Investigating H2O contents in clinopyroxene from explosive versus effusive eruption products from Merapi volcano, Indonesia

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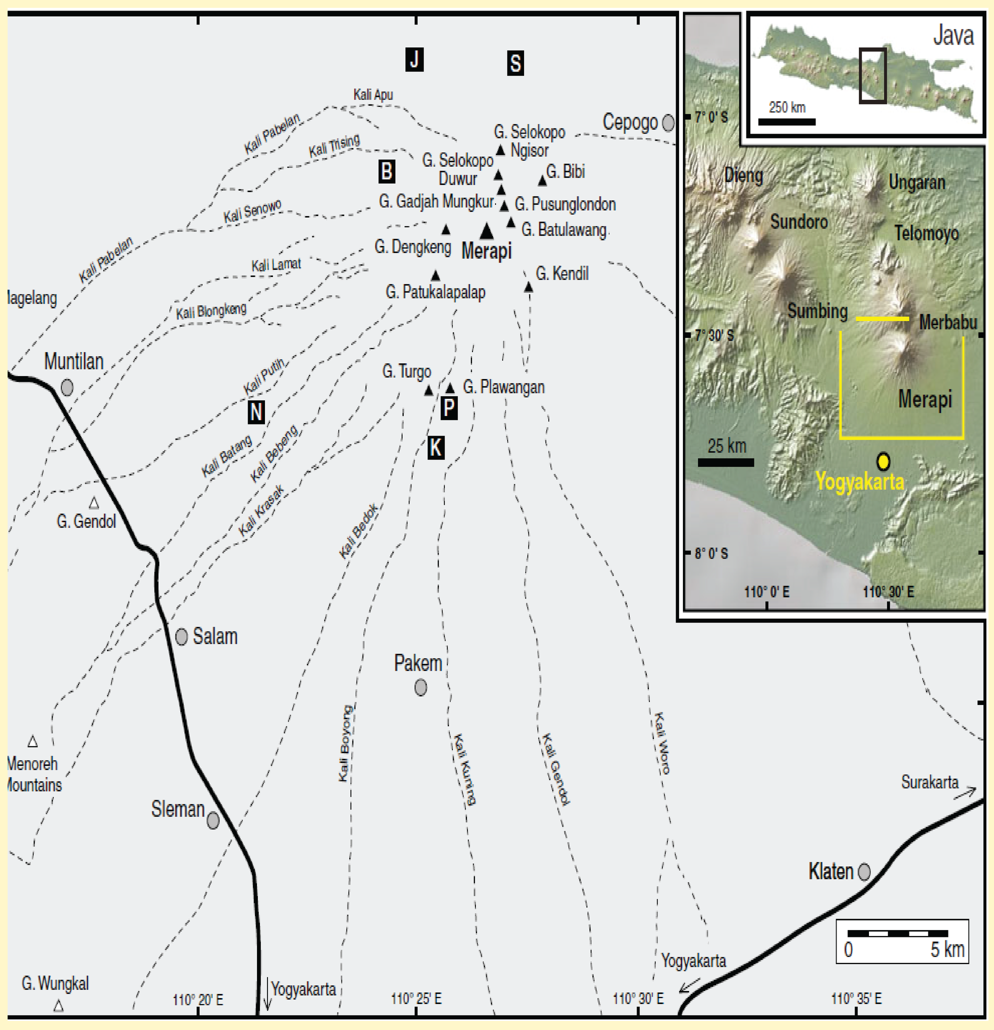
1 Intorduction to the Merapi volcano and the 2010 eruption

The eruption of Merapi on 2010 produced both pyroclastic and lava products. The composition of the two types of products appears similar.
So what is the reason behind the existance of the different types of eruptive materials?

