Constraining the size of Heinrich Events using an Iceberg/Sediment model and a 3D ice sheet model

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Heinrich Layers, anomalously thick layers of ice borne sediment in the north Atlantic ocean, and the events that caused them have long been associated with abrupt climate changes during glacial times. However, there is still no consensus about either how much ice is needed to transport this sediment or how such a large volume of ice could be produced. Estimates for this ice volume do exist and may be broadly separated into two categories: estimates derived from ice sheet models, and estimates derived from isotope records. There is a wide discrepancy between these two sets of estimates with the isotope derived estimates being at least one, and sometimes two, orders of magnitude larger than those from ice sheet models.

We shall describe here two different methods to further constrain these events. First, we use an iceberg model that includes sediment to simulate the delivery of sediment to the north Atlantic during a Heinrich Event. Second we use a three dimensional ice sheet model (Glimmer) with realistic topography to determine the volume of ice that leaves Hudson Strait during the thermo-mechanical surging events that the model simulates.

We show that the iceberg model can simulate the pattern of ice raft debris from a Heinrich Event and that we can simulate the sediment layer thickness that would result from the volume of ice released by the different estimates. We show that to best fit the observed Heinrich layer sediment thickness, 60×10^4 km^3 of ice needs to be released during the event. This matches the icesheet derived estimates better than the isotope derived estimates and suggests that Heinrich Events released relatively small volumes of ice. The surges from the 3-D ice sheet produce a larger volume of ice for each Heinrich Event than the iceberg model suggest is needed to form the Heinrich Layers, but the volume is consistent with other ice sheet models and significantly smaller than the volume that the isotopes suggest.

Variation in volatile content: Chichinautzin volcanic field, Mexico.

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Project

The Chichinautzin volcanic field (CVF) includes more than 220 volcanoes (cinder cones, shield volcanoes, maars) as well as larger stratovolcanoes (Popocatepetl) which erupted important quantity of volatiles since the Quaternary. It is located in the central portion of the Trans Mexican Volcanic Belt which is largely affected by the subduction of the Cocos plate and by effect of intra-continental rifting in Central Mexico [1]. This work focus on the volatiles content of three cones from the CVF selected based on their location, different range of documented ages and compositions [2]; Xitle (1665 yr B.P.), Pelagatos (< 14 000 yr B.P.), La Cima (<10 410 yr B.P.). Analyses of major gasses (H2O, CO2, Cl, S) trapped inside olivine-hosted melt inclusions were used to establish degassing mechanism. Crystals were selected from the main tephra deposits of these three cinder cones. Preliminary results show an overall dissolved sulphur concentrations varying between below detection limit (~ 50 ppm) and 1450 ppm and chlorine content varying from 56 to1601 ppm. FTIR analysis of doubly intersected olivine-hosted melt inclusions show that the dissolved H2O and CO2 contents vary from 0.1 to 4.31 Wt% and from 51 to 976 ppm respectively. The maximum H2O and CO2 content obtained for each volcano is presented in the table below:

	Xitle	Pelagatos	La Cima
H2O (%)	2.47	4.31	2.66
CO2 (ppm)	630	976	780

Table 1: Maximum H2O and CO2 content for each of the studied volcano.

Conclusion

For Xitle volcano, most melt inclusions have relatively low H2O and. This was previously found by [1] and may indicate that degassing at Xitle started at great depth as it is the case for the neighbour stratovolcano Popocatepetl [3]. Pelagatos volcano has the highest values, La Cima also have significant CO2 contents, but overall lower H2O compare to Pelagatos. The variations in volatile content suggest distinctive degassing mechanisms for each volcano.

[1] Wallace and Carmichael (1999), Cont. to Mineralogy and Petrology 135, 291-314. [2] Siebe et al. (2004), Bull. of Volcanology 66, p.203-225. [3] Roberge et al. (2009), Geology 37, 107-110.