

Sulphur isotopic composition of volcanic gases from Poás and Turrialba volcanoes, Costa Rica

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Introduction

Poás and Turrialba are active volcanoes located in the Central America Volcanic Range, Costa Rica.

-**Turrialba** volcano is a 3340 m high basaltic-dacitic stratovolcano with a summit area that has three craters, West, Central, and East craters, of which only the first two have active fumaroles.

- **Poás** volcano is a 2700 m high basaltic-andesite stratovolcano with three nested calderas and a hot ultra-acidic crater lake bordered by two cones. It is a volcano with a highly dynamic lake-hydrothermal system with intermittent cycles of phreatic and rare phreato-magmatic activity.

Fumarolic gases were collected from the West crater of Turrialba volcano, at 70-278°C, between August 2004 and August 2009. Samples from Poás came mainly from two areas: fumaroles north terrace and fumaroles from the north face of the "dome", at 93-200°C, between June 2004 and August ?? 2009. A characterization of these gases has been previously reported. Here, the $\delta^{34}\text{S}$ values of dissolved H_2S and SO_2 , and total sulphur in gases from these two volcanoes were determined to contribute to establish the source of fluids.



Methods

Sulfur isotopes ($\delta^{34}\text{S}$) were measured in 28 samples of barite from Poás and 42 from Turrialba at the Centres Científics i Tecnològics UB in Spain, using a Delta C Finnigan MAT continuous flow isotope-ratio mass spectrometer with an elemental analyzer TC-EA.

Temperatures of the equilibrium $\text{SO}_2\text{-H}_2\text{S}$ were calculated using the equation of Ohmoto and Rye (1979)

$$1000 \ln \alpha_{\text{H}_2\text{S}} = \frac{a \times 10^6}{T^2} + \frac{b \times 10^3}{T} + c; \quad (T \text{ in K}) \quad i = \text{SO}_2; a = 4.7; b = 0; c = -0.5$$

Results

In the Turrialba volcanic gas the H_2S content increases with the temperature and $\delta^{34}\text{S}$ values of total sulphur range between +3.1 and +7.5‰. In the Poás The $\text{SO}_2/\text{H}_2\text{O}$ ratio decreases with the temperature and $\delta^{34}\text{S}$ values are from -3.1 to +4.5‰. This composition is consistent with that of other total sulphur of volcanic gases, with some values heavier than the mantle sulphur.

In the Poás, there is a negative correlation between $\delta^{34}\text{S}_{\text{H}_2\text{S}}$ values (-15.2 to -8.2‰) and $\delta^{34}\text{S}_{\text{SO}_2}$ values (+1.2 to +9.0‰) whereas in the Turrialba $\delta^{34}\text{S}_{\text{H}_2\text{S}}$ values (-23.2 to -8‰) and $\delta^{34}\text{S}_{\text{SO}_2}$ values (+5.2 to +12.4‰) are not related. However, there is a good correlation for values of gases at low temperatures and for gases of values at high temperature.