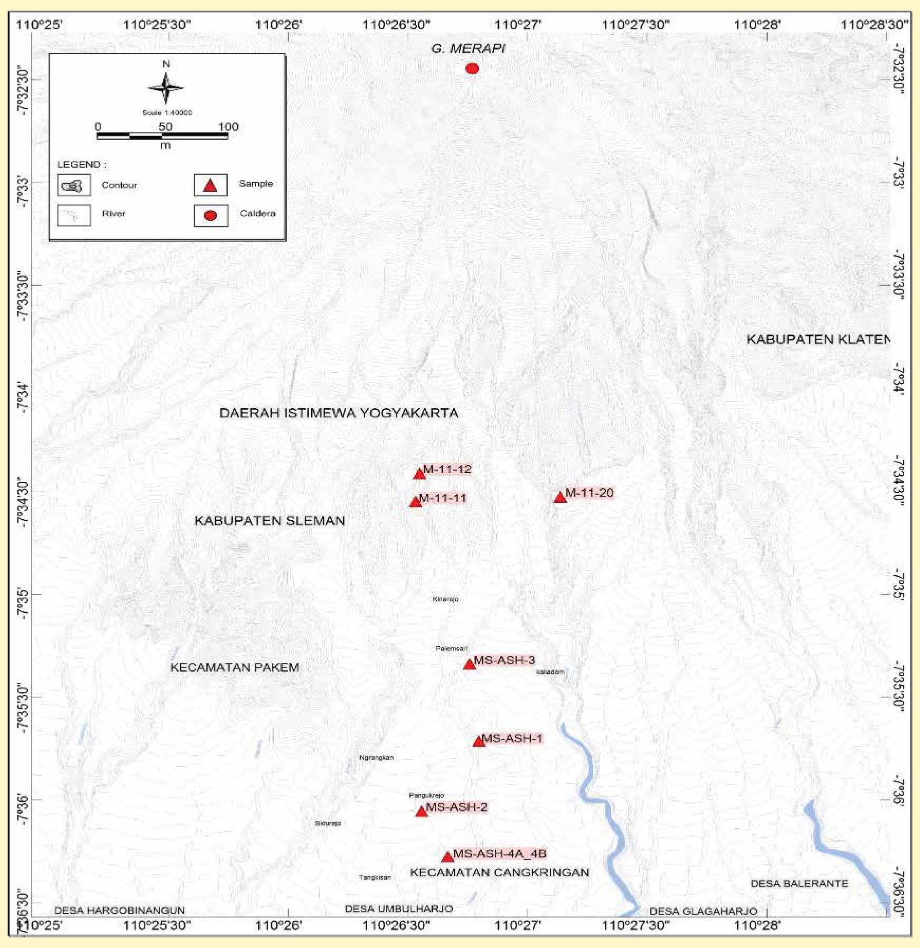


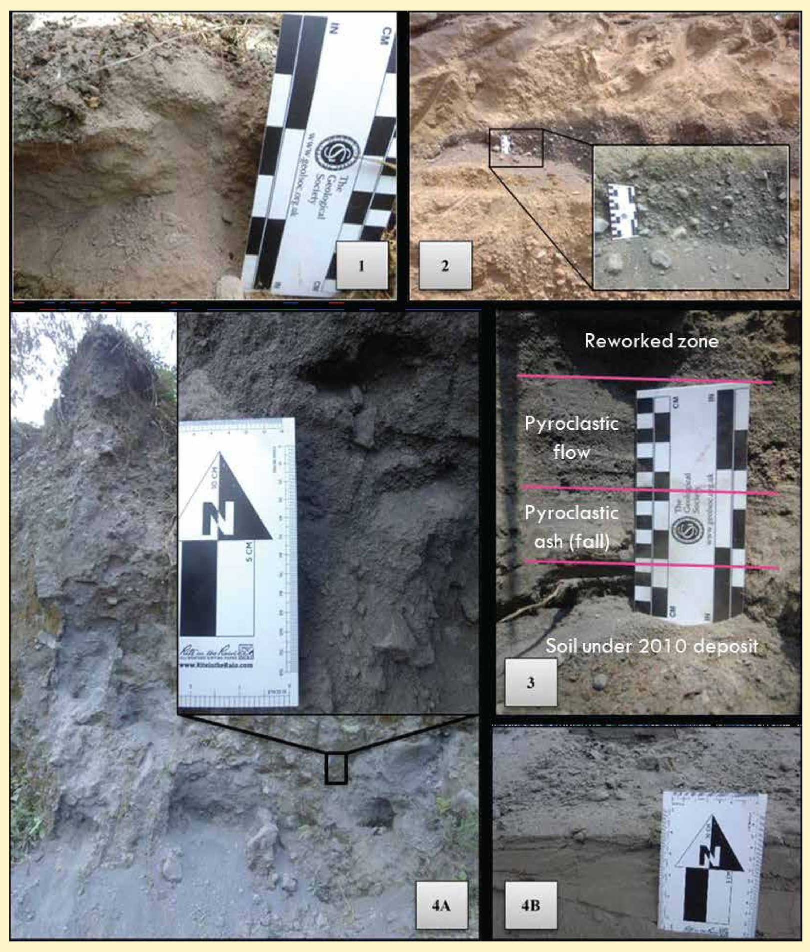
- Merapi is located in the central part of Java, Indonesia.
- It has a rich eruptive history with eruptions occuring every 3 to 5 years.
- The population on a 30 km radius around Merapi is 4,440,000.
- The 2010 eruption was one of the strongest historical eruptions with 353 victims and more than 340,000 people displaced.

