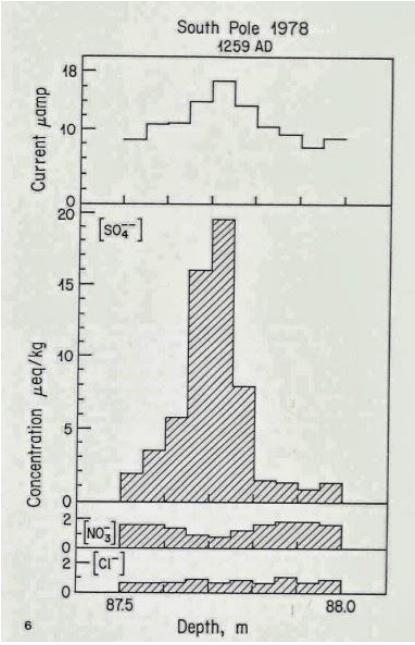
The source of one of the most powerful volcanic eruptions of the past 7000 years has been found

It's the story of a mystery which began in 1988 with the publication, in the *Annals of Glaciology*, of a study about an anomaly encountered in polar ice cores. The authors of the study, Langway JR, Clausen and Hammer, had measured a sharp peak of acidity (a high concentration in SO42- (ion sulfate) ions in several stations in Greenland as well as in Antarctica, at depth corresponding to a year around 1259. Just as important, this anomaly in sulfate ions came with fragments of volcanic glass.

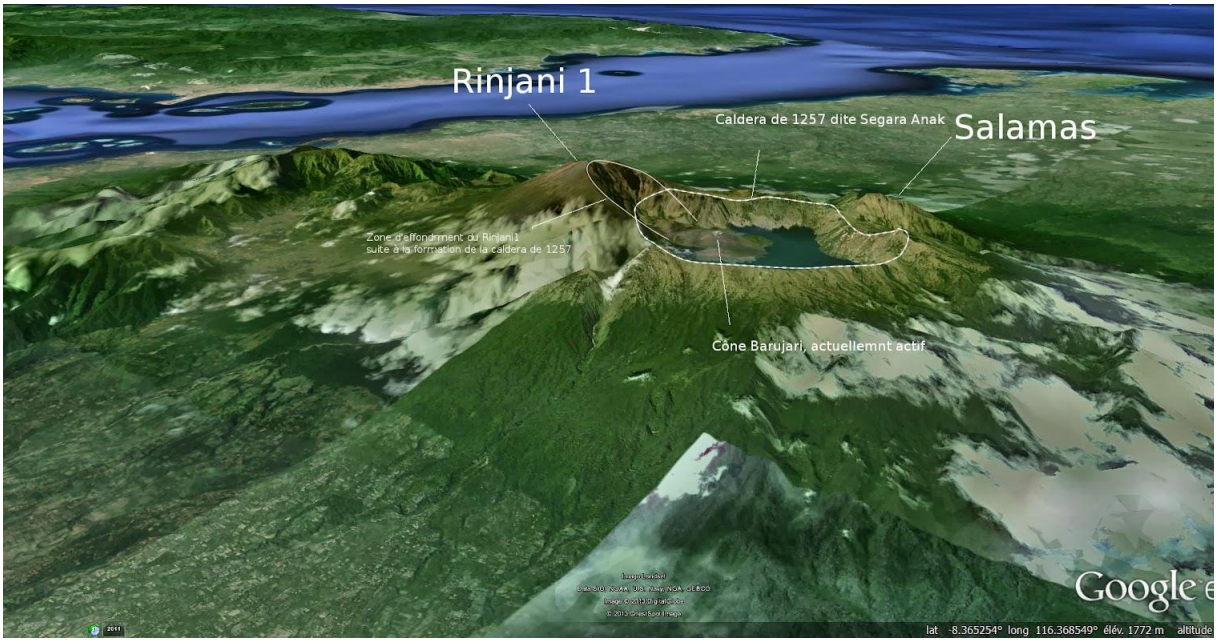


The peak in sulfate ions around1259. Picture: Longway et al 1988

The authors' hypothesis was that this peak, simultaneous registered at both poles, resulted from a very violent eruption around 1259, powerful enough to perturb the whole of the Earth atmosphere. In order to have such an impact on both hemispheres, the source volcano had to be situated in the interpropical zone.

Since then, numerous candidates have been proposed, none totally convincing, in order to explain this anomaly which became some kind of a persistent mystery, a volcanic Grail of sorts.
Now, an international team lead by the Frenchman Franck Lavigne has just published the results of several years of labor, aiming to determine that source and they have from all

evidence put an end to the mystery: the volcano in question is named Samalas, none other than the ancestor of the Rinjani, on the island of Lombok, close to Bali.



