The forcing of climate by CO_2 on geological timescales

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Understanding the role of atmospheric CO_2 in driving global climate is one of the great challenges facing Earth Scientists today. Ultimately we are driven by the pressing need to predict how hot the Earth will get in the near future. There are many ways we can achieve this increased understanding – ranging from examining the most recent historic past to basing our predictions on an understanding of the modern climate system encapsulated in numerical climate models. Increasingly the palaeo-community has been willing to contribute to the debate, since the geological record is littered with examples of warm climate states, in part associated with elevated levels of atmospheric CO_2. Whilst these provide real world examples of how the Earth System responds to CO_2 forcing, no geological period is an adequate analogue for our warm future. Furthermore, climate models suggest that a significant level of state dependency exists for climate sensitivity. Therefore examining the response of the climate system to CO_2 forcing in the Eocene, for example, does not have direct relevance due to the different continental arrangements, ice sheet configurations and vegetation. When these factors are accounted for, it has been recently shown that the available palaeo-data largely confirms the sensitivity of the Earth system to CO_2 forcing determined by climate models alone [1].

Despite this overall conformity, there are several warmer time periods in the geological record (e.g. the Pliocene) that apparently exhibit significantly elevated climate sensitivites (e.g. [1]). Importantly, these are above the range typically, but not always (e.g. [2]), achievable in climate models – clearly suggesting that the Earth can exist in states that appear to be particularly sensitive to CO_2 forcing. Such a state dependency to sensitivity has worrying implications for predictions of our warm future climate. In this contribution we use new data from a number of key periods to further probe the response of the Earth system to CO_2. This provides new insights into the possibility of "hidden" feedbacks and the likelihood of a state dependency to climate sensitivity.

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Dual explosive activity revealed by petrochemical and mineralogical data on tephra: Peculiar Roman-age eruptions of Stromboli volcano

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The Pizzo-Sopra-la-Fossa tuff cone of Stromboli volcano has been investigated by stratigraphic, petrographic, mineralogical, geochemical and isotopic studies. Its deposits are presently the remnant of a collapsed tuff cone formed by a thick pyroclastic sequence of bomb, lapilli and ash fallout and surge levels. The main outcrop is located above the active craters where acid fumarolic gases strongly altered the juvenile clasts. For this reason, the Pizzo-Sopra-la-Fossa sequence was poorly studied, although it represents a key point for recognising the recent evolution of Stromboli. We mainly focused our studies on Le-Croci outcrops characterized by a 6 meters thick sequence of mainly unaltered fall deposits.

Two groups of feeding magmas have been identified, a group constituted by high-K basalts to high-K basaltic-andesites (Pizzo-HKCA) and another formed by shoshonitic basalts (Pizzo-SHO). The two groups can be distinguished on the bases of petrographic, mineralogical and geochemical data. Pizzo-HKCA products have lower phenocryst contents, incompatible trace element abundances and Sr isotopic ratios, with higher $^{143}Nd/^{144}Nd$ values than Pizzo-SHO. They also show differences in mineral phase composition and zoning.

There are also clear evidences that the two magmas were erupted contemporaneously, suggesting the presence of two distinct magma reservoirs, possibly located at different depth.

Based on crucial stratigraphic correlations (S.Bartolo-lavas, Lower-Sequence and Post-Pizzo-series), it has been recognised that this dual explosive activity on top of Stromboli, forming the Pizzo-Sopra-la-Fossa tuff cone, occurred only 2 ka ago (during Roman-age), possibly along the activation of NE-trending eruptive fractures.

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