Left:Close-up of the Merapi volcano and the surrounding area. In black squares are the observation posts. Gray circles represent the populated areas around the volcano. The black triangles are the summit and hills formed from the volcanic complex (After Gertisser et al., 2012). Right: Photograph by Bay Ismoyo (AFP/Getty Images) showing Merapi erupting during the early morning of 6 November, 2010. (From The Guardian News: http://www.guardian.co.uk/world/gallery/2010/nov/05/indonesia-volcano-mount-merapi).

- The 2010 eruption was different than the previous eruptions observed
- The expected eruption should consist of effusive, dome-forming eruption
- The 2010 event began explosively and culminated in an effusive style eruption

2 Sampling and Fourier-transform infrared spectroscopy

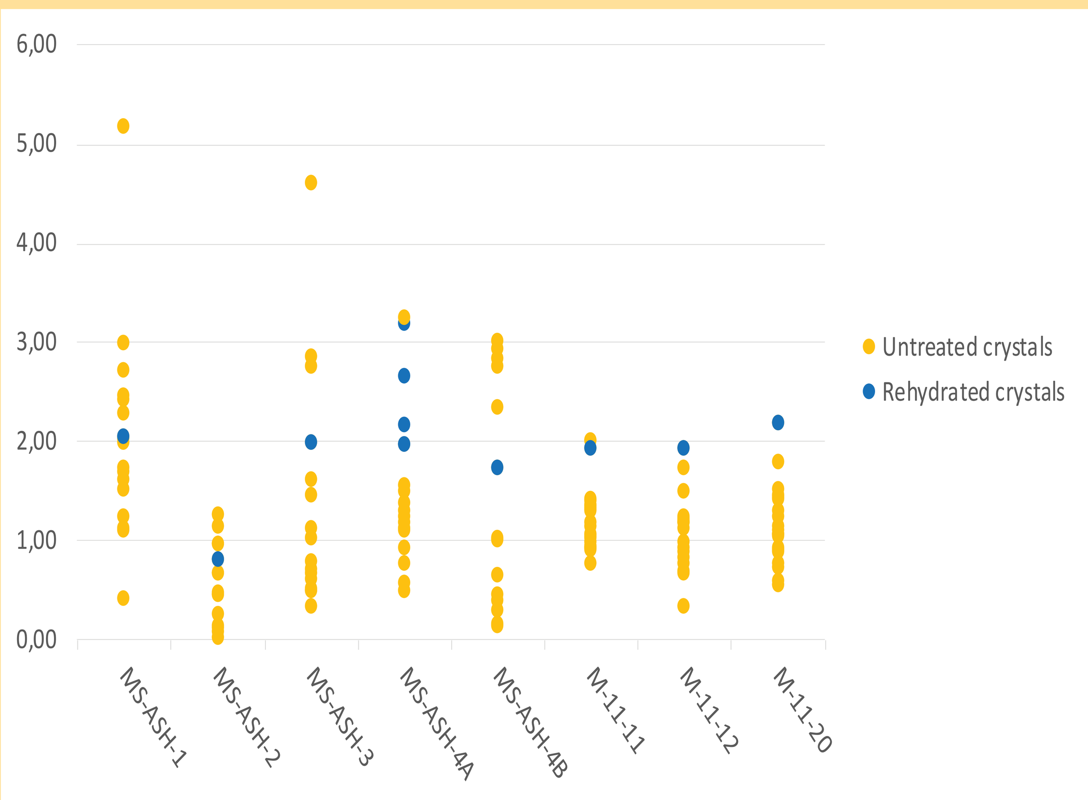