The principal elements of the Rinjani volcano.

How did the team end up connecting a layer of ice containing an excess of SO_4^{2-} to one of the Holocene's must powerful eruptions? That's the magic of volcanology, the investigative work which gives its zest to this peculiar domain of science.

First, we must be aware of the fact that the researchers did not start from nothing: their team is but the final link in this quest, at the end of a chain of other teams and other disciplines which all of them, directly or not, have been working at the mystery's resolution for almost 30 years.

Evidence for Northern Hemisphere Winter Warming in Western Europe in 1257/1258. ***Arras (France).***

En cest an, fut le temps si doulz et si souef (chaud) que en tout l'hiver ne gela que deux jours : ou mois de janvier, trouvoit on des violettes et les fleurs de fraisiers, et estoient tous les pommiers tous blancs flouris. (7)

Translation: At that time the wheater was so mild and so hot that frost barely lasted for more than two days. In January [1258], violets could be observed, and strawberries and apple trees were in blossom.

Paris (France).

Et en l'autre année après, qui est en l'incarnation par M.CC. et LVI (1256) fist trop durement fort hyvier ou royaume de France et pluvieus ésté dusqu'à la Nativité saint Jehan Bauptiste (24 juin). Et en l'autre année après, fist merveilleusement chaut esté et chaut temps jusqu'à la Chandeleur ; et puis après, fist merveilleusement grant froit jusqu'à la saint Marc (25 avril). Et en cèle année meismes, ot par toute la France grant chierté de pain, de vin et de toutes viandes. (8)

Translation: And the following year, which is the year 1256 of the Incarnation, the winter was very harsh in the kingdom of France and the summer was very rainy until the Nativity of Saint Jean Baptist (June 24). And the following year (1257), the summer was excessively hot, and the weather was warm until Candlemass (2 February 1258), and then it was excessively cold until the St. Mark (25 April 1258). And this year also, there was throughout France a great shortage of bread, wine and any meat.

Saint Alban Abbey (England).

Annus quoque iste, cronicarum infirmitatum genitivus vix occupatum permisit aliquatenus respirare. Non enim frigus vel serenitas vel gelu saltem aliquantulum stagnorum superficiem, prout consuevit, glacialem induravit, vel stiriam a stillicidiis coegit dependere ; sed continuae inundationes pluviarum et nebularum usque ad Purificationem beatae Virginis aera inspissarunt. (8)

Translation: This year (1257), too, generated chronic complaints, which scarcely allowed free power of breathing to any one labouring under them. Not a single frosty or fine day occurred, nor was the surface of the lakes at all hardened by the frost, as was usual; neither did icicles hang from the ledges of houses; but uninterrupted heavy falls of rain and mist obscured the sky until the Purification of the Blessed Virgin (2 February 1258) (10)

An anomalous season in 1257. Picture: Lavigne et al 2013

Some work had already been done studying the rings of ancient trees (dendrochronology) which had also registered an atmospheric anomaly around this period. The growth of trees, manifest in the size of their rings, depends on numerous atmospheric factors such as temperature, pluviometry, luminosity, etc. Historical data from the Middle-Ages tell of a particularly abnormal meteorological episode in Europe with a particularly cold and extremely rainy summer in 1257, and a warm winter, with apple trees in blossom in January.

There are also historic writings from Indonesia relating a large amplitude event on the island of Lombok for that time. Volcanologists had earlier on dated the forming of the immense caldera of Segara Anak, placing its opening to the time between 1210 and 1260.

But these eruptions still needed to be connected to the anomalies signaled at the four corners of the globe, be it in the ice or in the tree-rings. For other large eruptions, which were evoked

as possible sources, occurred at the same time, in Ecuador (Quilotoa), Southern Mexico (El Chichon) and in New Zealand (Okataina). So, how was one to sort out all these eruptions?

