19 |

# 1809 A.D. in Greenland



## Volcanic signals in Central Greenland[2]

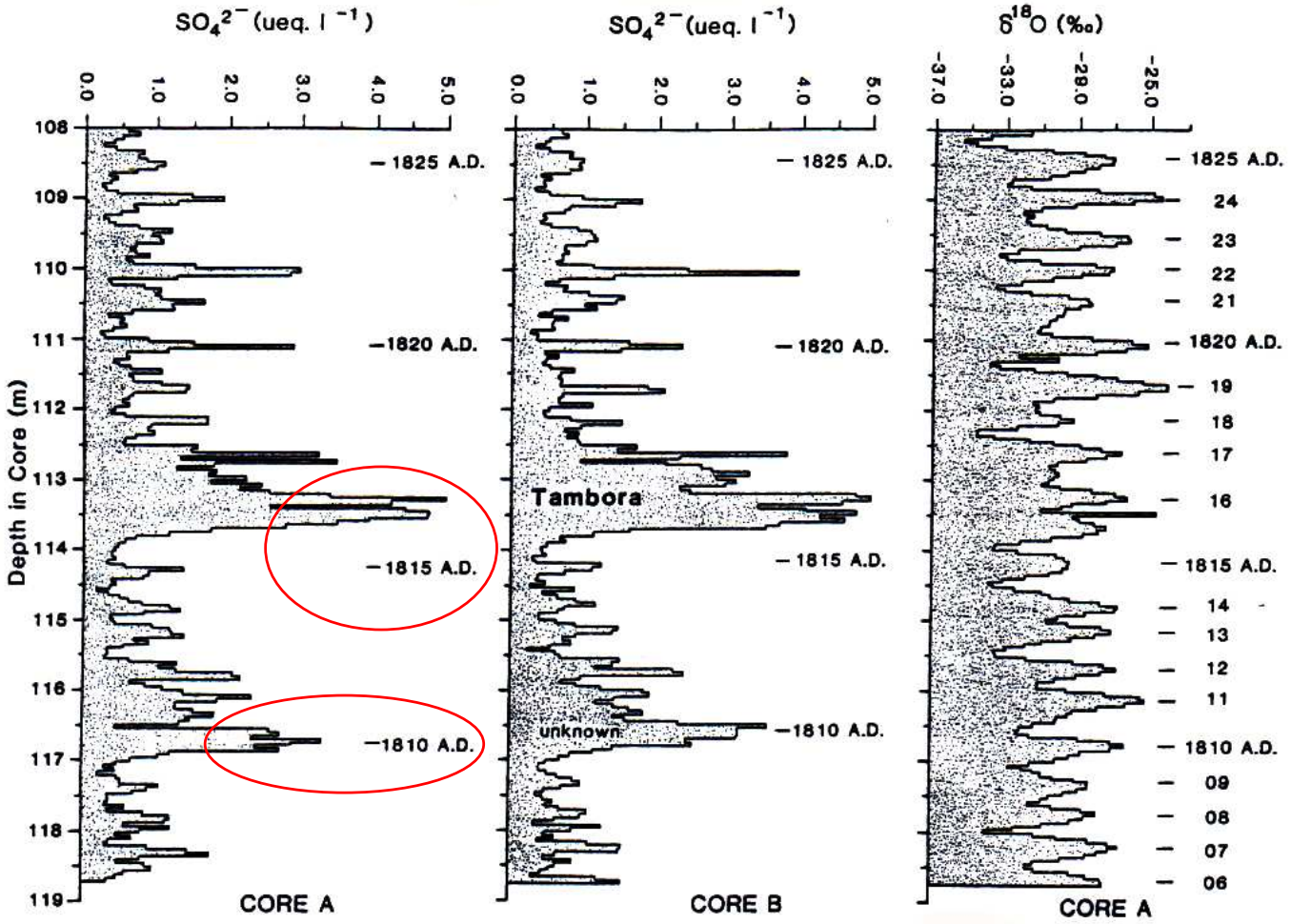



[2]Dai et a., 1991

# 1809 A.D. in Antarctica



## Volcanic signal from Siple Station[3]




[3]Dai et al., 1991

# 1809 A.D in Antarctica



## Volcanic signals from Plateau Remote[4]

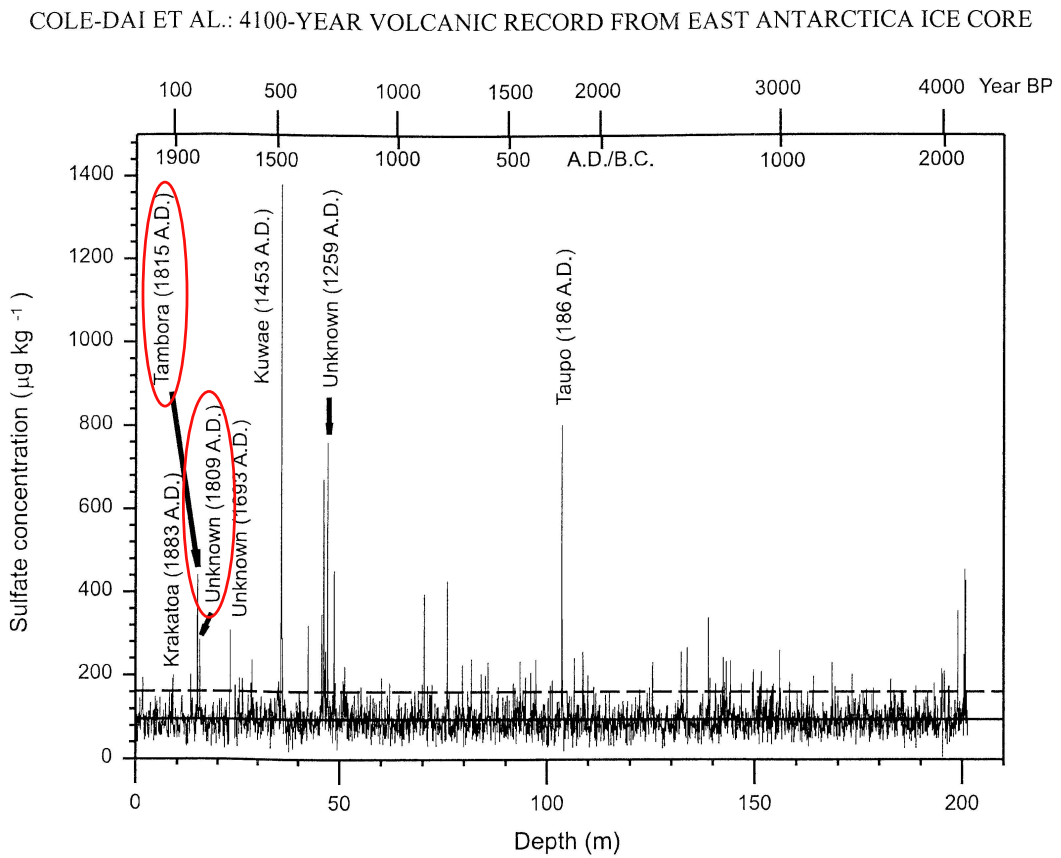


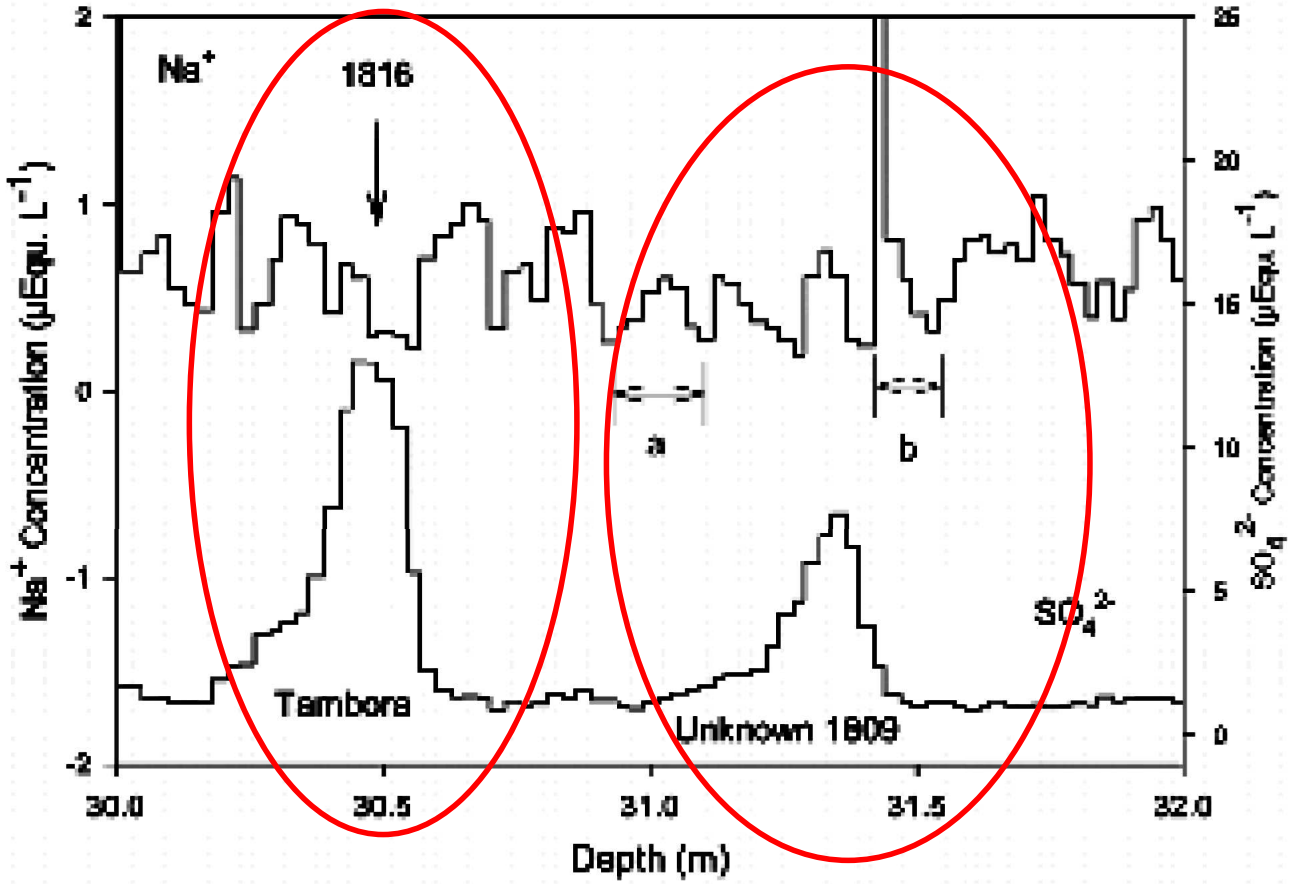

**Figure 2.** Continuous (except for a 1-m gap between 23.14 and 24.14 m) profile of sulfate concentrations ($\mu$g kg$^{-1}$) in the Plateau Remote core (PR-B) as a function of depth (bottom axis). Labeled volcanic events are known eruptions used as time stratigraphic horizons to construct the time-scale displayed as the top axis. The solid horizontal line indicates the nonvolcanic background and the dashed line represents the detection threshold (background +2$\sigma$).