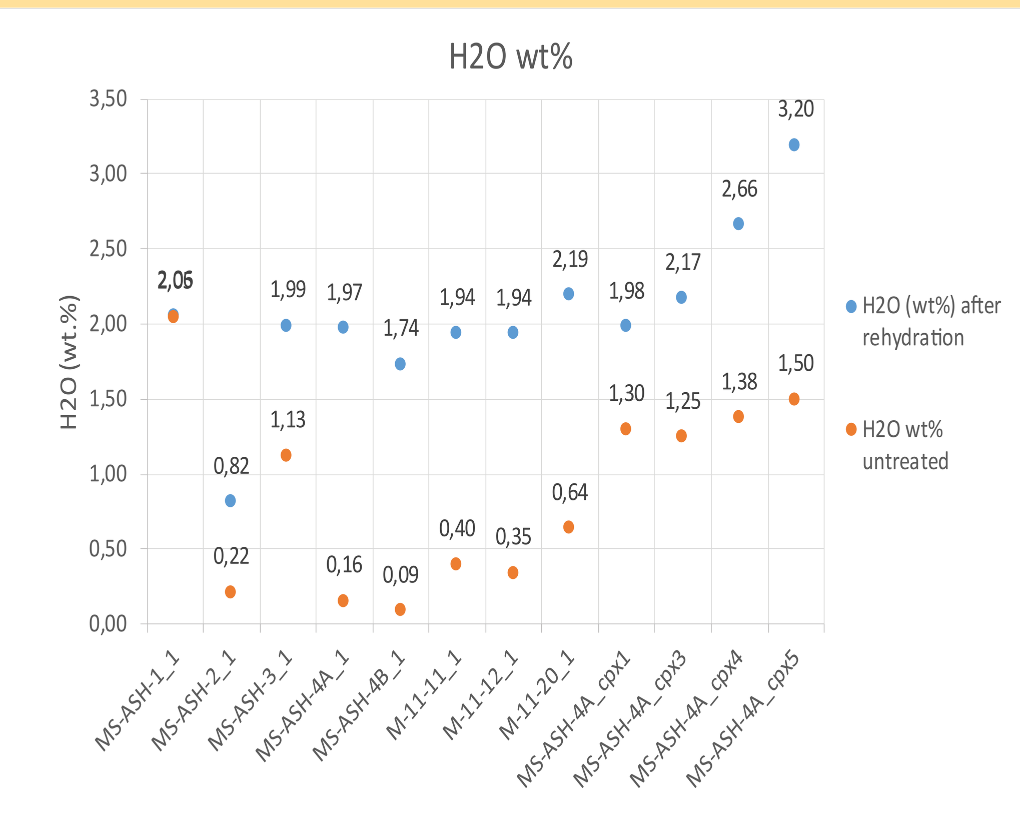
Left: Map of the location of the ash samples (After Seraphine, 2018). Right above: Photos of the outcrops from which samples were collected (After Seraphine, 2018). Right below: Photo of the Fourier-transform infrared spectroscopy configuration in Natural History Museum of Stockholm (Image courtesy of B. Radu, Natural History Museum of Stockholm)

- Five ash samples and three lava samples courtesy of Seraphine N. and Gertisser R. respectively were collected
- The samples were crushed and clinopyroxene crystals were separated.
- One set of unoriented and oriented clinopyroxene crystals where Fourier-transform infrared spectroscopy (FTIR) was conducted.
- Another set of only oriented clinopyroxene crystals which were analysed with the use of FTIR before and after being experimentally rehydrated.