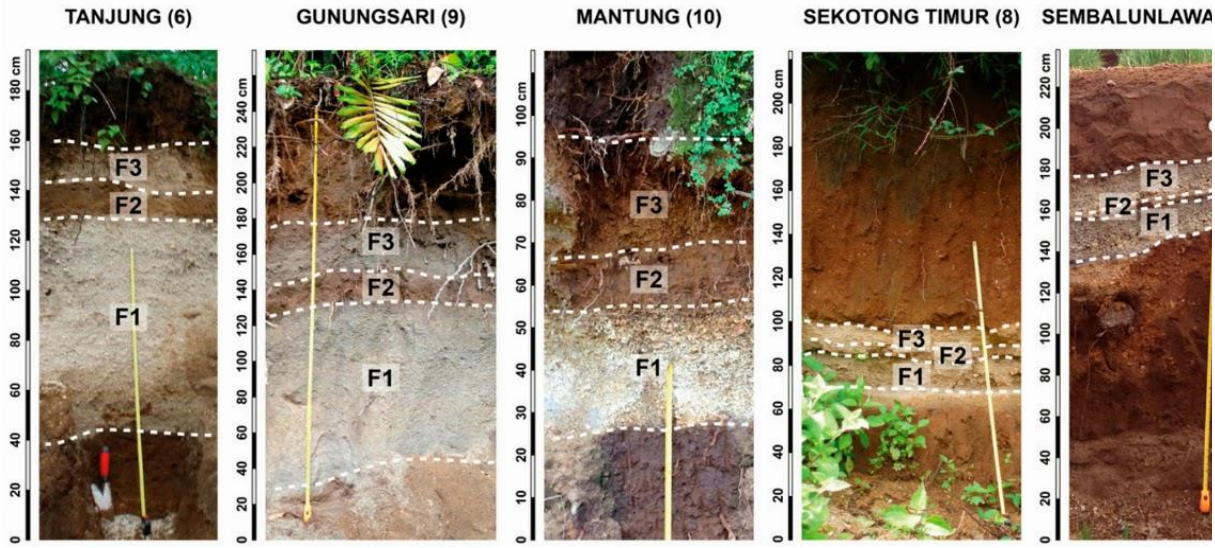
One cannot stress it enough: science, in order to understand, needs first and foremost data. The Rinjani comes up as a serious candidate? It still needs to be proven that the hypothesis is right, or wrong. Which means going on the spot to gather as much information as possible. In order to find the main parameters of this eruption (precise date, volume of expulsed magma, height of the plume, etc.), and be able to assign to it its true importance and to recognize its traces in other parts of Earth, volcanalogists decrypted no less than 130 outcroppings (zones where the rock is bare), dispersed all over the island of Lombok.

Here are some of the results from the analysis of these outcroppings, of their spreading, and of the rocks which make them out :

1- The eruption happened in four distinct phases, in a chain of events covering a short period of a few days only. The first (F1) is an eruptive phase of extreme power which generated a column of ashes the altitude of which is estimated to 43km! It would have lasted only about four hours and liberated a volume of magma of 2.5 km^3.

The second phase (F2), a little less intense, shows that there was an interaction avec water, but it is not described in detail in the article just published.

The authors concentrated on the third phase (F3), similar to the first but which took place over a longer period, estimated to around 18 hours, which generated a column of ashes about 20 km high. The volume of magma released in F3 is estimated to a little less than 2 km^3. All is covered with very voluminous pyroclastic flows signaling the collapse of the caldera of Segara Anak and the disppearance of the Salamas volcano.



Deposits associated to the first three phases of the eruption. Pictures: Lavigne et al, 2013

2- C14 datings made from carbonized wood trapped in the eruption deposits confirm that the eruption took place in the middle of the 13th century.

3- Calculation of the Volcanic Explosivity Index (VEI) gives a minimal value of 7, considering that the maximum known is 8 (Taupo for the eruption of Oruanui, 26 500 years ago). The total volume of magma liberated over a few days is estimated at 40 km^3 : enough to cover practically all of Paris in 400m of ashes (100m higher than the Eiffel Tower…)!

4- The composition of volcanic glass recovered in the Greenland ice is very similar to the one of the ashes making up the deposits from this eruption. This is a particularly strong point for identifying the source.

The overall data designates this eruption the best ever candidate in order to explain the numerous climatic anomalies recorded in Europe in the middle of the 13th century.

What remains fascinating in all of this is that up until now, despite the fact that volcanologists had already identified the formation of the Segara Anek caldera as a violent event, this eruption had not been much studied, and its planetary importance had remained unnoticed.

What really gets me is that it just needed a little peak in sulfate ions trapped at the poles in order to find the track of a giant eruption close to the Equator. *C'est pas beau, la science?*

Sources:
Lavigne et al, 2013: "Source of the great A.D. 1257 mystery eruption unveiled, Samalas volcano, Rinjani Volcanic Complex, Indonesia"

Langway et al, 1988: "An inter-hemispheric volcanic time-marker in ice cores from greenland and antarctica." annales de glaciologie.

Read also, about the same event, Erik Klemetti's blog Eruptions

*: the VEI (Volcanic Explosivity Index) is a comparison scale of magnitudes of volcanic eruptions (by volume of liberated magma) having a similar role as the Richter scale for earthquakes.

From the site: La Culture Volcan

http://laculturevolcan.blogspot.fr/2013/10/la-source-de-lune-des-plus-puissante.html

Translated from the French by Anne-Marie de Grazia