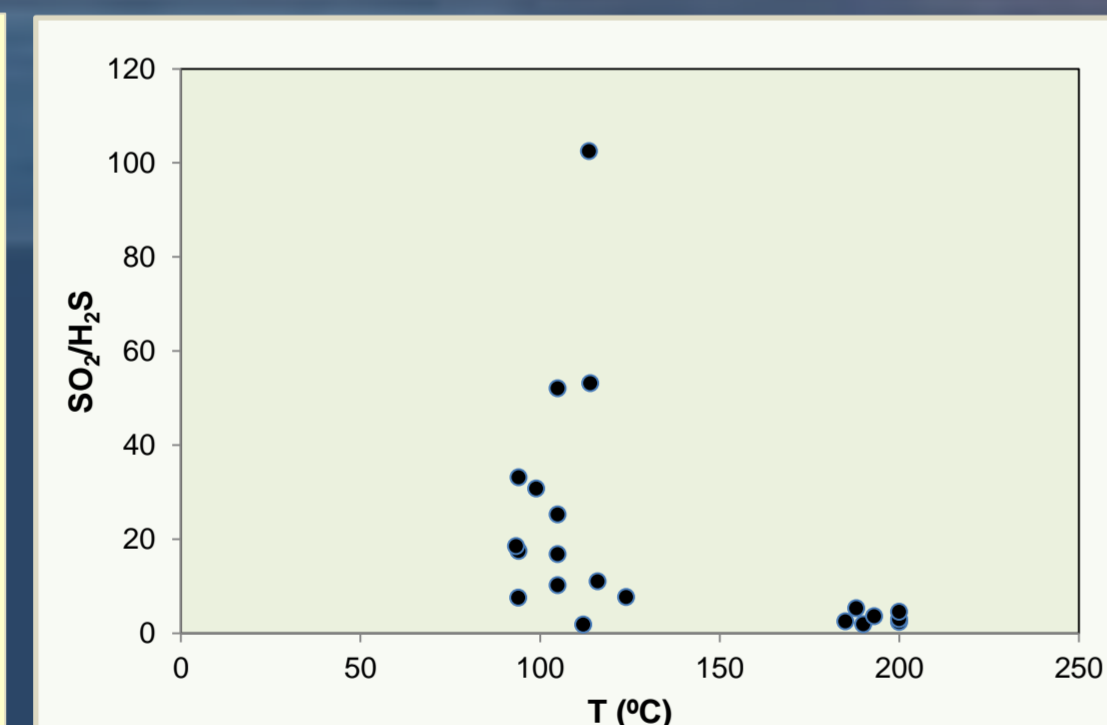
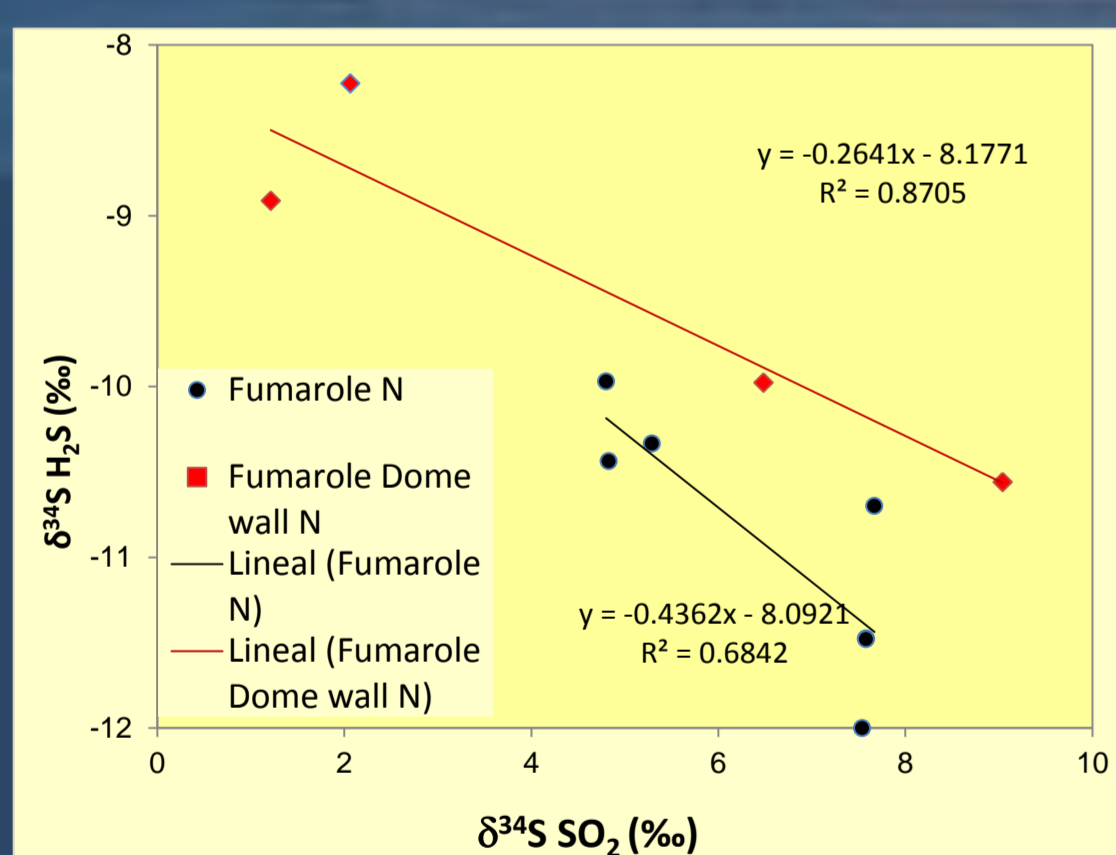
Sampling and $\delta^{34}\text{S}$ isotopic results of barite precipitated from H_2S and SO_2 in the gases from the West Crater fumaroles from Turrialba volcano.