[4] Cole-Dai et al., 2000

# 1809 A.D in Antarctica



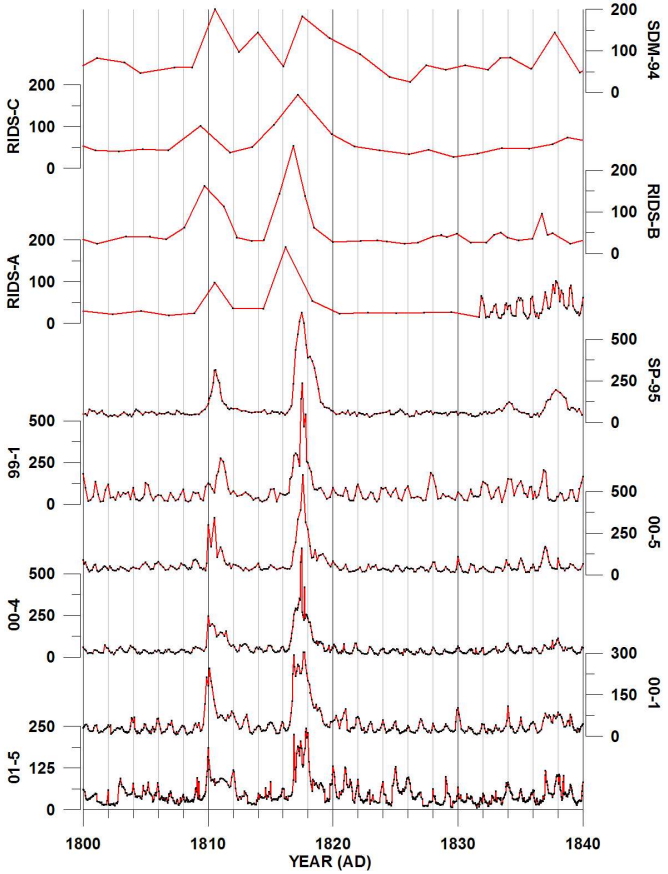
## Volcanic signals from South Pole ice core [5]

