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Interactive Comment

Interactive comment on "Post-coring entrapment of modern air in polar ice cores collected near the firn-ice transition: evidence from CFC-12 measurements in Antarctic firn air and shallow ice cores" *by* M. Aydin et al.

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Responses to Referee Comments

1. Comparison of these results with Law Dome (Etheridge et al., 1996)

The referee is correct in pointing out that Etheridge et al. (1996) looked closely at the mixing ratios of CO2 at the firn-ice transition at Law Dome. They found good agreement between the CO2 mixing ratios in the two deepest firn air samples at the DE08-2 site (80 and 85 m) and the air extracted from three DE08-2 ice core samples (81, 81, and

85 m). The referee considers these observations to be contradictory to our inference of post-coring entrapment of modern air based on CFC-12 measurements. In fact, the results of Etheridge et al. (1996) at Law Dome are consistent with our observations: the post-coring entrapment of air in shallow ice cores is dependent on the accumulation rate.

Of the three ice cores we studied, shallow samples from the SPRESSO core from South Pole display by far the strongest indications of post-coring entrapment, followed by Siple Dome and WAIS-D. WAIS-D has the fastest accumulation rate among our study sites and there was no evidence of post-coring entrapment at this site below the firn air sampling threshold. We suggest in the manuscript that the extent of this artifact appears to be inversely correlated with accumulation rate. The accumulation rate at the WAIS-D site is 22 cm/y (ice equivalent), followed by 11.4 cm/y at Siple Dome, and 8.3 cm/y at South Pole. In contrast, the accumulation rate at the DE08 site from Law Dome is 1.2 m/y (Etheridge et al., 1996), or about 6 times faster than the accumulation rate at WAIS-D. Therefore it is not surprising that Etheridge et al. (1996) do not observe any discrepancies within a few meters of the full close-off depth. The effects of post-coring entrapment could become apparent at shallower depths in the Law Dome firn, yet might still be hard to detect due to the unusually high accumulation rate at this site. We are suggesting changes to the conclusion section of our manuscript (see below) to discuss the relationship between our results and Etheridge et al. (1996).

There is one caveat to the interpretation of the Etheridge et al. (1996) Law Dome data. In that study, "modern air" had a CO2 mixing ratio of about 355 ppm while the CO2 levels near the firn-ice transition were 335 ppm. They state that agreement between CO2 in firn air and ice core bubbles was within 1.3 ppm, with no bias. Assuming that any entrapped air was modern (as opposed to CO2 enriched freezer air), this places an upper limit of about 5% on the possible extent of modern air entrapment that could have been present in their samples but may have gone undetected.

2. Measurement of other tracers of modern entrapment

The primary focus of our manuscript is the identification of the post-coring entrapment phenomenon. The section about the quantification merely represents upper limits and we propose to change the title of section 5 in the manuscript accordingly (see below). As the referee suggests, measuring other trace gases of anthropogenic origin would certainly be helpful and be useful in further constraining the amount of air that is getting trapped in. Unfortunately, we did not measure other anthropogenic trace gases during these analyses. Post-coring entrapment of air in shallow ice cores was hitherto unknown to us, which we stumbled upon because we use CFC-12 measurements as a diagnostic tool for leak detection. Furthermore a robust quantitative estimate would be difficult even if these additional compounds were measured because the air in walk-in freezers could be enriched with respect to many trace gases. If the data presented in the manuscript are consistent with the explanation offered and the conclusions have scientific merit, as the referee agrees, we argue that the manuscript should be published and the additional measurements be left for future studies as suggested in the last two sentences of the conclusions section.

3. Proposed revisions to the manuscript based on the referee suggestions and our responses above.

The title of section 5 is modified as follows: Previous version: Quantitative estimate of the post-coring entrapment of modern air Revised version: Upper limits on the extent of the post-coring entrapment of modern air

The last paragraph of the conclusions will read as follows in the revised version: “A notable result from this study is that at the two sites with slower accumulation rates (Siple Dome and South Pole), open porosity seems to persist well below the depth at which firn air can no longer be extracted from a borehole. The accuracy of empirical relationships between closed porosity and density seem to be site specific and appear to be less reliable at sites with lower accumulation rates. At all three study sites, the extent of post-coring entrapment appears to increase rapidly once above the FSTD. Air extracted from ice core samples collected from above the FSTD should be assumed to contain some fraction of modern air at most drilling sites. One notable exception could be sites with very high accumulation rates. Etheridge et al. (1996) compared CO2 measurements in air from the deepest 5 m of the firn at Law Dome, Antarctica with measurements in ice core bubbles and did not observe any discrepancy. The accumulation rate at their study site was about 6 times higher than the WAIS-D site at 1.2 m/y (ice equivalent), consistent with our hypothesis that the alteration of ice core trace compositions due to post-coring entrapment of modern air may be inversely related to accumulation rate."

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