Sample	Date	Gas T (°C)	$\delta^{34}\text{S}$ (SO_2) ‰	$\delta^{34}\text{S}$ (H_2S) ‰	$\delta^{34}\text{S}$ (S_T) ‰	$\text{SO}_2/\text{H}_2\text{S}$
VT-1-61	24/01/2009	88.3	7.62	-10.83	-	-
VT-52-54	02/03/2005	89.6	-	-0.93	7.5	-
VT-46-48	02/03/2005	92	7.27	-8.73	6.27	-
VT-49-51	12/07/2005	90.4	7.70	-7.79	4.9	89.5
VT-58-59	03/08/2004	90.8	-	-0.87	-	3.8
VT-43-45	03/10/2005	91	7.89	-10.40	5.99	23.0
VT-55-57	26/01/2005	91	5.2	-1.6	3.1	1.1
VT-40-42	26/01/2007	92	6.87	-12.71	6.32	45.38
				6.64	-	-
VT-5-65	13/11/2007	250	7.46	-13.56	-	-
VT-4-64	05/10/2007	250	7.46	-13.23	-	-
VT-17-18	05/09/2007	185	7	3.66	-	1149.25
VT-9-11	05/09/2007	270	7.2	2.82	5.03	4.13
VT-12-14	07/08/2009	278	8.16	-7.22	7.06	-
VT-6-8	22/07/2008	237	8.49	-9.17	3.08	2.20
VT-2-63	14/11/2008	157	8.61	-10.55	-	-
VT-3-62	17/05/2009	70	8.99	-14.17	-	-
VT-19-21	22/08/2005	92	9.74	-23.24	6.27	35.47

Sampling and $\delta^{34}\text{S}$ isotopic results of barite precipitated from H_2S and SO_2 in gases from Poás volcano.

Sample	Location	Date	Gas T (°C)	$\delta^{34}\text{S}$ (SO_2) ‰	$\delta^{34}\text{S}$ (H_2S) ‰	$\delta^{34}\text{S}$ (S_T) ‰	$\text{SO}_2/\text{H}_2\text{S}$
VP-129-131	Poás	21/06/2004	93.9	-	-	3.3	7.62
VP-132-134	Poás	21/06/2004	114	-	-	4.2	53.2
VP-126-128	Fumarole North Terrace	25/08/2004	113.6	-	-	3.3	102.51
VP-120-122	Poás	22/10/2004	94	-	-	3.9	17.53
VP-123-125	Poás	22/10/2004	116	-	-	4.2	11.09
VP-114-116	Poás NE	25/01/2005	93.3	-	-12.20	3.40	18.59
VP-117-119	Poás E	25/01/2005	98.9	-	-	4.5	30.82
VP-111-113	Fumarole North Terrace	12/04/2005	124	5.29	-10.33	0.59	7.73
VP-66-67	Fumarole North Terrace	11/08/2009	97	7.54	-12.0	-	-
VP-105-107	Fumarole North Terrace	16/06/2005	200	4.83	-10.44	-0.92	3.06
VP-108-110	Fumarole North Terrace	26/06/2005	200	4.80	-9.97	-3.09	2.42
VP-102-104	Fumarole North Terrace	14/07/2005	188	7.58	-11.48	0.23	4.57
VP-99-101	Fumarole North Terrace	08/08/2005	190	7.6	-11.5	0.2	1.93
VP-98	Fumarole North Terrace	20/09/2005	193	-	-	1.90	3.67
VP-95	Fumarole North Terrace	28/02/2006	188	-	-	3.00	5.34
VP-89	Fumarole North Terrace	03/05/2006	185	-	-	-11.5	2.53
VP-83	Fumarole North Terrace	27/02/2007	124	7.67	-10.7	-0.20	-
VP-79-81	Fumarole North Terrace	28/08/2007	108	-	-	-0.20	-
VP-77-78	Fumarole Dome North Face	05/05/2008	109	2.06	-8.22	-	-
VP-74-76	Fumarole Dome North Face	10/06/2008	112	1.21	-8.91	-	1.85
VP-68-69	Fumarole Dome North Face	11/11/2008	-	-	-	-	-
VP-72-73	Fumarole Dome North Face	19/03/2009	93	9.04	-10.56	-	-
VP-70-71	Fumarole Dome North Face	20/05/2009	93	6.48	-9.98	-	-

