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Five drills across four decades: large-volume ice coring for atmospheric gas concentration and isotopic studies at the high-accumulation DE-08 site, Law Dome, Antarctica

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The record of past atmospheric gases preserved in ice at the “DE08” site, located 16 km east of the summit of Law Dome, East Antarctica, has been the subject of analysis since the late 1980s. Three ice coring projects have been completed at this location, all exploiting the benefits of high local snowfall rates—1.2 m ice eq. a-1 at DE08. Such snow accumulation rapidly traps gases, resulting in narrow gas age distribution (~8-9 a), and also rapidly advects ice to depths where it is shielded from cosmic ray bombardment. This shielding reduces in-situ ^{14}C production and enables studies of radiocarbon-containing atmospheric trace-gases trapped in the ice (e.g. ^{14}CO , $^{14}\text{CH}_4$). First, in 1987, an Australian team used a custom thermal drill to extract cores to 234 m depth (195 mm ϕ) at DE08 for the purpose of developing paleoatmospheric reconstructions. DE08-2, located approximately 300 m southeast of the DE08 site, was drilled in 1993 by an Australian-French team using a French electromechanical drill (100 mm ϕ) and reached 243 m depth. In the 2018-2019 Antarctic summer season, a joint Australian-US team recovered ice cores from six separate boreholes at “DE08-OH,” located 900 m northeast of the original DE08, for the purpose of reconstructing past atmospheric ^{14}CO , which provides insight into past atmospheric oxidative capacity dictated by the hydroxyl (OH) radical. One core to 100 m depth was recovered using the Badger-Eclipse drill (81 mm ϕ) and the borehole subsequently sampled with the CSIRO firn-air sampling device; two cores to 95 m depth were recovered using the Blue Ice Drill (241 mm ϕ); and three cores to 240 m depth were recovered using the 4-inch drill (104 mm ϕ). All of these ice cores were extracted without the use of drilling fluid, and as such provide lessons in dry ice coring to depths >200 m, where deteriorating core quality is experienced due to increased ice overburden pressure. We examine drill performance and sample quality from all DE08 drilling projects, with an emphasis on recent findings from three parallel, 240 m-depth boreholes (~4 m horizontal spacing) recovered using the US 4-inch electromechanical drill.

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