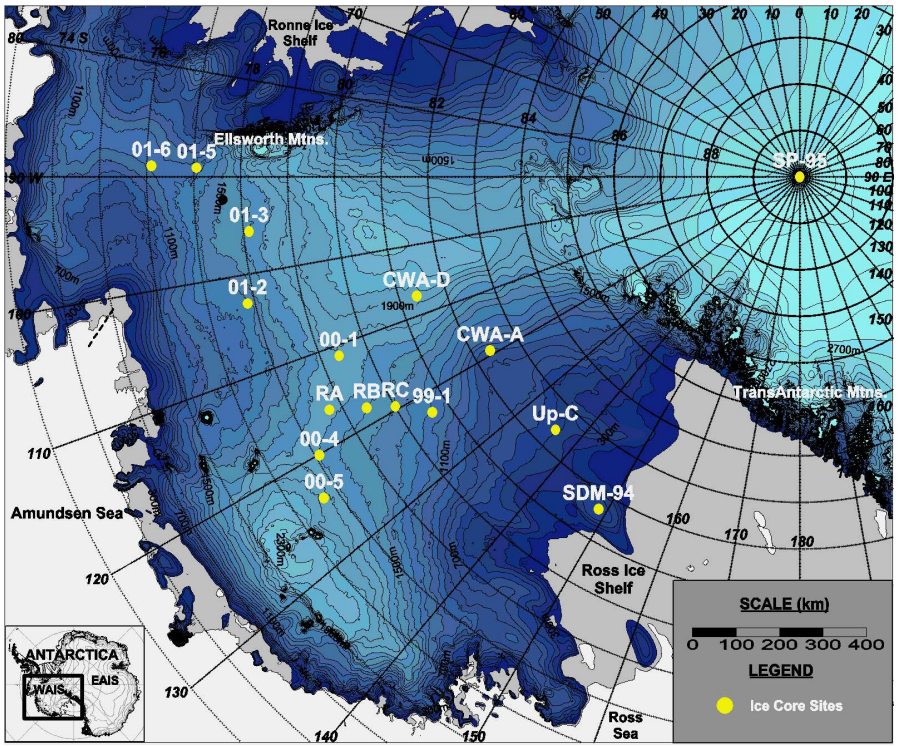



[5] Budner and Cole-Dai, 2003

# Volcanic signals in west Antarctica

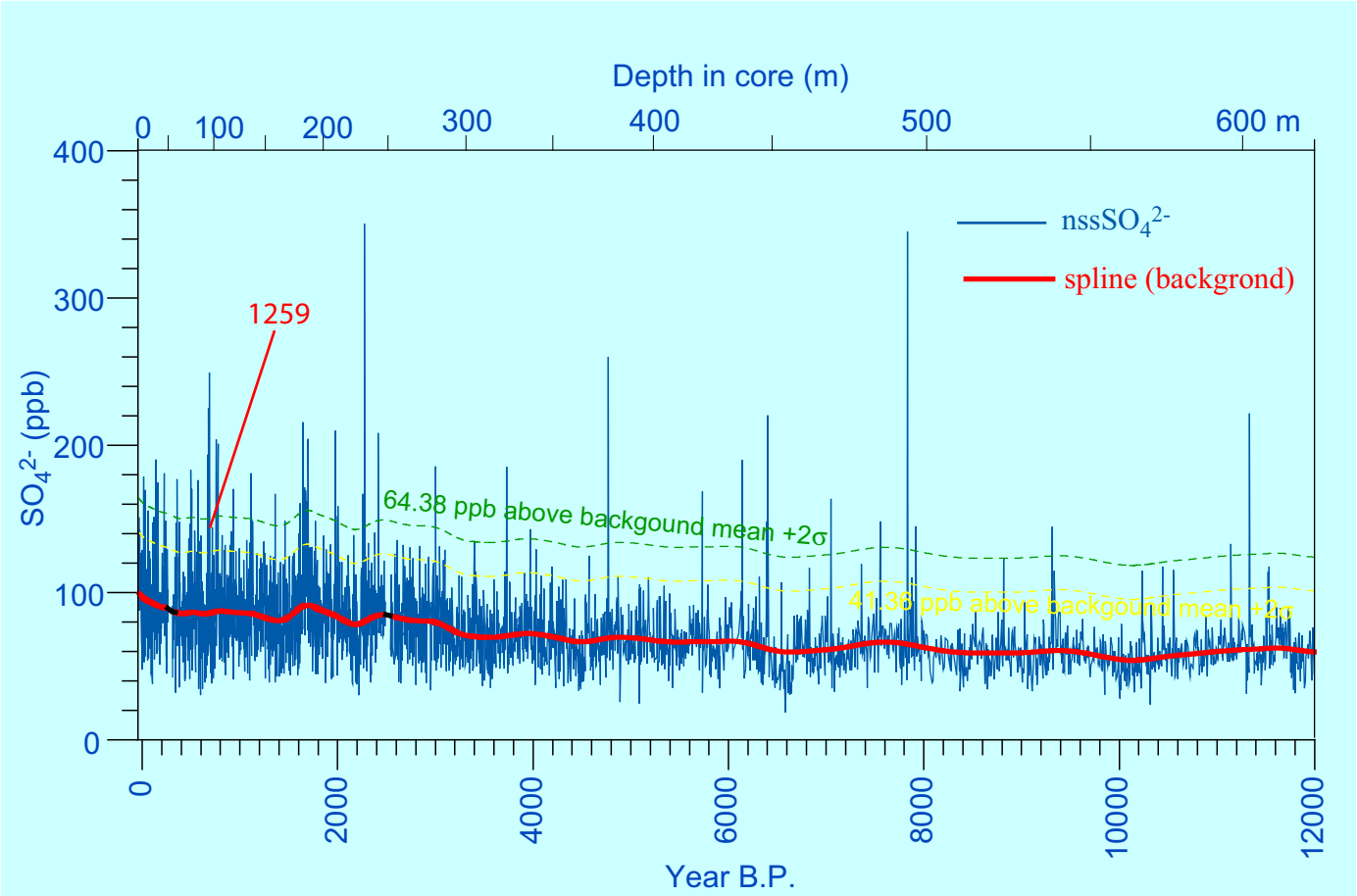




# Siple Dome A record





# SDMA volcanic signals



| Year (Duration) | Spline | EOF | Tephra | Source |
|---|---|---|---|---|
| 1831 (1.9) | 59 | {47} | n.d. | Hodson, Antarctica 1831 |
| 1809 (3.1) | **99** | {**72**} | A | Buckle Is., Pleiades, Antarctica |
| 1805 (3.0) | | | T | no match found |
| 1804 (1.0) | | | A | Buckle Is., Antarctica |
| 1346 (2.2) | 53 | 38 | | Cerro Bravo, Columbia |
| 1278 (2.7) | **108** | **90** | | no match found |
| 1271 (2.7) | **139** | **108** | | no match found |
| 1262 (3) | **163** | **133** | B core | Mt. Melbourne |
| 1259 (2.6) | 45 | 43 | | Quilotoa, Ecuador |
| 1234 (2) | 58 | 44 | | Cotopaxi, Ecuador |

1259 A.D. and 1809 A.D. coincide with local eruptions?