Poás

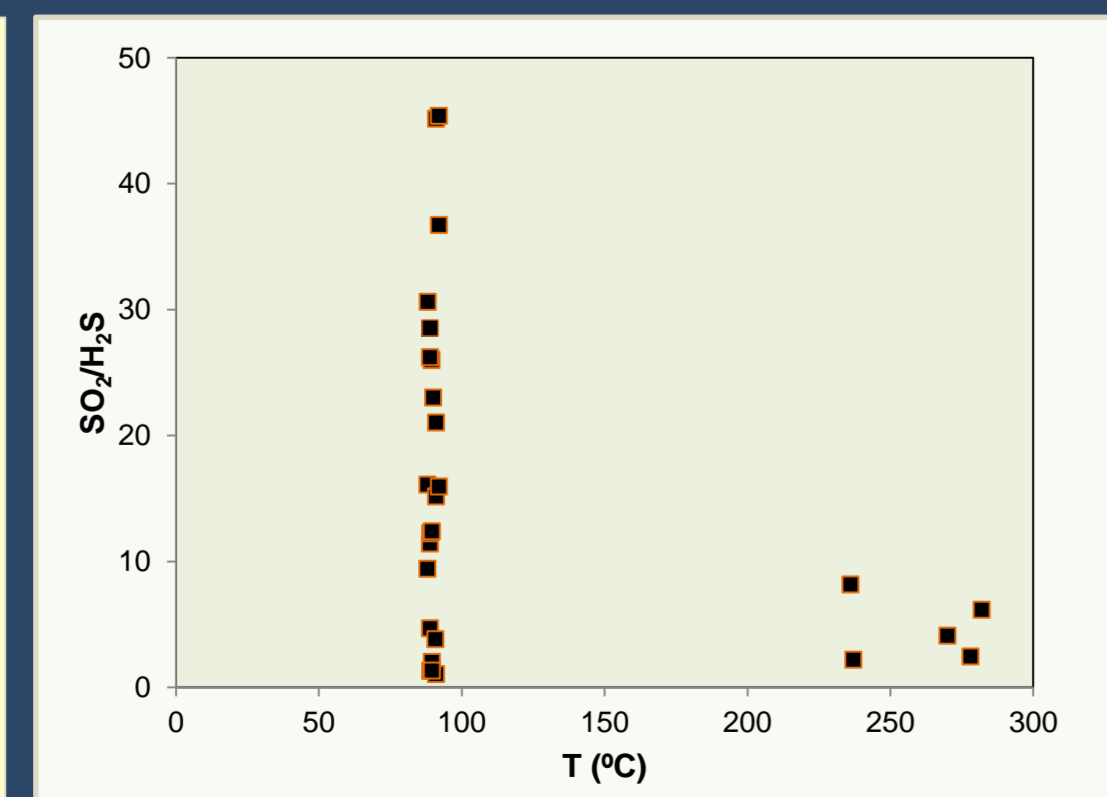
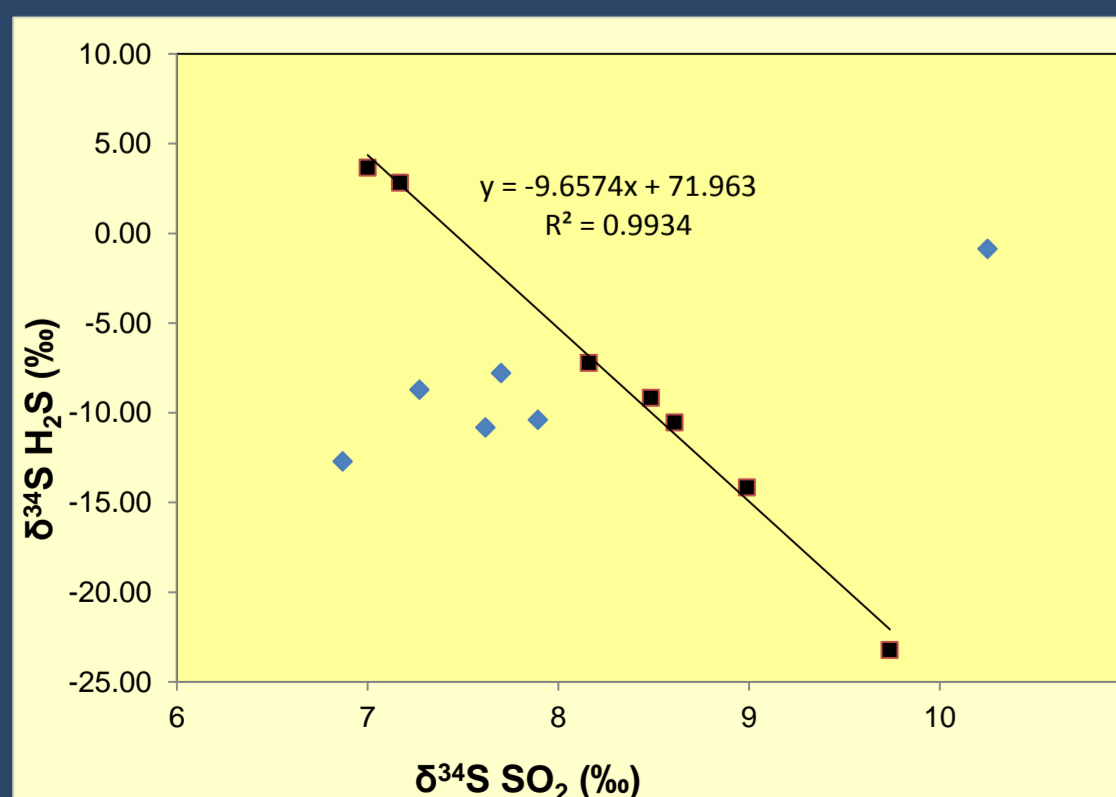


$\text{SO}_2/\text{H}_2\text{S}$ ratio according to the temperature of volcanic gases from Poás.



Turrialba volcano in May, 2013.

