Suo 43(4–5): 199–201, 1992(1993)

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ISOTOPE GEOCHEMISTRY OF GAS AND WATER SAMPLES FROM DEEP PEATS IN BOREAL CANADA

Charman, D.J., Aravena, R. & Warner, B.G. 1992: Isotope geochemistry of gas and water samples from deep peats in boreal Canada. — Suo 43:199–201. Helsinki. ISSN 0039-5471

A number of determinations of carbon isotopes of gas from deep peats in northern Ontario, Canada are presented. ^{14}C contents of both CO_2 and CH_4 are higher than in adjacent peats indicating younger sources of carbon for their production with transport of these sources or of the gases themselves. High tritium levels indicate the presence of water derived from relatively recent precipitation and hydraulic gradients within the peat show that significant vertical water movement is possible. These preliminary results suggest that the carbon dynamics of boreal peatlands are far more complex than is generally realised.

Keywords: Carbon dioxide, carbon isotopes, methane, tritium, water movement

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INTRODUCTION

The world's peatlands are an important component of the global carbon cycle as emphasised recently by Gorham (1991) and estimates of the total carbon pool held range from 329–528 Gt (Immirzi & Maltby 1992). The Boreal Wetland Region of Canada (*sensu* Zoltai et al. 1988) covers 3 034 000 km^2 with about 20% of this area (60 680 000 ha) covered by peatlands, representing approximately 55% of Canada's total peatland resource. Much of this is covered by forest, typically of black spruce (*Picea mariana*) and it is these peatlands which are the subject of this study.

Surface fluxes from northern peatlands have been widely reported (Gorham 1991) and long term carbon accumulation has also been studied (Clymo 1984, 1991, Tolonen et al. 1992) but the study of carbon dynamics at depth has proved more difficult. However, it has recently been shown that it is possible to sample gases at depth (Dinel et al. 1988). In this study we report on the ^{14}C content of methane and carbon dioxide content of gases sampled using this method. Detailed discussion is presented elsewhere (Aravena et al. 1993, Charman et al., unpublished).

METHODS

The two sites sampled were at Wally Creek experimental forestry area near Cochrane, northeastern Ontario (49°04´N, 80°36´W) and at Rainy River, northwest Ontario (48°47´N, 94°33´W). The Wally Creek site is a small part of a flat to undulating peatland complex, with peat of 1–2 m depth, covered by black spruce forest. Rainy River is a more open ombrotrophic bog which has developed approximately 2.5 m of peat within a shallow basin. Procedures at both sites were similar. Gas and water samples were extracted from several depths in the profile, all below the water table at the time of sampling (Wally Creek, September; Rainy River, August), using the technique of Dinel et al. (1988). CO_2 and CH_4 were separated and ^{14}C contents measured using AMS.

Undisturbed monoliths of peat were removed from a pit and bulk peat samples were radiocarbon dated by liquid scintillation counting.

RESULTS

In both sites the radiocarbon ages of the gas are considerably younger than those of the peat by up to about 3 000 years (Table 1). Ages are similar for both gases at Rainy River but at Wally Creek CO_2 is 500 years older than CH_4. The differential between gas and peat ages can be explained in several ways. Firstly, the gas may not have been produced *in situ* but may have been transported from elsewhere, dissolved in pore water. Secondly, younger carbon may have been transported to the sampling zone and been utilised for *in situ* methanogenesis and fermentation. The most likely form for this carbon would be dissolved organic carbon (DOC) within pore water. Finally, it is possible that the sampling mechanism which relies on the application of negative pressure allows the introduction of younger material, although this has not been apparent in field tests (H. Dinel, personal communication). The difference between the ages of C–CO_2 and C–CH_4 at Wally Creek further suggests that somewhat different carbon sources may be being used for the production of the two gases.

DISCUSSION

Although preliminary, these results indicate that gas production and carbon movement within deep peats are likely to be more complex than has hitherto been realised, and in particular, that there is significant transport of gases or their precursors from younger to older regions of the peat. Presumably this will involve some downward movement of water, although this will not necessarily be vertical flow at each sampling site, given the rather higher lateral hydraulic conductivities which are known to exist (Ingram 1987). There is not room here to give all the information that has been gathered relating to this phenomenon, but support for this hypothesis can be found in hydrological data and the geochemical properties of pore water. In addition to this, hydraulic head measured within the Wally Creek peats suggests that potential exists for vertical water movement in different directions at different times of year (Aravena et al. 1993, Charman et al., unpublished).

Although, it has been suggested that vertical water movement is negligible in raised mires (Ingram 1987), it has been shown that in boreal peatland complexes both discharge and recharge zones are often present (Siegel & Glaser 1987). This suggests that while efflux of gases at the surface is clearly important, it is also possible that dissolved gases may be exported from the system via groundwater.

In situ undecayed plant matter is an obvious carbon source for gas production, but it is also likely that DOC is important in this respect and it would help explain the apparent mobility of carbon. The subsequent movement of gases may result in surface emissions or removal from the system via dissolution in groundwater and also

Table 1. Uncalibrated ^{14}C age estimates (radiocarbon years B.P.) for gas and peat samples at comparable depths.

Gas			Peat	
Depth (cm)	Age		Depth (cm)	Age
	CH_4	CO_2		
Wally Creek				
91–111	2400	2930	93–95	3 440 ± 70
			108–110	4 060 ± 70
117–137	2400	2930	119–121	4 860 ± 70
			133–135	6 140 ± 80
Rainy River				
65–85	640 ± 70	760 ± 80	71–73	1 780 ± 70
102–122	540 ± 60	470 ± 60	100–101	2 070 ± 70
			129–130	2 690 ± 70
150–170	1160 ± 70	1 150 ± 70	155–156	2 990 ± 70

possibly surface runoff. Oxidation of CH_4 may occur during emission to the peat surface, particularly if the water table is low (Moore & Knowles 1989). Clearly, there are a whole series of processes which determine the nature and fate of the gaseous products of these peatlands which will need to be investigated more thoroughly if a comprehensive understanding of the peatland carbon cycle is to be gained.

ACKNOWLEDGEMENTS

This work was supported by an NSERC operating grant to BGW and a postdoctoral fellowship to DJC. The Royal Society assisted with travel costs for DJC.

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