Dating Antarctic ice sheet collapse: A molecular approach

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Abstract

During the last interglacial period (the Eemian), 130,000-116,000 years ago, global temperatures are estimated to have been around 2°C warmer and sea levels 5.5–9 m higher than today (Dutton and Lambeck, 2012, Otto-Bliesner et al., 2013). Similar or even higher global temperatures are projected for the late 21st century (IPCC AR5, 2013), making the Eemian a valuable analogue for future climate change and an important test for the temperature threshold required to trigger West Antarctic Ice Sheet (WAIS) collapse. The source of the Eemian sea level rise — particularly the contribution from WAIS — is unresolved (Kopp et al., 2009): to reach the upper bound of the Eemian sea level rise estimate a complete WAIS collapse would be required, however the lower end of the sea level rise estimate can be accounted for by loss of the Greenland ice sheet (2 – 4m, [NEEM Community Members, 2013]), ocean thermal expansion and small ice caps and glaciers (<1 m). Results from coupled ice sheet climate models suggest a ca. 2°C warming is sufficient to cause WAIS collapse (de Conto and Pollard, 2016) but such models are not definitive. Observational evidence from sediment cores provide evidence of a past WAIS collapse but do not constrain the timing (Scherer et al., 1998). Ice core and geological techniques have also failed to resolve the question, with some authors arguing they support Eemian collapse (Steig et al., 2015) and others that they support stability (Holloway et al., 2016). WAIS collapse would lead to the opening of a trans-Antarctic seaway, providing a potential ecological genetics approach to resolve whether the WAIS collapsed during the Eemian.

We propose independent testing of the hypothesis that a trans-Antarctic seaway occurred at the last interglacial. Our previous work suggests genetic connectivity between the Weddell, Amundsen and Ross Seas (Strugnell et al., 2012). Examination of the genomic signatures of bottom-dwelling marine species using the latest methods will provide an independent window into the integrity of the WAIS more than 100,000 years ago. Periods of connectivity facilitated by trans-Antarctic seaways could be revealed by dating coalescent events recorded in DNA. These powerful methods allow different scenarios to be tested against a fit to genomic data including 1) a Weddell Sea-Amundsen Sea seaway, 2) a Amundsen Sea-Ross Sea seaway and 3) a Weddell Sea-Ross Sea seaway. Ideal candidate taxa for this work would need to possess a circumpolar distribution, a benthic habitat, and some level of genetic structure indicated by phylogeographical investigation. We will detail the importance of these traits, propose ideal candidate taxa and detail an approach to examine this important question.

Keywords: Eemian, molecular genetic, West Antarctic Ice Sheet

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