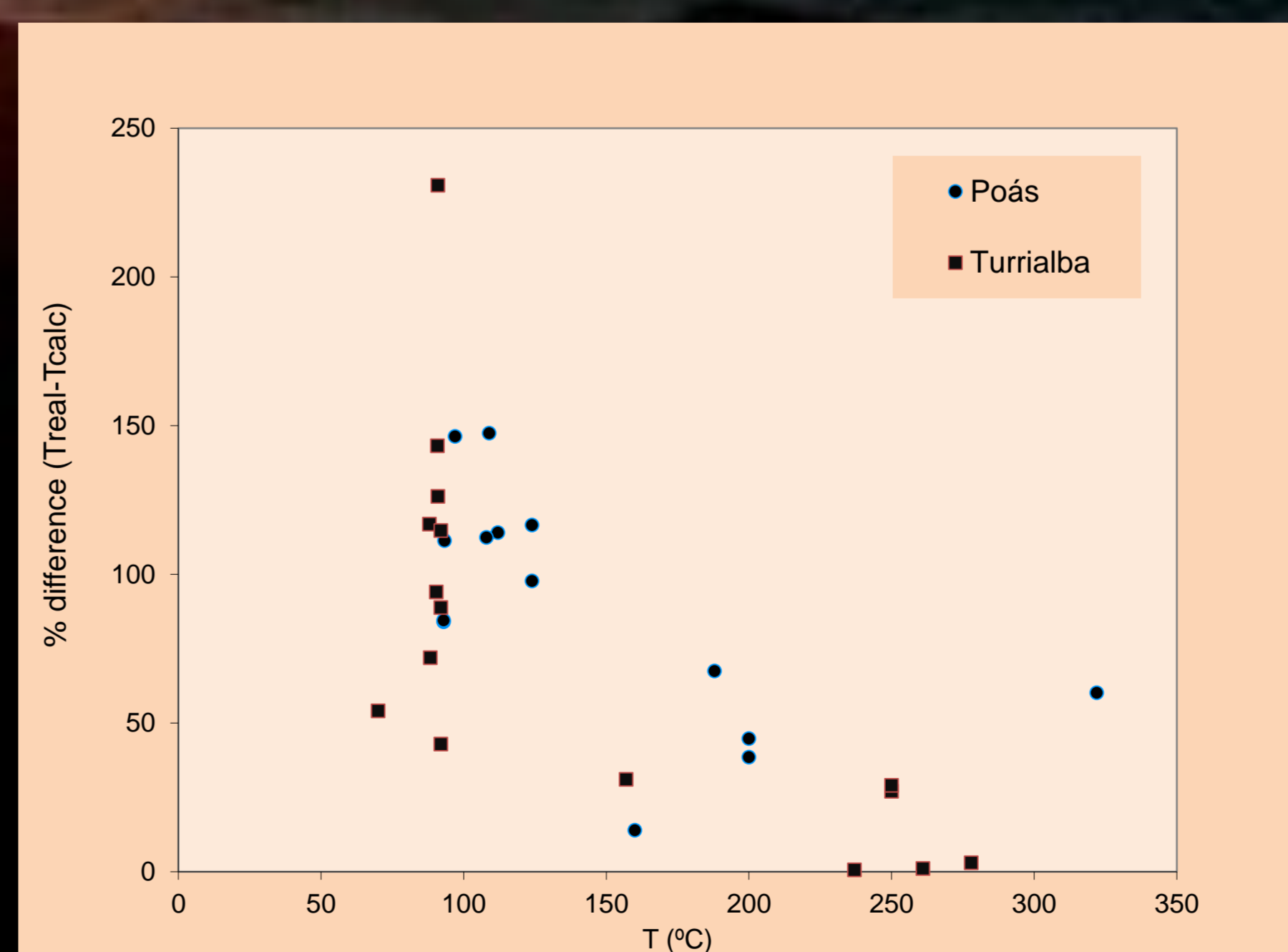
Turrialba



$\text{SO}_2/\text{H}_2\text{S}$ ratio according to the temperature of volcanic gases from Turrialba.



Poás 1999 (photo Federico Chavarria)



% of difference between the temperature of gas during the volcanic emission and the calculated from the fractionation $\text{SO}_2\text{-H}_2\text{S}$ pair.

The increase of difference at lower temperature could be indicative of lack of equilibrium between both sulphur species.

Conclusion

Isotopic sulphur composition of barite precipitates from gases confirm a dual source of fumarolic fluids at Poás and Turrialba volcanoes: 1) part of the sulphur comes from a mantle origin and other component is from a 2) hydrothermal aquifer.

References

Ohmoto H., Rye RO. (1979) Isotopes of sulfur and carbon. In: Geochemistry of Hydrothermal Ore Deposits. Barnes H.L. (ed) J Wiley and Sons, p 509-567