3 Magmatic water as observed by the samples



- The magmatic water of untreated ash crystals appear to be between 0.04 and 5.19 wt%.
- The vast majority of the ash crystals show magmatic water content of around 1-3 wt%.
- Two clear outliers at 4.62 wt% and 5.19 wt%.
- Ash sample MS-ASH-2 appears to have lower values.
- The magamtic water of untreated lava samples has a range of 0.35 to 2.02 wt%.
- Most values appear to be around 0.5 to 1.5 wt%.

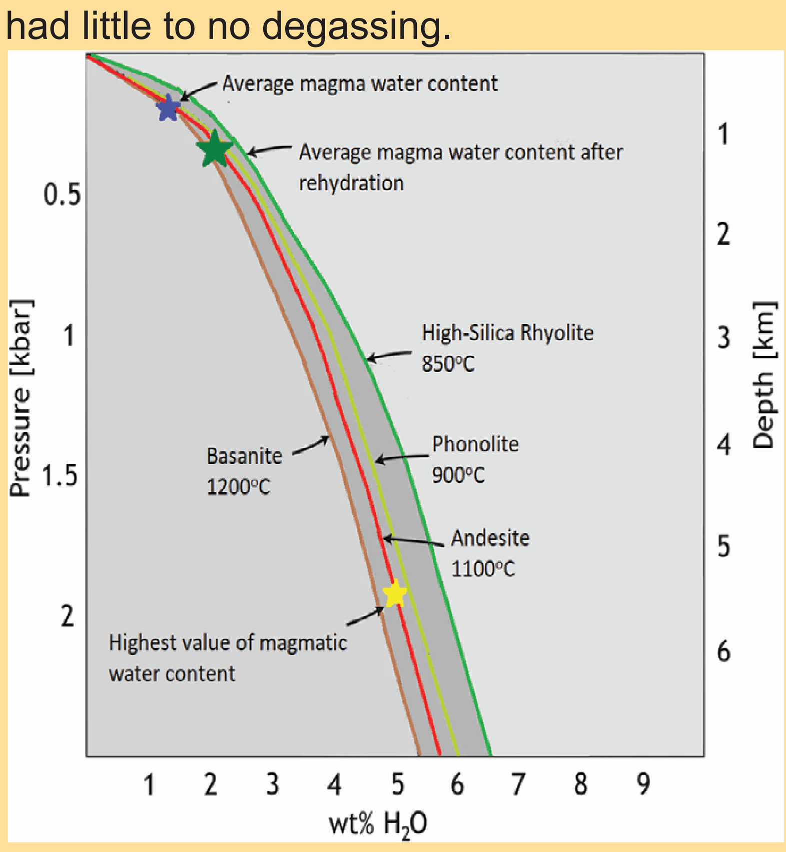


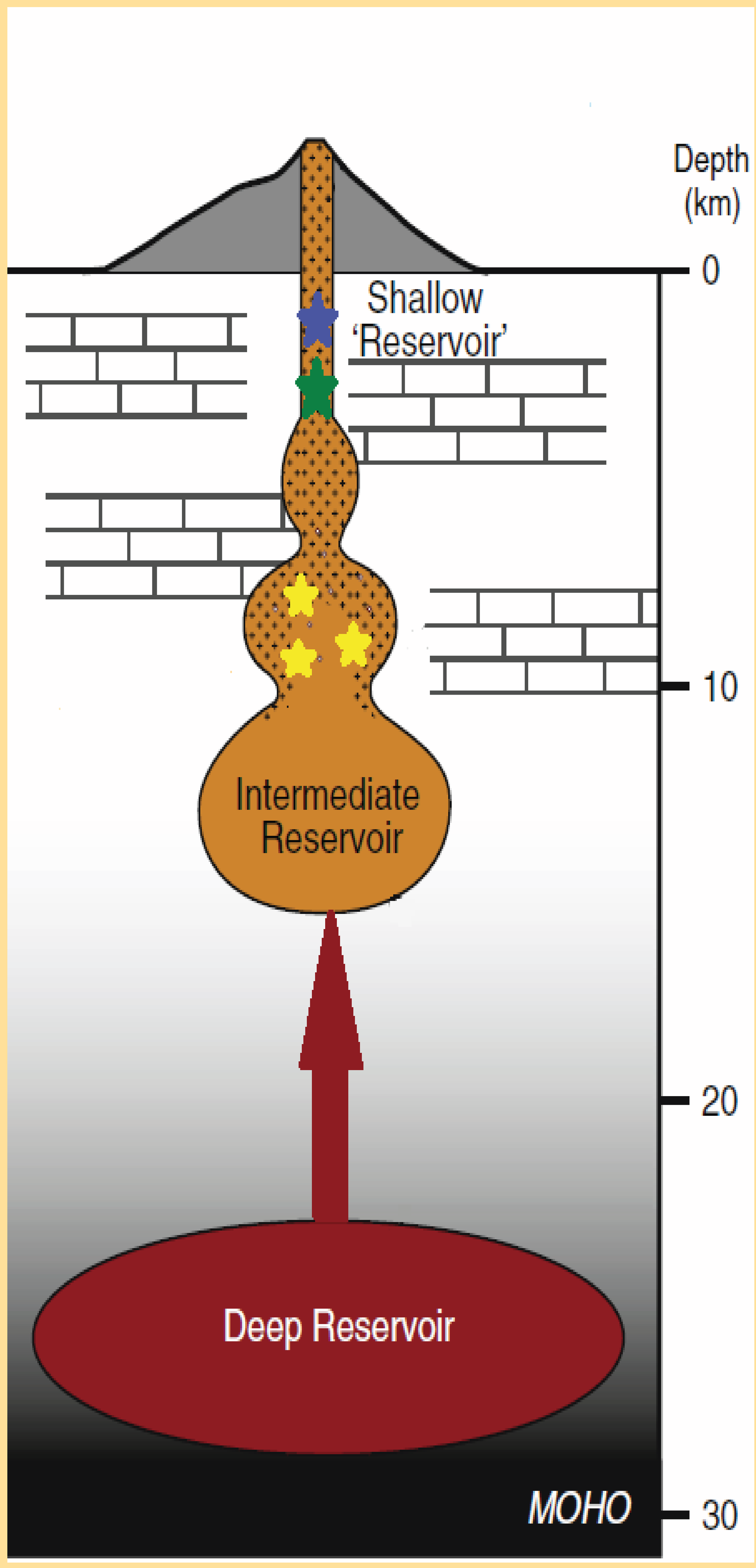
- Ash sample MS-ASH-1 appears to have the same magmatic water percentage before and after rehydration.
- The magmatic water content for sample MS-ASH-2 after rehydration appears to be the lowest.
- Most of the other samples appear to have consistent values after rehydration at around 2 wt%.
- The exception is the crystal MS-ASH-4A_cpx5 with a higher value of 3.2 wt%.

Above: Graph showing the magmatic water content of all the crystals tested for each sample. Also plotted the magmatic water content after rehydration. Below: Magmatic water content as shown by crystals before and after experimentally rehydrated.

4 Interpretation of the results and possible explanation for the 2010 eruption

- The eruptive products are of different crystal populations
- The main population is of crystals coming from shallow magma reservoir, ie. 2-3 km depth.
- There are several outliers with higher water content. These are thought to come from deeper magma replenishing the shallower parts and activating the 2010 events ie. an intermediate reservoir.
- These outliers belong in the products that erupted as ash. The ascent was fast and they had little to no degassing.





Left: Possible model of the 2010 eruption (Modified after Costa et al., 2013) Shallow magma mixing with deeper magma and rapid ascent with little to no degassing.
Above: Curves displaing H2O solubility as a function of pressure and wt% H2O (Modified after Bouchard et al., 2016. Original by Holloway and Blank,1994)

5 Uncertainties and future studies

- The geochemical composition used for the the calculation of the magmatic water for the second set of crystals are averages based on earlier works done on the same crystals.
- More crystals are to be tested to verify the existence of the small percentage of crystals with higher magmatic water values.

References

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